MINISTRY OF AGRICULTURE AND ANIMAL RESOURCES
REPUBLIC OF RWANDA

DATA COLLECTION SURVEY ON IRRIGATION DEVELOPMENT IN NGOMA DISTRICT OF EASTERN PROVINCE IN RWANDA

Final Report

(ANNEXES)

July 2012

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

Sanyu Consultants Inc.

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Annex-1. Questionnaire on the MINAGRI's policy regarding irrigation development

Questionnaire on the MINAGRI's policy regarding irrigation development

Co-manager of JICA survey team on Ngoma-22 scheme

Haruo Hiki (12th of April, 2012)

[Interlocutor; Mr. Jean Claude, a member of Irrigation and Mechanization Task Force]

1. Total plan for irrigation development

Please let us know the total plan for irrigation development scheme by scheme, and also their concepts and number of projects.

Scheme	Concept	Number of projects in plan	Number of projects under studying or construction
LWH project	・Land husbandry ・Water harvesting ・Hillside irrigation	About 10 projects	About 4 projects
RSSP project	・Paddy field developments on marshlands	Phase-3 (20 projects, 7,000ha)	Phase-2 (7 projects, 3.100 ha) Phase-1; Infrastructure
Pumping Project	Pumping up irrigation water from a lake	In plan, 5,000 ha Procurement; 1,700 ha Others; 1,000 ha	On going; 2 projects, 1,000 ha

2. LWH project

(1) Land Husbandry

・ Definition of Land Husbandry

We have been understanding that Land Husbandry is the countermeasure against erosion, that is to say, the method to prevent the top soil from being eroded by rain water, and is classified into three categories composed of the ditch along the counter line, the progressive terracing and the radical terracing. But nowadays, it seems that the economical effectiveness of the radical terracing is emphasized and the word 'Land Husbandry' means the radical terracing.

① Is this recognition correct? Does MINAGRI intend to extend the radical terracing to the whole farmlands on the hill slopes nationwide?

No, not correct. The radical terracing is only a part of the land husbandry.

MINAGRI intends to extend the land husbandry nationwide not the radical terracing.

② Is there a formal paper that indicates the change of definition of Land Husbandry?

No.

③ If there is a study result in terms of the economical effectiveness of the radical terracing, please provide us with that result.

I have ever seen such papers, but I don't have here. Please ask Mr. Dan.

・ Construction works of the radical terracing

① Is construction works of the radical terracing carried out based on design drawings?

Yes.

② Is the designing of radical terracing carried out under consideration of land features and land owner ships? To which is the priority given?

Yes, it is and the priority is given to land features.

③ In the radical terracing works, the plow layer (cultivated soil) must be scraped off and dumped temporally before the land shaping is started. Is this process considered in the construction works of radical terracing? (As far as our inquiry survey on the radical terracing in Ngoma District where the construction works was done by prisoners or non-experienced workers regardless of this process, most of the farmers' assessments to the radical terracing were negative.)

There are examples constructed poorly but in many areas the land husbandries have been constructed successfully and have brought productivity improvement and large benefit.

④ Please introduce us the area where the perfect radical terracing works were constructed.
In Byumba, land husbandries have been constructed successfully since 20 years ago. And in Karongi the plantation of Irish potatoes on the terraced farmlands has gained a big success.

(2) Hillside irrigation

- Inequality in opportunities to the benefits brought by irrigation
In LWH projects, the scale of command area is some one hundred hectares, which is at most only several percent of the farmlands on the surrounding hill slopes. This means that the farmers who can receive the benefits of irrigation are limited to be several percent of the neighboring farmers. We are afraid that our project brings up economical inequality that might cause discords and conflicts among villagers. Does MINAGRI have any idea to avoid such a situation?
Nationwide, the area to which the priority of the project implementation is given is decided based on the necessity the concerned area has to that project. At the project site, the project affects not only the direct beneficiaries but also common villagers indirectly and contributes to the improvement of livelihood of whole villagers. Moreover, other projects are also implemented in collaboration with the irrigation project. Therefore, the situation mentioned above would not occur.

- Project cost and the philosophy of MINAGRI
We have already recognized through the results of some feasibility studies that the cost of LWH projects ,US$/ha, is about three to four times higher than the RSSP projects that were/have been constructed with the unit cost of some thousand US$ per hectare. Whereas, MINAGRI is going to push forward the hillside irrigation projects. What are the reasons and the philosophy of MINAGRI challenging the hillside irrigation?
The conditions are different between the RSSP projects and the LWH projects. In RSSP projects, dams are low, command areas are large, and earthen canals are enough for water conveyance systems. On the other hand in LWH projects, dams are high, command areas are small, and sometimes pipe line systems are needed for the water conveyance.
If the hillside irrigation becomes too costly, we might adopt a choice that the land husbandry only shall be applied and the hillside irrigation shall be given up considering the budget conditions. But fundamentally, more than 60% of land is hilly area and 10,000,000 people live on this hilly area in Rwanda, so that we can not abandon the LWH projects because of their low benefit-cost ratio.

- Assistance of MINAGRI to the operation and maintenance (O&M) of the main irrigation facilities
In RSSP (Rural Sector Support Program) projects, RSSP staffs supervise O&M works such as the discharge control, estimation of water fee, etc. Does MINAGRI have a plan to establish an organization similar to RSSP?
It's of course, because RSSP belongs to MINAGRI.
Apart from RSSP, we have established WUA (Water User Association) Support Unit that would take care of O & M works to all kinds of water utilization facilities.

3. RSSP project and rice

- Self-sufficiency of rice

① It is said that the nationwide self-sufficiency of rice has not yet achieved. Does MINAGRI keep challenging toward the accomplishment of self-sufficiency of rice?
Yes.

② If so, how many hectors of paddy fields must be newly developed and does MINAGRI have the development plan already?
No, we don't have.

③ We suppose the development of paddy fields would be done on marshlands; and we have heard that there is an environmental law that forbids the intrusion of agricultural/economical activities into marshlands. How does MINAGRI arrange the situation between the necessity of development and the protection of marshlands?

The law does not forbid the utilization of marshlands. The regulations of the law show the conditions/rules in terms of their utilization.

- Export of rice

  There is a high potential of producing rice for export as quantity of rice production is not enough in many African countries. Does MINAGRI keep challenging to increase the rice production level enough for exporting?

  Yes.

- Upland rice

  We suppose the area between the marshland and the hill foot would be suitable for planting upland rice. Does MINAGRI have a plan of introducing upland rice?

  Please get an answer form RAB.

- Floating rice

  We are now studying the possibility of introducing floating rice that would grow on the water surface of the reservoir. This idea has come up through thinking about how to compensate the farmers whose farmlands are submerged in the reservoir water. How does MINAGRI think of this idea?

  Welcome, personally.

4. Large scale irrigation project

   We have heard that some large scale irrigation projects where irrigation water is pumped up from a lake onto a high point of the hill slope are now under studying or construction.

   ① How many large scale irrigation projects are under studying or construction?

   The answer is already given.

   ② Please give us the information of the representative project in terms of the following items.

- Project name;
- Capacity of the pump; Pump discharge: Lifting height:
- Command area;
- Pump power;
- Construction cost of pumping system;
- On-farm irrigation method;
- Main crops planted;
- Organization in charge of operation and maintenance of the pumping system;

  An adequate person shall be introduced later.

   ③ If a pumping irrigation system is introduced to a LWH project, are engineers who belong to the organization above able to take care of this installed one?

   There are many engineers/technicians in Rwanda who can maintain pumps.

   ④ In these large scale projects, is the radical terracing provided to the command area?

   The land husbandry would be provided; the radical terracing is only a part of land husbandry.

5. Food security and market-oriented agriculture

   The importance of both the food security and the market-oriented agriculture is emphasized at the beginning of every feasibility study report, but actually many of the reports show the cropping program only for cash crops. We would like to give greater importance to the crops such as maize, plantain, etc that have a high market demand and also contribute to the food security. How does MINAGRI think of our fundamental policy on selecting the crops?

   We agree it; but I don’t think F/S reports show the cropping program only for cash crops. RAB has the criterion for the selection of crops where soil conditions, climate conditions, market conditions and the social habits, and of course the food security, are taken into account.

6. Relationship between the promotion of one family one cow policy and LWH projects

   It is said that the average body count of cows per one household is less than 0.5 heads. On the other hand, there is an opinion that there is no room to increase the body count of cows under the condition of feeding cows by grasses growing on the side of roads and paths, and that to increase the body count of cows it is necessary to plant pasture in the farmland. We would like to make it the fundamental policy that the cow's matter shall not be included in our study of the cropping program but shall be left on the hands of farmers in future. Does MINAGRI agree on this fundamental policy?

In Rwanda, grasses for cows grow on openings among other crops under a mixture condition so that it is not necessary to consider the pasture in the cropping program.

7. Infrastructure in rural areas

Does MINAGRI have any developing plan for introducing infrastructures in rural areas?

Yes, we have feeder road projects.

We don't have the projects for electricity, which is belongs to 'Energy, Water and Sanitation Authority'. When this institution carries out a project in rural area, we collaborate since demands are provided to them by us.

In rural area, solar electricity systems are familiar these days. You can see every governmental office has a solar electricity system on its roof.

How about the capacity building plan of O & M staff for these infrastructures?

We don't have any plan. It seems there are enough engineers/technicians in the society.

If MINAGRI does not have and other institutions have, please introduce us the plans of the other institutions.

Sincerely yours, Haruo Hiki

Questionnaire on your development support program to Rwanda

Co-manager of JICA survey team on Ngoma-22 scheme

Haruo Hiki (11th of April, 2012)

[Interlocutor; Mr. MWUMVANEZA Valens, Rural Development Specialist, World Bank – Kigali]

1. Development support programs WB is offering or is going to offer

   Please let us know development support programs WB is offering or is going to offer, and fund scales to them if it is permissible.

・ WB commits the design quality of LWH Projects by sending the Project Implementation Unit composed of three specialists, Mr. Dan, Dr. Hadush and Mr. Gaspard, of which duty is to manage the conditions from designing to the construction.

Aid scheme	Project name	Fund scale
Agricultural development program	RSSP phase-1 (2001~2008)	45 million US$
	RSSP phase-2 (2008~2012)	35 〃
	RSSP phase-3 (2012~2017)	80 〃
	LWH (2010~2015)	WB; 34 〃
		GAFSP; 50 〃
		USAID; 14〃
		CIDA; 9〃

・ The dam height of small dams should be less than or equal to 15m according to the WB procurement standard.

・ In case of the dam height being higher than 15m, its design contents shall be examined by the international panel of experts one of which member must be an affiliate of International Commission of Large Dams.

・ After that, the project concerned must be approved by the WB headquarters.

2. Policy of supporting hillside irrigation projects

   We have already recognized through the results of some feasibility studies that the cost of hillside irrigation projects ,US$/ha, is about three to four times higher than the RSSP projects that were/have been constructed with the unit cost of some thousand US$ per hectare.

   Based on what policy does WB support hillside irrigation projects with low benefit-cost ratio?

・ Topographical conditions are different between RSSP projects and LWH projects. In RSSP, the dam height is 5m or so and the command area is large. On the other hand in LWH, the dam height is around 15m and the command area is small, so that the benefit-cost ratio of LWH projects becomes low.

・ The condition that we can not order the construction works of LWH projects to the local contractor also makes the cost high.

・ To raise the economical effectiveness of the LWH projects, crops with high profit performance or export orientation should be planted

・ We should assess the economical balance totally by including the land husbandry that gives back two or three times of productivity increase.

Questionnaire on your country's development support program to Rwanda

Co-manager of JICA survey team on Ngoma-22 scheme

Haruo Hiki (13th of April, 2012)

[Interlocutor; Mr. Gary Cramer, Senior Agricultural Advisor, USAID/Rwanda]

3. Development support program USAID is offering or is going to offer
   Please let us know the development support program USAID is offering or is going to offer, and fund scales to them if it is permissible.

4. Policy of supporting hillside irrigation projects (If your country is supporting or is going to support hillside irrigation projects, please let us know your policy.)

Aid scheme	Project name	Fund scale
Irrigation development	LWH project	14million US$ (to fund basket)
Socio-economical development	Feeder Road Project	
	Entrepreneur Project	
Others	Water & Sanitation Project	

We have already recognized through the results of some feasibility studies that the cost of hillside irrigation projects ,US$/ha, is about three to four times higher than the RSSP projects that were/have been constructed with the unit cost of some thousand US$ per hectare.

Based on what policy does USAID support hillside irrigation projects with the low benefit-cost ratio?

- The benefit-cast ratio is important but the social effect, such as strengthening the community's solidarity through participating to the land husbandry construction or through establishing/activities of cooperative, should be counted.
- The economical effectiveness should be assessed by the benefit-cost ratio totally that includes the benefit brought after the completion of the project not by the unit cost of construction only.

Sincerely yours, Haruo Hiki

Questionnaire on your country's development support program to Rwanda

Co-manager of JICA survey team on Ngoma-22 scheme

Haruo Hiki (13th of April, 2012)

[Interlocutor; Mr. James Parsons, Chef de Bureau et Chef de la Cooperation]

5. Development support program your country is offering or is going to offer
   Please let us know the development support program your country is offering or is going to offer, and fund scales to them if it is permissible.

6. Policy of supporting hillside irrigation projects (If your country is supporting or is going to support hillside irrigation projects, please let us know your policy.)

Aid scheme	Project name	Fund scale
Irrigation development	LWH project	9 million US$ (to fund basket)
	GAFSP (Global Agriculture Food Security Program)	15 million US$
	Assistance to NGOs	
Socio-economical development		
Others		

We have already recognized through the results of some feasibility studies that the cost of hillside irrigation projects ,US$/ha, is about three to four times higher than the RSSP projects that were/have been constructed with the unit cost of some thousand US$ per hectare.

Based on what policy does your country support hillside irrigation projects with low benefit-cost ratio?

- If the benefit-cost ratio is too low, we can not help abandoning the hillside irrigation as we did not implement it but the land husbandry only in Gatsibo Project and Karongi Project.
- But it is inevitable that the benefit-cast ratio of the LWH project becomes low compared with the one of the RSSP.

Sincerely yours, Haruo Hiki

Questionnaire on Agriculture in Rwanda
Co-manager of JICA survey team on Ngoma-22 scheme
Haruo Hiki (11th of April, 2012)

1. What is the role of RAB?

RAB, the former Rwanda Agriculture Development Authority (RADA), Rwanda Animal Resources Development Authority (RARDA) and Rwanda Agriculture Research Institute (ISAR) has the major roles of;

- Research and,
- Agriculture extension

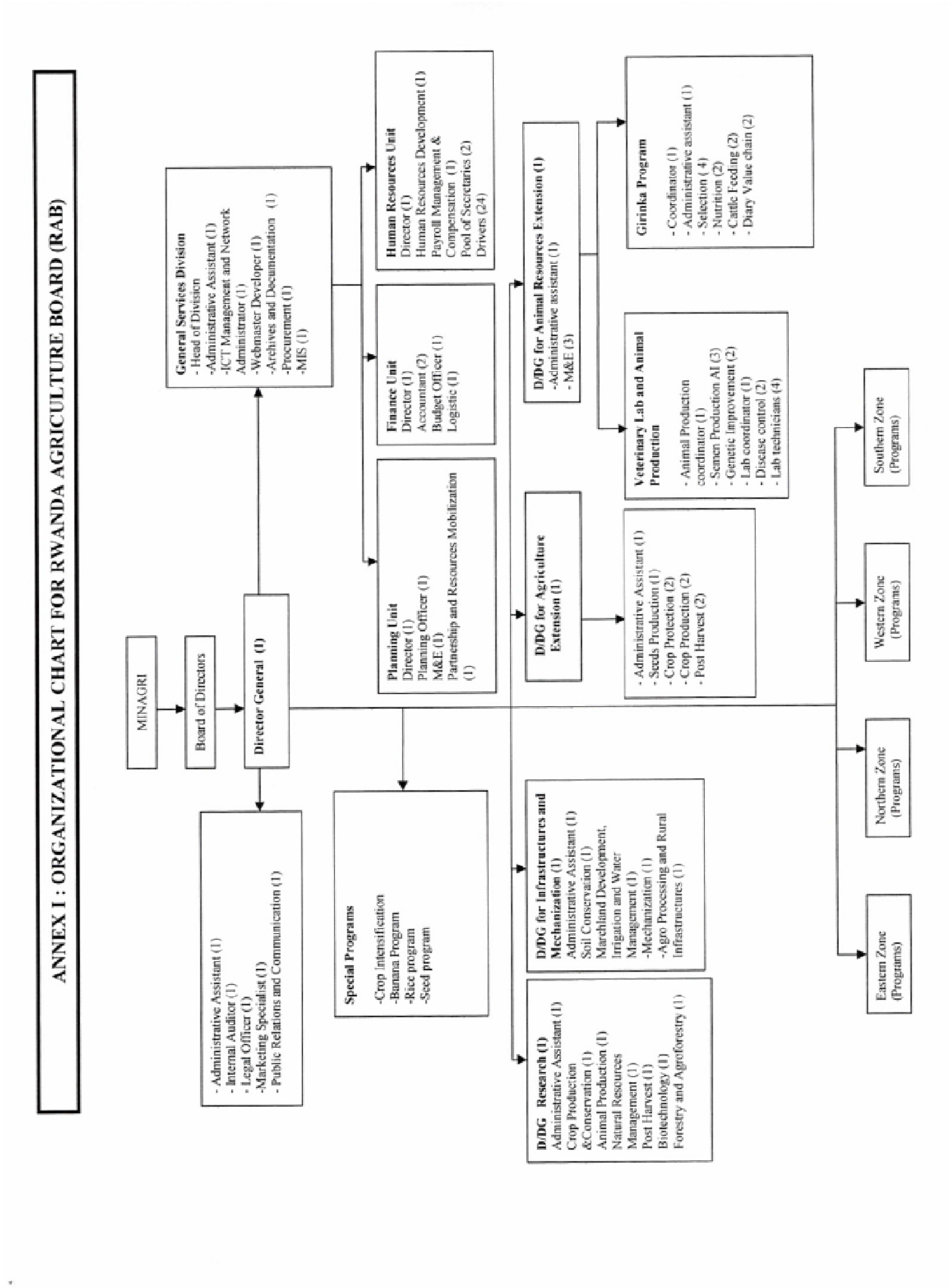
2. Every cooperative of rice farmers answers that seeds are obtained from RAB. Does RAB produce all the seeds provided to cooperatives in Rwanda?
    - RAB provides improved rice seeds to farmers free of charge
    - There is still resistance of farmers to adapt to improved seeds that's why RAB provides them for free

3. Upland rice
   We rate rice as an attractive crop from the view point of the market demand and the contribution to food security. But the further development of paddy fields on marshland has a dilemma of environmental destruction. Then, upland rice comes up to our consideration though this is not popular in Rwanda. Please lecture us on its suitableness/unsuitableness, the history/experiences of research as a crop in Rwanda.
    - There is an on – going upland rice research by Chinese which started in 2006 in KABUYE and now in NGOMA

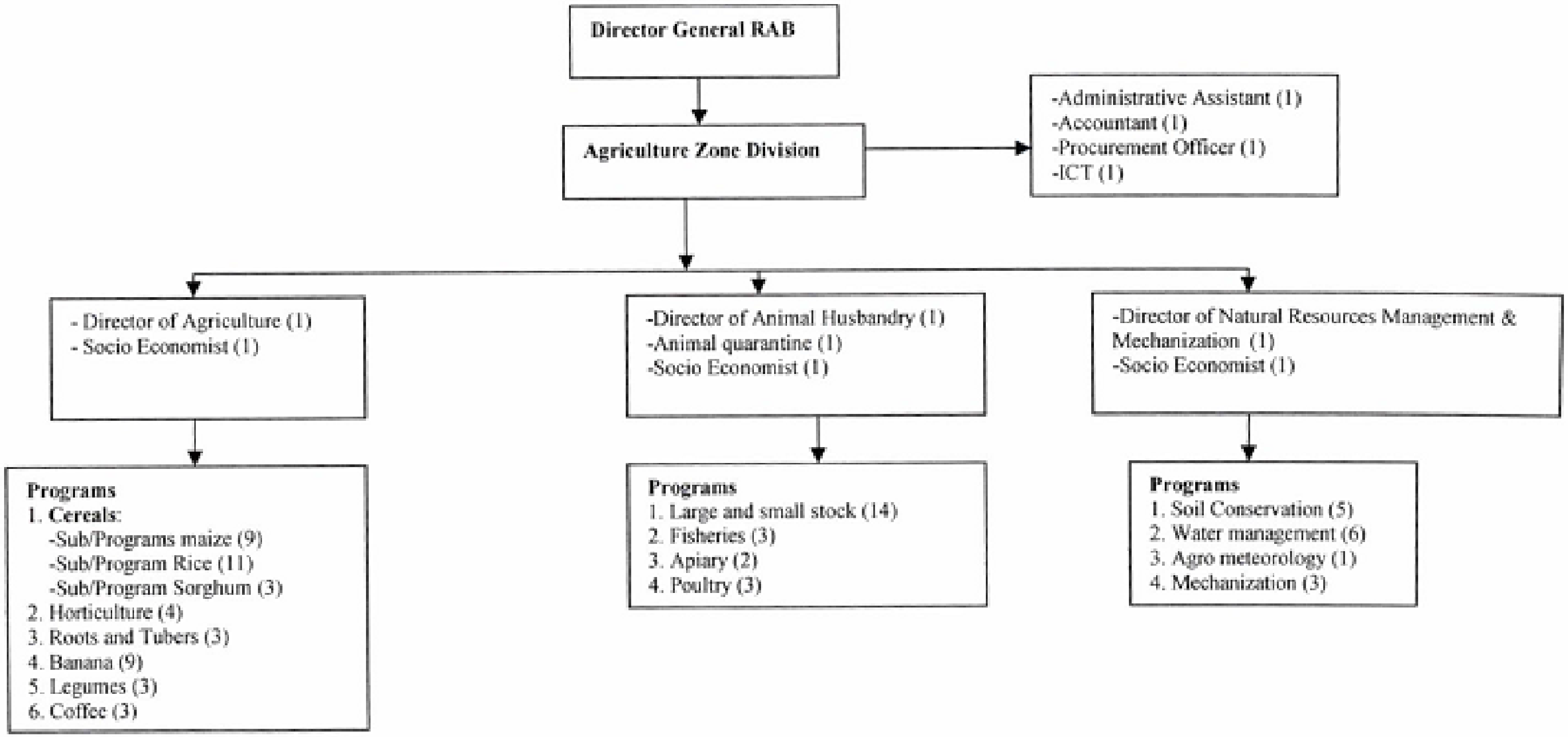
4. Floating rice
   Based on the recognition above, floating rice comes up to the surface as one of the alternatives for increasing rice production, because there are many lakes in Rwanda and wide space extends there. What opinion does RAB have to floating rice?
    - No experience of floating rice in Rwanda

5. Agronomists of RAB
   Please lecture us on the role of RAB's agronomists and the relationship between them and the sector/district agronomists.
    - There are several RAB workers in the 4 zones (Eastern, Northern, Western, and Southern) as referred to Organizational chart attached below

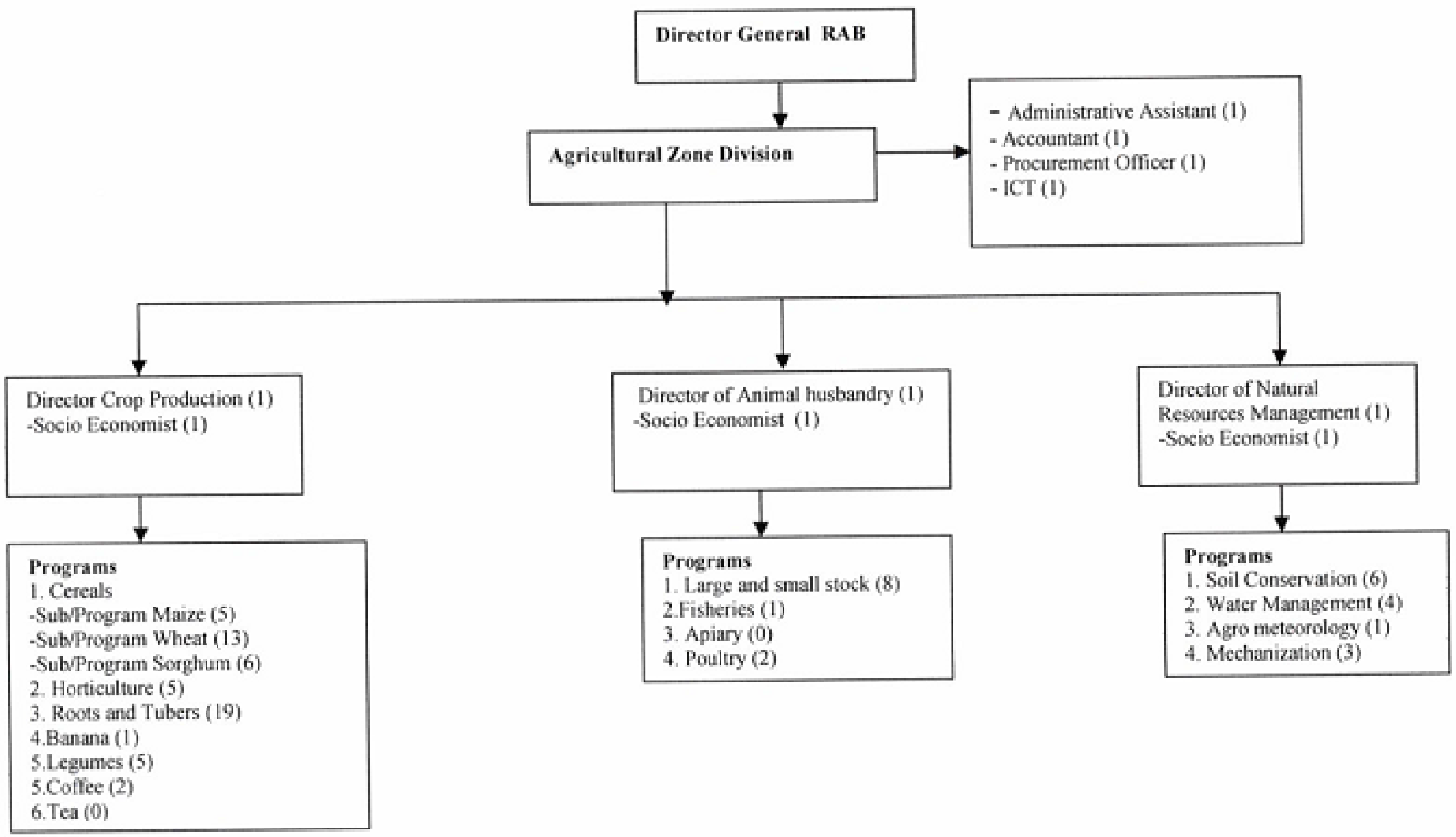
Please provide us with your organization chart and a national climate change risk map.



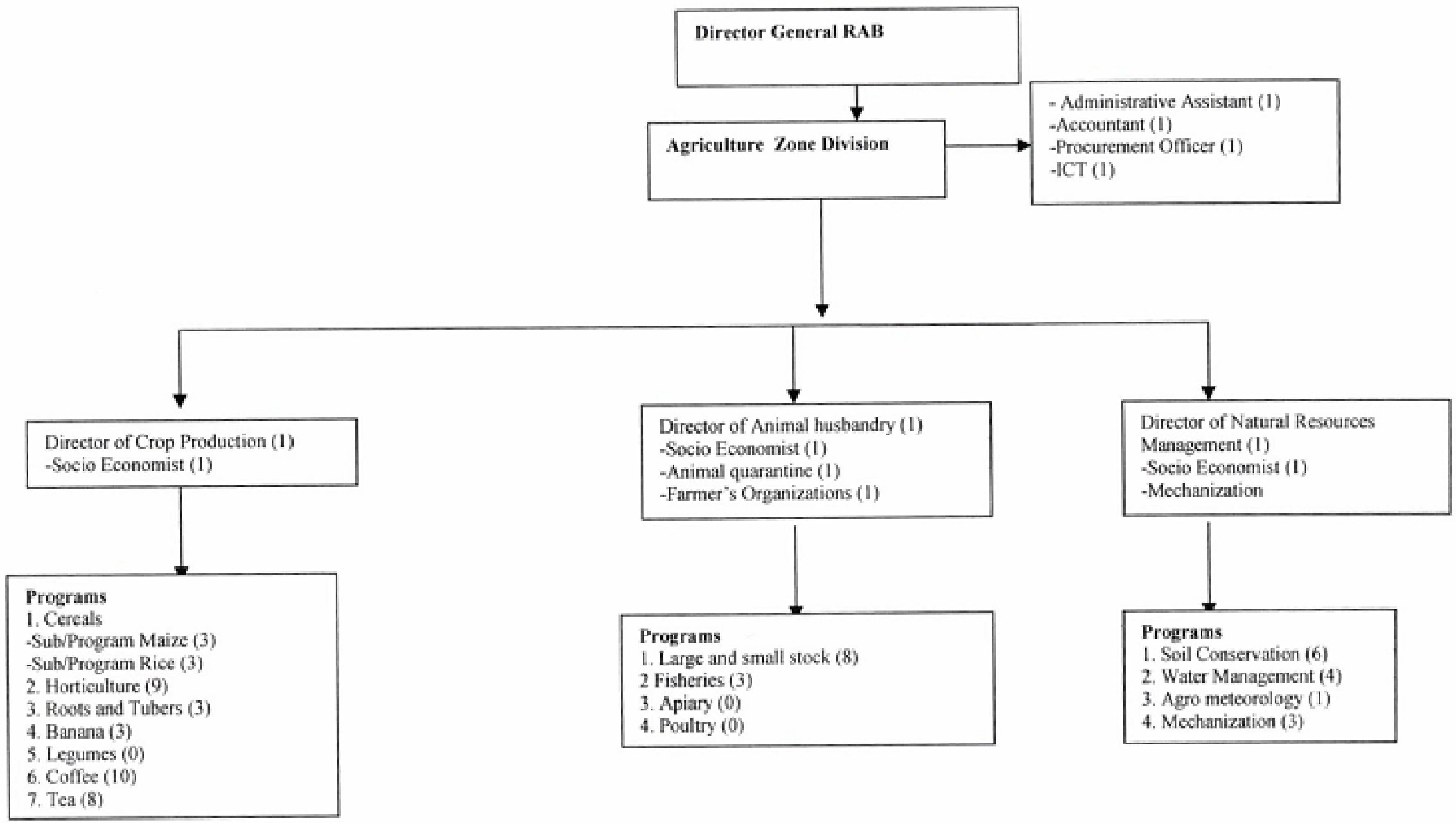
EASTERN AGRICULTURAL ZONE ORGANIZATIONAL CHART- 2011



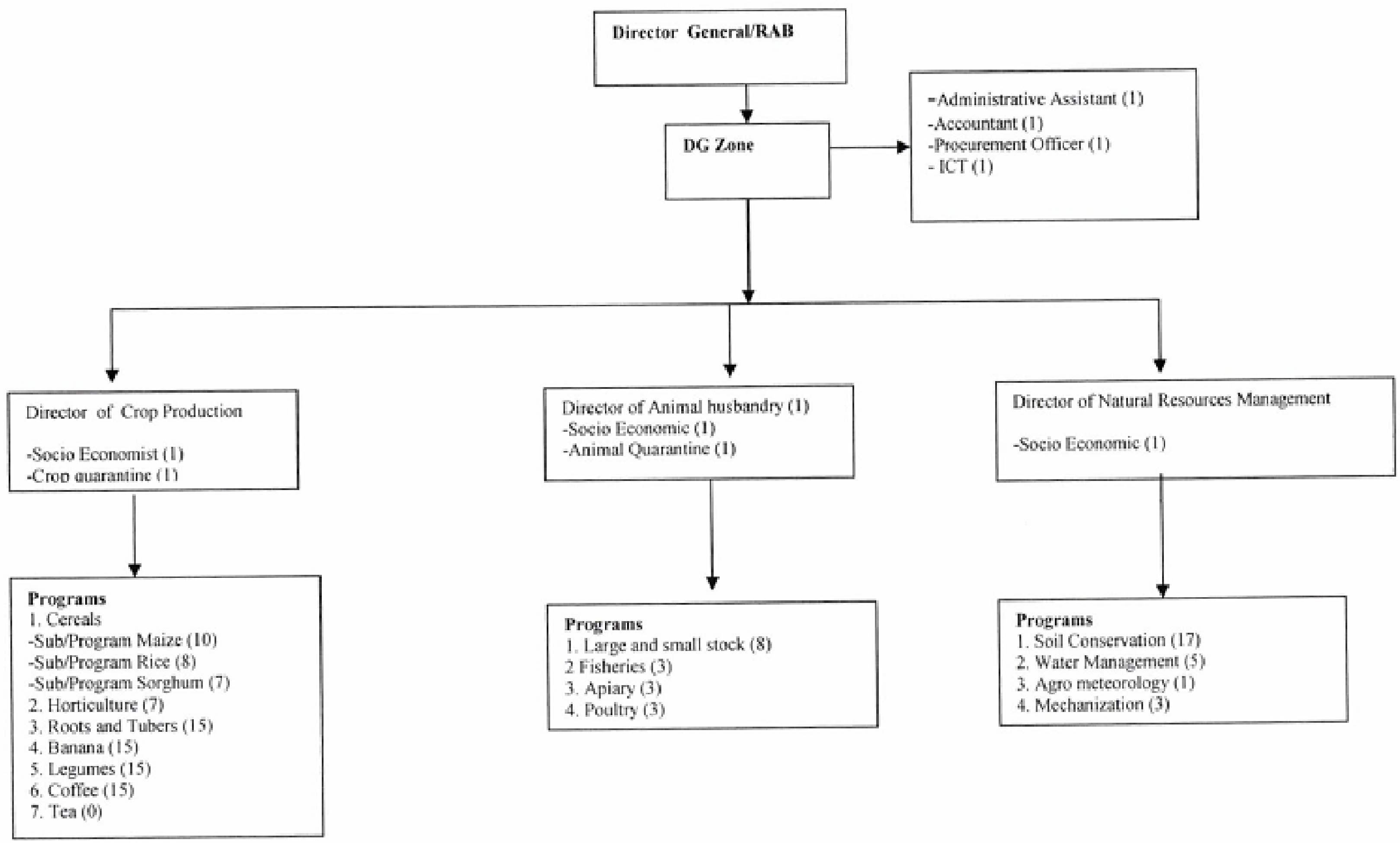
NORTHERN AGRICULTURAL ZONE ORGANIZATIONAL CHART- 2011



WESTERN AGRICULTURAL ZONE ORGANIZATIONAL CHART- 2011



SOUTHERN AGRICULTURAL ZONE ORGANIZATIONAL CHART- 2011



RAB in price support scheme

The prices of agricultural products such as maize, tea and coffee tend to fluctuate more than the prices of manufactured products and services. This is largely due to the **volatility in the market supply** of agricultural products coupled with the fact that demand and supply are price inelastic. One way to smooth out the fluctuations in prices is for the government of Rwanda to operate price support schemes through the use of **buffer stocks**.

It's due to this factor that the Rwandan government through Rwanda Agriculture Board (RAB) operates a **buffer stock scheme** (commonly implemented as **intervention storage),** in an attempt to use commodity storage for the purposes of stabilizing prices in an entire economy. Specifically, commodities maize in particular, are bought when there is a surplus in the economy, stored, and are then sold from these stores when there are economic shortages in the market.

Result of Ntende Dam and Kiliba Dam

NTENDE Valley Planting plan for season B 2012

No	Date	Item	Requirements	To be done by	To be done where
1	01/09-31/10/2011	Leveling	Labour	RSSP&COOPERATIVE	Every zone
2	01-15/11/2011	Nursery Preparation	Buying seeds on time	COOPERATIVE	NTENDE Valley
3	16/11-15/12/2011	Paddling Transplanting	Keeping time	Farmers	In NTENDE valley
4	15-20/12/2011	Destroying all seedlings that have surpassed transplanting stage in the nursery	Communal work	Groups	NTENDE Valley
5	20-31/01/2012	First weeding Application of NPK Pesticide application	Keeping time Acquiring inputs	Farmers COOPERATIVE	NTENDE Valley RAB RAB
6	01-29/02/2012	Second weeding First application of UREA Pesticide application	Keeping time Acquiring inputs	Farmers COOPERATIVE	NTENDE Valley RAB
7	01-31/03/2012	Third weeding Second application of UREA	Keeping time Acquiring inputs	Farmers COOPERATIVE	NTENDE Valley RAB
8	01-30/04/2012	Birds prevention Securing loan for season A 2013	Looking for noisy materials Preparing business plan	Farmers COOPERATIVE	NTENDE Valley Cooperative Office
9	01-31/05/2012	Drying the produce Selling of produce	Preparing drying yard & bags Looking for Market & truck to carry the produce	COOPERATIVE	Cooperative drying yards

Expenses Used on 20 Ares of Paddy in NTENDE Valley

No	Item	Quantity	Price per each (FRW)	Total Amount (FRW)
1	Land clearing	4	800	3,200
2	Sloughing	25	800	20,000
3	Leveling	18	800	14,400
4	Nursery Preparation	1	800	800
5	Paddling	18	800	14,400
6	Transplanting	15	800	12,000
7	First weeding	15	800	12,000
8	Second weeding	18	800	14,400
9	Third weeding	10	800	8,000
10	Fertilizer application (3 times)	3	800	2,400
11	Pesticide application (2 times)	2	800	1,600
12	Preventing paddy from birds	N/A		20,000
13	Harvesting	25	800	20,000
14	Drying	8	800	6,400
15	Winnowing	15	500	7,500
	Sub - Total			**157,100**
	Input costs			
16	Seeds	4	450	1,800
17	NPK	40	380	15,200
18	UREA	20	470	9,400
19	Pesticides	150	8	1,200
	Sub - Total			**27,600**

	Other equipments			
20	Bags	15	250	3,750
21	Hoes	1	1,500	1,500
22	Sickle	2	400	800
23	Panga/Machete	1	1,000	1,000
24	Plastic shitting	2	6,700	13,400
	Sub - Total			**20,450**
	Grand Total			**205,150**

Profit and Loss Account

Incomes	390,000
Less: Expenses	205,150
Profit	**184,850**

Result of Rilima pump irrigation project

[economic analysis]

	Maize
	KOAIGR
Agricultural Inputs	6 947 500
Plowing	9 900 000
Processing and transportation	5 265 000
Irrigation	4 708 025
Running cost and salary	4 102 000
Total of costs	30 922 525
Cost per Ha	343 584
Outputs	120 375 000
Gross margin benefit	89 452 475
GMB/ha	993 916
	Tomatoes
Agricultural Inputs	14 150 000
Plowing	5 640 000
Transportation	9 000 000
Irrigation	8 057 000
Running cost and salary	6 486 000
Total of costs	43 333 000
Cost per Ha	1 444 433
Outputs	90 000 000
Gross margin benefit	46 667 000
GMB/ha	1 555 567
capital rate factor/tomatoes	1,076939053

Result of PiCROPP

Abakundamahoro Cooerative

Name of the cooperative	ABAKUNDAMAHORO			
Date of inquiry survey, Inquirer	14/04/2012 by Impeta Fred			
Interlocutor's name, position	Mr. Mudaheranwa Francois, Cooperative Secretary			
Planted vegetable	Tomatoes	Cabbages	Onions	Eggplant
Planted area	23 plots 35m/plot			
Irrigation method	Hand irrigation			
Timing of irrigation (When?)	Evening			
Quantity of irrigation water	16th Jan – 20th March 80cans of 21litres each Skipping one day			
Water price	20FRW/can			
Hours needed for irrigation	4 hours/day			
Farmers needed for irrigation	10 people 7 water collection 3 watering			
Market, transportation	Karembo & Local people Head, Bicycles			
Yield / ha	98kg/plot			
Selling price (FRW/kg or ton)	400FRW/Kg			
Input;				
Fertilizer etc.(quantity, price)				
・compost manure	5000FRW/ton			
・NPK	30gms/tomato			
Tax etc.				
Number of related farmers	10 people			
Net Income per person	No income sharing yet 87,000Frw first harvest			

Farmer 1

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	COPARWE	
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya	
Interlocutor's name, position	BICAMUMPAKA Berchmas/Advisor	
Planted vegetable	Tomato	Egg plant
Planted area	30x40	6x3
Irrigation method	Hand irrigation Water pump	Hand irrigation
Timing of irrigation (When?)	Hand irrigation: afternoon Water pump: Morning time.	Hand irrigation: afternoon
Quantity of irrigation water *20L/person x 15 times x 4 persons*	1200L/Day	40L/day
Water price	Water from the marshland	100F/Jerican
Hours needed for irrigation	4 hours (from 6 H to 10 H)	30 minutes
Farmers needed for irrigation	4 Persons 4 hours	1 person 30 minutes
Market, transportation	Rweru market, Nyamata Bicycle, Vehicle	Not yet harvested
Yield / ha	960/30x40	Not yet harvested
Selling price (FRW/kg or ton)	125/Kg	200/Kg next month
Input;	Compost manure made by farmers themselves	Compost manure
Fertilizer, etc.(quantity, price)	2 Kg /Total	25 Kg Compost manure
Urea	360 Kg	
Tax etc.	5500/30 days	
Number of related farmers	4 persons	

Coop. (20 persons)

1 labour: 600 RwF up to noon.

Farmer 2

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	COPARWE		
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya		
Interlocutor's name, position	UWIZEYIMANA J. Nep, Treasurer		
Planted vegetable	Tomato	Onion	Water Melon
Planted area	15 are	2 are	7 are
Irrigation method	Hand irrigation Water pump	Hand irrigation	Hand irrigation
Timing of irrigation (When?)	Morning & Afternoon	Afternoon	Afternoon
Quantity of irrigation water	200 cans of 12 liters each	30 cans of 12	80 cans of 12 liters
Water price	Water from the marshland	Water from the marshland	Water from the marshland
Hours needed for irrigation	4 hours: can 3 hours: 3 L petrol	1h 30 Minutes	3 Hours
Farmers needed for irrigation	5 persons: can 4 persons with water pump	3 persons including him	4 persons including him
Market, transportation	Rweru market Kicukiro Bicycle and vehicle	Rweru market Bicycle	Not yet harvest
Yield / ha	2.5 Tons	Not yet harvest	Not yet harvest
Selling price (FRW/kg or ton)	200 RwF/Kg	400 RwF/Kg	-
Input; compost manure	Made by himself	Made by himself	None
Fertilizer, etc.(quantity, price)			
・Urea	He uses 2 Kg 360RwF/Kg		
Tax etc.	5500/30 days	Same amount	
Number of related farmers	5 persons	3persons including him	4 persons Including him

Coop. (20 persons)

1 labour: 600 RwF before noon.

1 labour: 300 RwF after noon.

Farmer 3

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	COPARWE		
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya		
Interlocutor's name, position	MIBURO Léodomir, President		
Planted vegetable	Tomato	Onion	Cabbage
Planted area	15 are	6 are	4 are
Irrigation method	Hand irrigation Water pump	Hand irrigation	Hand irrigation
Timing of irrigation (When?)	Morning & Afternoon	Afternoon	Afternoon
Quantity of irrigation water	200 cans of 12 liters each	100 cans 5 persons x 2cans	80 cans 3 persons
Water price	Water from the marshland	Water from the marshland	Water from the marshland
Hours needed for irrigation With	4 hours/ day Water pump. 3 H: 3L petrol	3 hours/day	2 hours/day
Farmers needed for irrigation	5 persons: can 4: Water pump	5 persons	3 persons
Market, transportation	Rweru market Kicukiro Bicycle and vehicle	Rweru market Bicycle	Rweru market
Yield / ha	3 Tons	Not yet harvested	Not yet harvested
Selling price (FRW/kg or ton)	250 RwF/Kg	400 RwF/Kg Next month	100/kg
Input; compost manure	Made by himself	Made by himself	Made by himself
Fertilizer, etc.(quantity, price)			
・Urea	He uses 2 Kg 300RwF/Kg	-	-
Tax etc.	5500/30 days	30 days	30 days
Number of related farmers	5 persons	5persons	3 persons

Entire coop. (20 persons)

1 labour: 600 RwF before noon.

1 labour: 300 RwF after noon.

Farmer 4

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	KOPUBIGA	
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya	
Interlocutor's name, position	BASANGIRA Etienne	
Planted vegetable	Tomato	Water melon
Planted area	1ha	1,5 ha
Irrigation method	Hand Irrigation, Water pump	Hand Irrigation, Water pump
Timing of irrigation (When?)	Morning From 5am to 9 am	Before noon After noon
Quantity of irrigation water 1 person: 20Lx 50 in 1000L	1000x6= 6000L 3L of petrol 1hour	1000x9= 9000 L 6L of petrol 2Hours
Water price	Water from the marshland	Water from the marshland
Hours needed for irrigation With	3 hour: hand irrigation 1 hour: water pump	3 hours 1 hour
Farmers needed for irrigation	6 persons: hand irrigation 3 persons: water pump	9 persons: Hand irrigation 9 persons water pump.
Market, transportation	Nyabugogo, Goma Vehicle (20,000 RwF/Trip)	Simba Super market Serena Hotel
Yield / ha	18 tons	2500 pcs
Selling price (FRW/kg or ton)	200 Rwf/kg	1pc/1000 Rwf
Input; compost manure *1 ton (RwF10,000*)	3 tons	3 tons
Fertilizer, etc.(quantity, price)		
・N.P.K 17.17.17	50 kg 1kg/400	50kg 1kg/400
・Urea	20 kg 1kg/420	
DAP		40 kg 1kg/600
Tax etc.		
Number of related farmers		

Coop. (20 persons)

1 labour: 800 RwF before noon.

1 labour: 400 RwF after noon.

60 days irrigating

Farmer 5

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	KOPUBIGA	
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya	
Interlocutor's name, position	MPORWIKI Evariste Store keeper	
Planted vegetable	Tomato	Green pepper
Planted area	80 are	20 are
Irrigation method	Hand Irrigation, Water Pump	Hand Irrigation, Water pump
Timing of irrigation (When?)	Afternoon afternoon	Afternoon Afternoon
Quantity of irrigation water *Petrol 8 L/ 5*	1 person x 50 20 L	1 person x 50 X 20 L
Water price	Water from the marshland	Water from the marshland
Hours needed for irrigation	5 hours with Water Pump 3 hours for hand irrigation	1 hour 30' for water pump 2H 30' hand irrigation
Farmers needed for irrigation	15 persons for hand irrigation 4 persons for water pump	5 persons for hand irrigation 4 persons for water pump
Market, transportation	SORWATOM, Nyabugogo Gashora Vehicle and bicycle	Kimisagara, Nyabugogo Gashora, Kimironko Vehicle, bicycle
Yield / ha	2.5 ton	400 water melon
Selling price (FRW/kg or ton)	200 RwF/Kg	150 RwF/Pc
Input; compost manure	-	4 tons
Fertilizer, etc.(quantity, price)		
・N.P.K 17.17.17	60 Kg, 400 RwF/Kg	30 Kg, 1 kg/400 RwF
Tax etc.	-	
Number of related farmers	15	5 persons x 20 days, hand irrigation 4 persons x 10 days, water pump Within two months

1 labour: 800 RwF before noon.

1 labour: 400 RwF after noon.

Farmer 6

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	KOPUBIGA	
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya	
Interlocutor's name, position	AHISHAKIYE Francois accountant	
Planted vegetable	Tomato	Water melon
Planted area	50x100	35x50
Irrigation method	Hand Irrigation, Water Pump	Hand Irrigation, Water pump
Timing of irrigation (When?)	Afternoon, afternoon	Afternoon, Afternoon
Quantity of irrigation water 1 person: 20Lx 10 Tin x 5 persons	1000L hand irrigation	- 700 L - 1 L petrol/1 hour
Water price	Marshland water	Marshaland water
Hours needed for irrigation	3 hours Hand Irrigation 2 hours for water pump	2 hours for hand irrigation 1 hour water for pump
Farmers needed for irrigation	5 persons hand irrigation 5 persons water pump	3 persons for hand irrigation 3 persons for water pump
Market, transportation	Nyabugogo, Gashora Vehicle and bicycle	Kimisagara, Kimironko Vehicle, 25,000 RwF/ hiring vehicle
Yield / ha	1 ton	500 water melon
Selling price (FRW/kg or ton)	250 RwF/Kg	900 RwF/Pc
Input; compost manure	2 tones	500 Kg
Fertilizer, etc.(quantity, price)		
・N.P.K 17.17.17	25Kg, 460 RwF/Kg	15 Kg 1 kg/460 RwF
Tax etc.	-	
Number of related farmers	10 persons/ 50 days	6 persons /40 days

1 labour: 800 RwF before noon.

1 labour: 350 RwF after noon.

Farmer 7

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	IMBARAGA				
Date of inquiry survey, Inquirer	2/5/2012, Muvunyi Yahaya				
Interlocutor's name, position	Nyanzungu Déo				
Planted vegetable	Tomato	Cabbage	Onion	Carrot	Egg plant
Planted area	24 are	97 are	19 are	10x15	20x30
Irrigation method	Hand Irrigation				
Timing of irrigation (When?)	Before noon, Afternoon				
Quantity of irrigation water 1 person: 20Lx 20	2000L	2000L	2500 L	1000L	3200L
Water price	Water from the marshland				
Hours needed for irrigation	4 Hours, 4-17H)	4 Hours	4 Hours	1 Hours	3 Hours
Farmers needed for irrigation	5 persons	5 persons	5 persons	5 persons	8 persons
Market, transportation	Mutenderi, Bicycle				
Yield / ha	173/Kg	4397Kg	108 Kg	120 Kg	465/Kg
Selling price (FRW/kg)	150/Kg	40/Kg	220/Kg	125/Kg	100/Kg
Input; *compost manure*	1680Kg	4 tones	1 ton	350 Kg	2 Tons
Fertilizer, etc.					
・DAP	Gift from JICA				
・Urea		480/Kg, 40 Kg			
・N.P.K 17.17.17			600/kg, 15Kg		
・Urea				480/Kg	
Tax etc.					
Number of related farmers	30 persons	30 persons	30 persons	30 persons	

Coop members 192

one Kg of Compost manure= 8F

Farmer 8

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	Private	
Date of inquiry survey, Inquirer	4/5/2012, Muvunyi Yahaya	
Interlocutor's name, position	Shyaka Francois	
Planted vegetable	Cabbage	Tomato
Planted area	5 are	4 are
Irrigation method	Hand irrigation	Hand irrigation
Timing of irrigation (When?)	Afternoon	Before noon and afternoon
Quantity of irrigation water 1 person: 20Lx 60 time	1200L	1 person 20L(Jerican x 2) 40Lx10 Tin= 400L
Water price	From Canal	Water tap, 20L= 20 RwF
Hours needed for irrigation	2 hours	2 hours
Farmers needed for irrigation	2 persons	2persons
Market, transportation	Gafunzo market, Karembo, Mugesera By bicycle	Karembo, Mugesera By bicycle
Yield / ha	350 Kg (5 Bags of 70 Kg each)	300 kg (25 baskets of 12 Kg each)
Selling price (FRW/kg or ton)	1 bag: 3500 Rw, 1 Cabbage: 50 Rwf	166 RwF/Kg
Input; *compost manure*	12000 RwF (estimation)	4000 RwF (estimation)
Fertilizer, etc.		
・N.P.K 17.17.17	32 Kg: 400 RwF/Kg	16Kg: 400 Rwf
・Urea ½ Kg	600 RwF	Ditane: 4Kg 2600/Kg
・Thioda	700 RwF	Indofile 3 kg: 1200 RwF/Kg
		Agrolax 2kg: 1500/Kg
Tax etc.	200 RwF/Bag	5000 RwF, 200Fx25 basket
Number of related farmers	4 farmers	4 farmers

2 labour 7 days: 1 labour 500 RwF/Day

Farmer 9

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	DUKORE	
Date of inquiry survey, Inquirer	4/4/2012, Muvunyi Yahaya	
Interlocutor's name, position	Habyarimana Juvenal	
Planted vegetable	Tomato	Cabbage
Planted area	25 x25	12x25
Irrigation method	Hand irrigation	Hand irrigation
Timing of irrigation (When?)	Afternoon	Afternoon
Quantity of irrigation water 1 person: 60Lx 25 persons	1500L	1500L
Water price	Water from the marshland	Water from the marshland
Hours needed for irrigation	3hours	3 hours
Farmers needed for irrigation	25persons	25persons
Market, transportation	Karembo, Ngoma market By bicycle	Karembo, Ngoma By bicycle
Yield / ha	235 Kg	210 Kg
Selling price (FRW/kg or ton)	200/Kg	57 RwF/Kg
Input; *compost manure*	10,000 RwF estimation	3000 RwF estimation
Fertilizer, etc.		
・N.P.K 17.17.17	16 Kg 400 RwF/1 Kg	-
Tax etc.	1000 RwF/Bag	600 RwF
Number of related farmers	25	25

Farmer 10

Questionnaire on the horticulture farming

JICA survey team for Ngoma-22 scheme, LWH project

Name of the project/cooperative	DUKORE	
Date of inquiry survey, Inquirer	4/4/2012, Muvunyi Yahaya	
Interlocutor's name, position	Mukakamanzi Gaudence (Vice President)	
Planted vegetable	Cabbage	
Planted area	5 x7	
Irrigation method	Hand irrigation	
Timing of irrigation (When?)	Afternoon	
Quantity of irrigation water 1 person: 60Lx 25 persons	200L	
Water price	Water from the marshland	
Hours needed for irrigation	1h 30	
Farmers needed for irrigation	1 person	
Market, transportation	Karembo, Mugesera market By bicycle	
Yield / ha	300Kg	
Selling price (FRW/kg or ton)	45 Rwf	
Input; *compost manure*	3,000 RwF (estimation)	
Fertilizer, etc.		
・N.P.K 17.17.17	400 RwF/1 Kg	
Tax etc.	300 RwF/	
Number of related farmers	2 farmers	

Approximate estimation of runoff rate based on the observation record

The river runoff rate was estimated approximately based on the observation records of the river flow rate and the rainfall both obtained by Mr. Nakano, the JICA expert and the MINAGRI advisor.

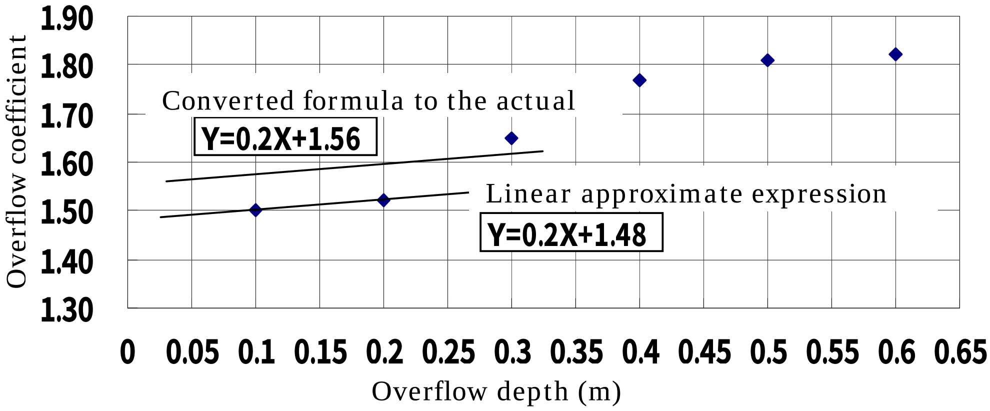
ｉ)Conversion from the overflow depth to the overflow volume

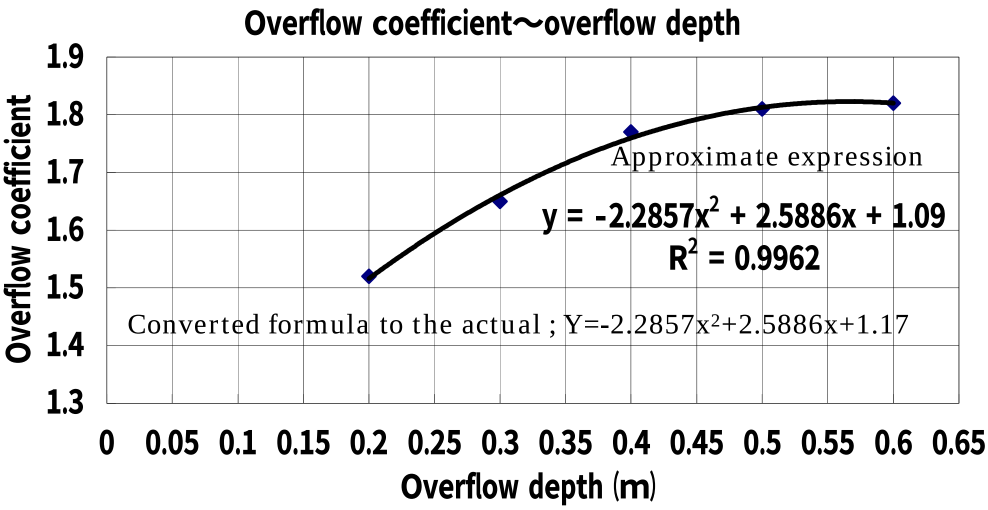
Mr. Nakano obtained the overflow coefficient C=1.57 at the overflow depth of 0.05m (H=0.05m) by comparing the measurement of overflow depth with the observed flow rate. The overflow coefficient of the broad crested weir with 30cm wide crest is shown as follows in HAND BOOK OF HYDRAULICS (Horace Williams King and others, Boston Massachusetts). Mr., Nakano's value C=1.57 is larger than the one shown on this table. The reason is that the overflow depths on the table are observed at the point apart upstream from the weir's front surface by 2.5H, and on the other hand Mr. Nakano's observation depth was measured on the weir crest for the convenience's sake of observation. Here, the observed value C=1.57 is adopted, and the overflow coefficients to the other region shall be calculated by the formula shifted parallel from the one expressing the relationship between the overflow depth and the overflow coefficient on the table. To the range from 0.1 to 0.2, one dimensional formula shall be adopted, and the region over 0.2, the two dimensional formula shall be adopted

Overflow coefficient ~ overflow depth

Overflow depth (m)	Overflow coefficient
0.1	1.50
0.2	1.52
0.3	1.65
0.4	1.77
0.5	1.81
0.6	1.82

Overflow coefficient ~ Overflow depth





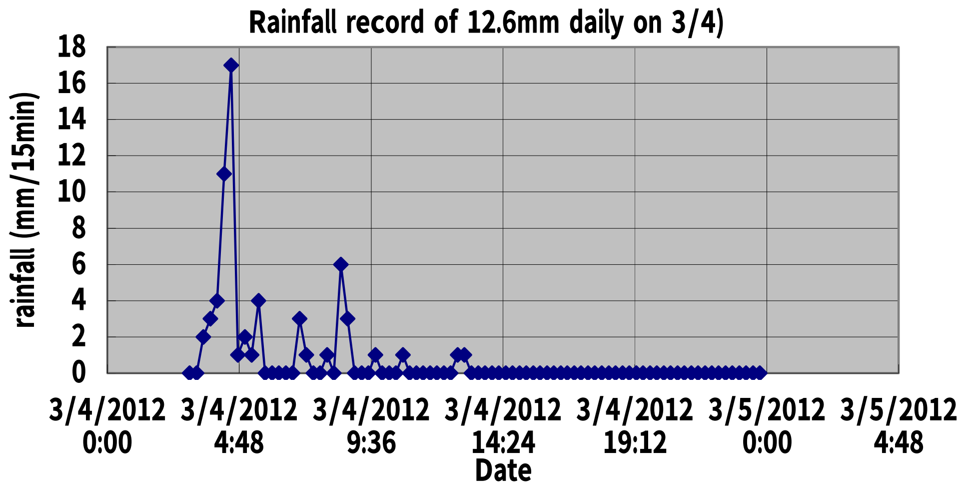
Flow rate is calculated by the following formula

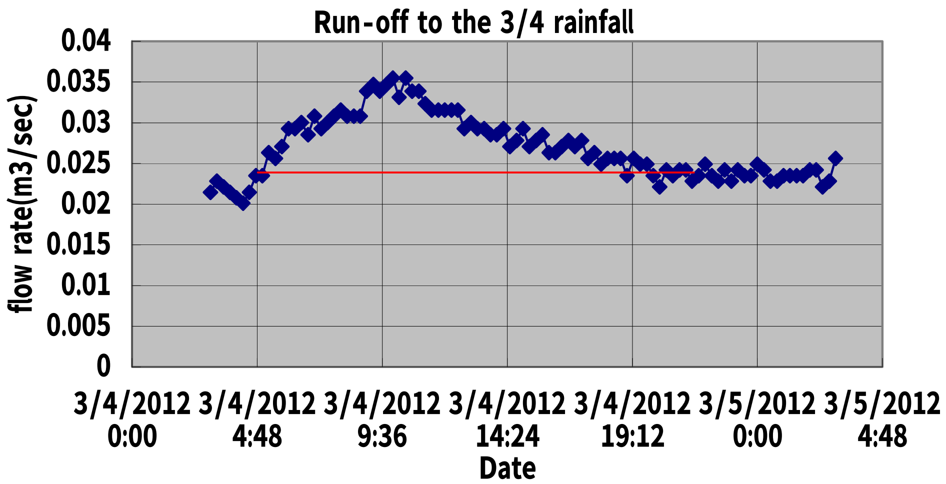
$Q=C \cdot L \cdot H^{3/2}$

Here, Q ; flow rate(m3/sec)、C ; overflow coefficient、L ; weir length、H ; overflow depth(m)

ⅱ) Study about the relationship between rainfall and flow rate

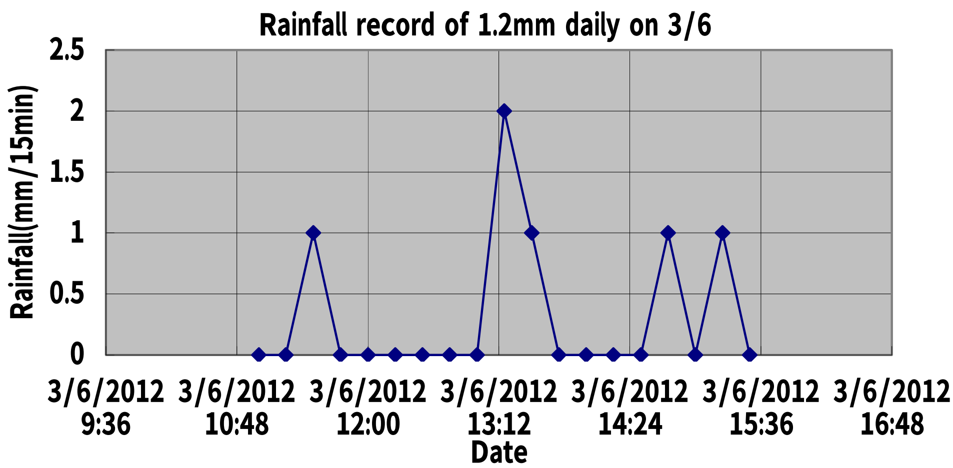
① Run-off to the rainfall of 12.6mm on 4th of March

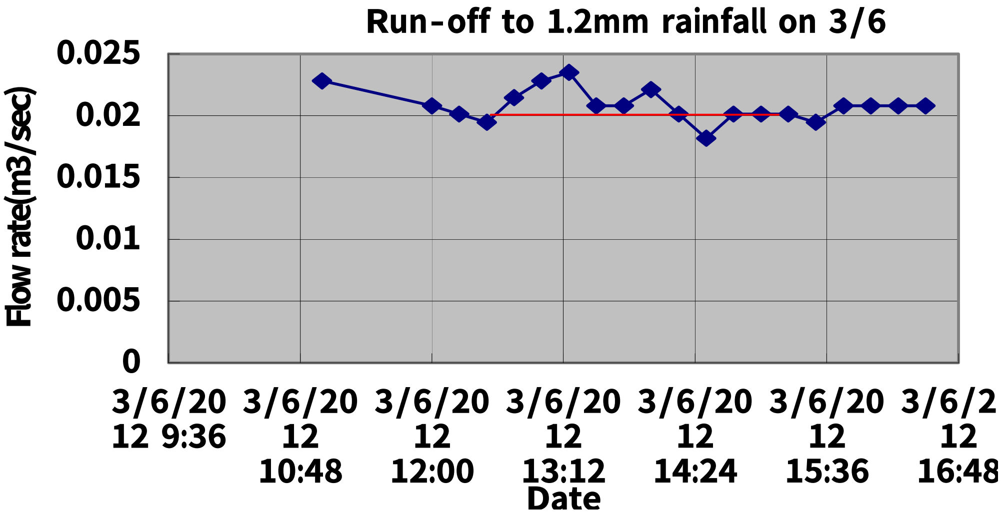




Run-off affected by this rainfall is estimated to arise from 4:45 to 19:30 on 3/4; then the accumulative flow rate during this period becomes 1,574.2m3. The basic flow rate during this period is estimated to be 0.024m3/sec; then the accumulative basic flow rate is 0.024m3/sec×(19.5-4.75)×60×60＝1,274.4m3, and the direct run-off is 299.8m3. Ratio of the direct run-off becomes [299.8m3/{(0.0126m×(8.8×1,000,000)m2)}]×100=0.27%.

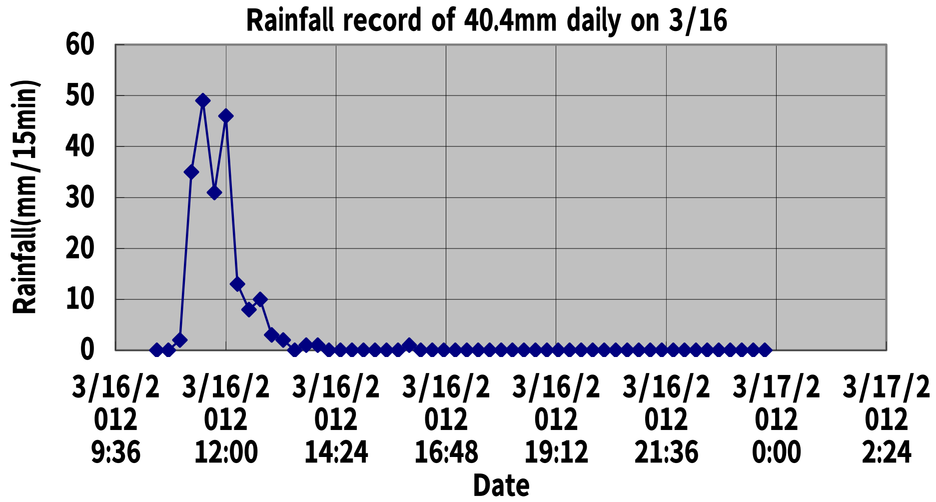
② Run-off to the rainfall of 1.2mm on 6th of March

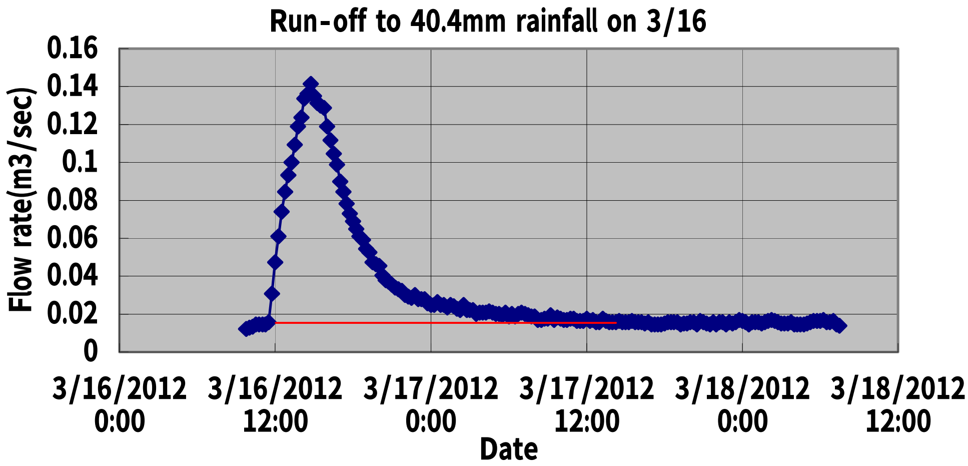




Run-off affected by this rainfall is estimated to arise from 12:30 to 16:00 on 3/6; then the accumulative flow rate during this period becomes 276m3. The basic flow rate during this period is estimated to be 0.02 m3/sec; then the accumulative basic flow rate is 0.02m3/sec×(16.0-12.5)×60×60＝252m3, and the direct run-off is 21.6m3. Ratio of the direct run-off becomes [21.6m3/{(0.012m×(8.8×1,000,000)m2)}]×100=0.20%.

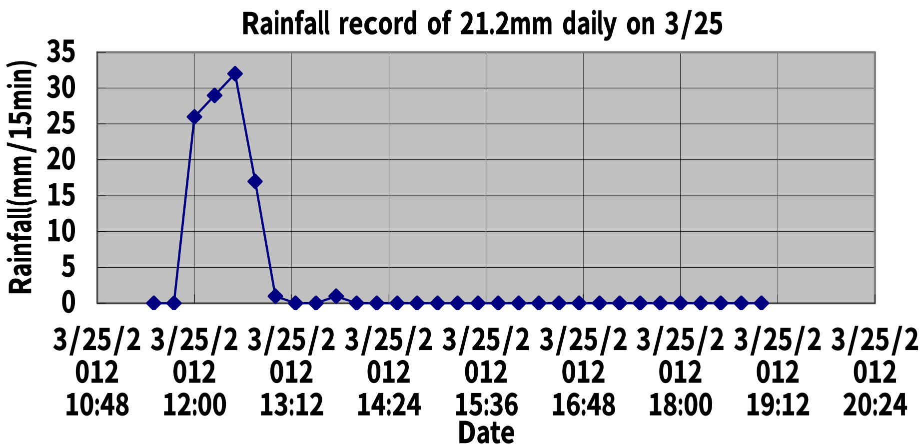
③ Run-off to the rainfall of 40.4mm on 16th of March 3/16

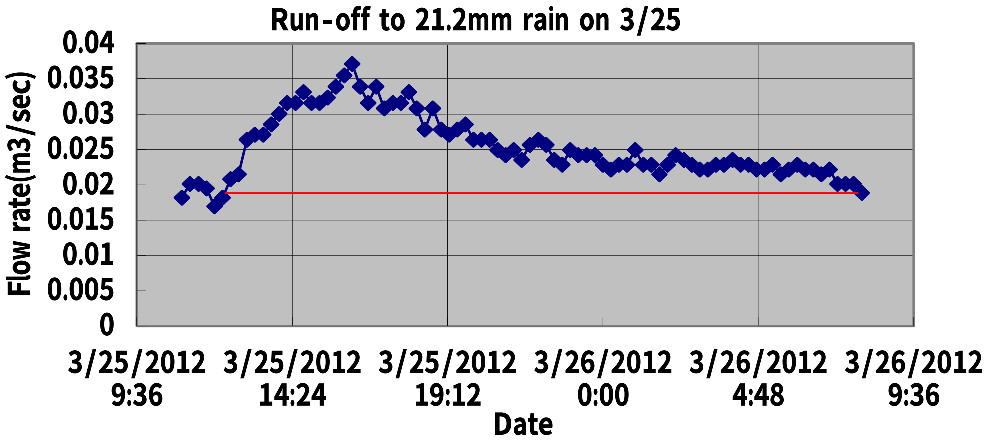




Run-off affected by this rainfall is estimated to arise from 11:30 on 3/16 to 12:30 on 3/17; then the accumulative flow rate during this period becomes 4,101.8m3. The basic flow rate during this period is estimated to be 0.017 m3/sec; then the accumulative basic flow rate is 0.017m3/sec×(24.0-11.5+12.5)×60×60＝1,530.0m3, and the direct run-off is 2,571.8m3. Ratio of the direct run-off becomes [2,571.8m3/{(0.0404m × (8.8 × 1,000,000)m2)}] × 100=0.72%.

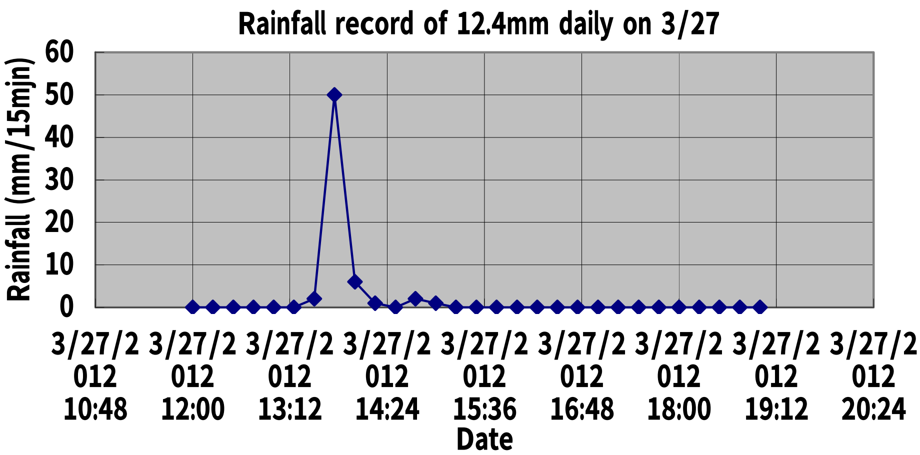
④ Run-off to the rainfall of 21.2mm on 25th of March

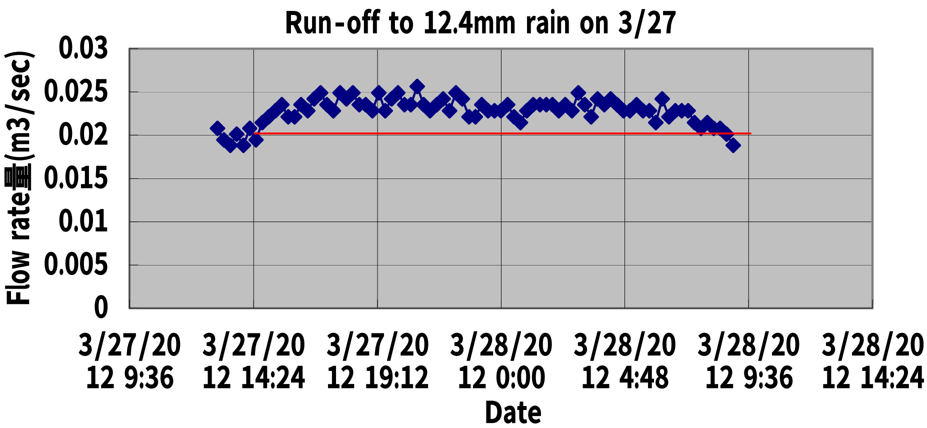




Run-off affected by this rainfall is estimated to arise from 12:30 on 3/25 to 7:00 on 3/26; then the accumulative flow rate during this period becomes 1,764.7m3. The basic flow rate during this period is estimated to be 0.018 m3/sec; then the accumulative basic flow rate is 0.018m3/sec×(7+24.0-12.5)×60×60=1,198.8m3, and the direct run-off is 565.9m3. Ratio of the direct run-off becomes [565.9m3/{(0.0212m×(8.8×1,000,000)m2)}]×100=0.30%.

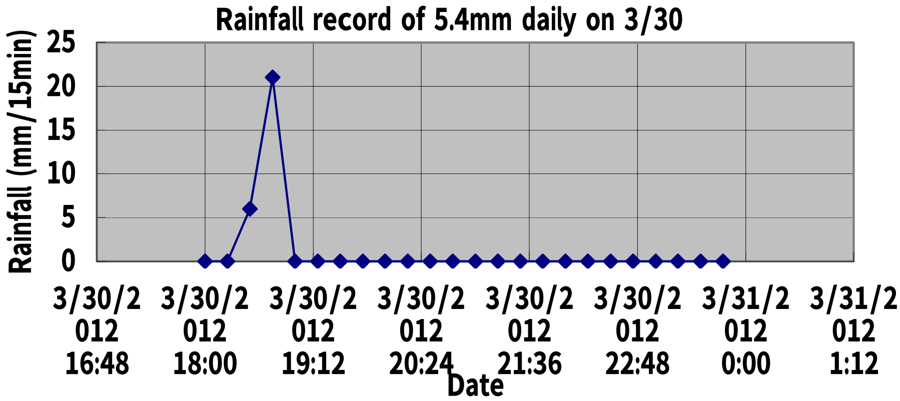
⑤ Run-off to the rainfall of 12.4mm on 27th of March

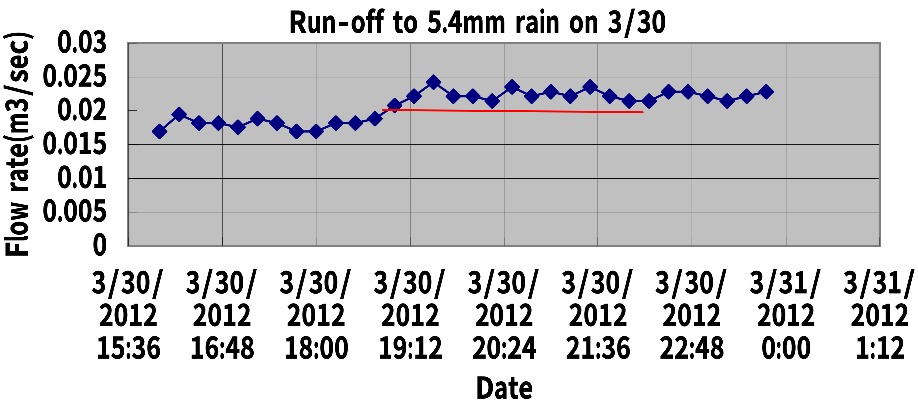




Run-off affected by this rainfall is estimated to arise from 13:45 on 3/27 to 8:30 on 3/28; then the accumulative flow rate during this period becomes 1,571.6m3. The basic flow rate during this period is estimated to be 0.02 m3/sec; then the accumulative basic flow rate is 0.02m3/sec×(24.0-13.75+8.5)×60×60＝1,350.0m3, and the direct run-off is 221.6m3. Ratio of the direct run-off becomes [221.6m3/{(0.0124m×(8.8×1,000,000)m2)}]×100=0.20%.

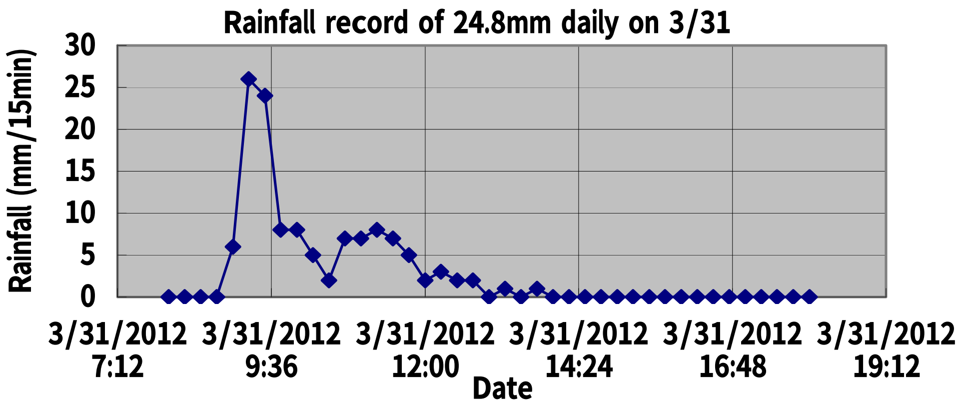
⑥ Run-off to the rainfall of 5.4mm on 30th of March

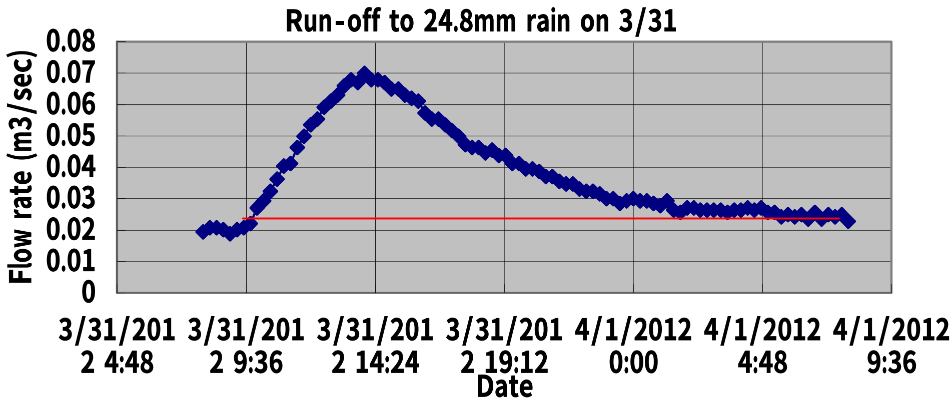




Run-off affected by this rainfall is estimated to arise from 19:00 to 22:00 on 3/30; then the accumulative flow rate during this period becomes 261.5m3. The basic flow rate during this period is estimated to be 0.02 m3/sec; then the accumulative basic flow rate is 0.02m3/sec×(22.0-19.0)×60×60＝216.0m3, and the direct run-off is 45.3m3. Ratio of the direct run-off becomes [45.3m3/{(0.0054m×(8.8×1,000,000)m2)}]×100=0.10%.

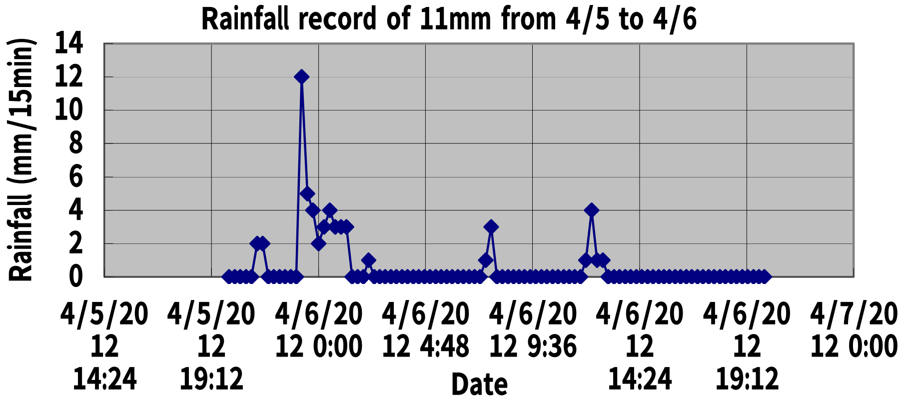
⑦ Run-off to the rainfall of 24.8mm on 31st of March

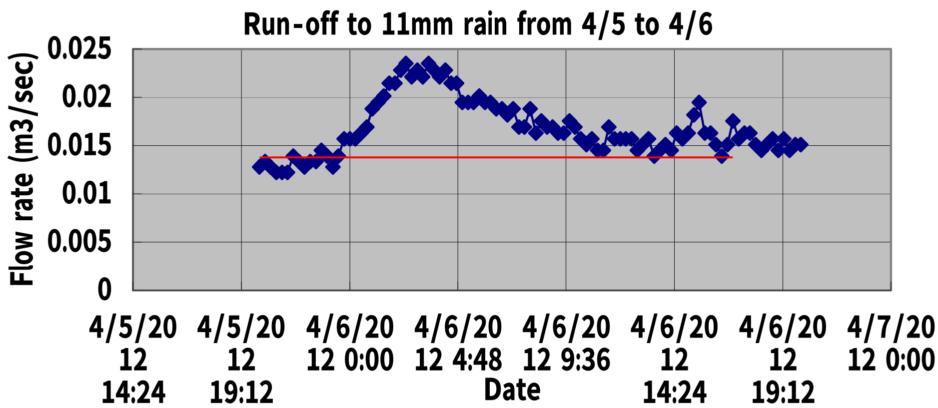




Run-off affected by this rainfall is estimated to arise from 9:30 on 3/31 to 5:30 on 4/1; then the accumulative flow rate during this period becomes 2,983.0m3. The basic flow rate during this period is estimated to be 0.0225 m3/sec; then the accumulative basic flow rate is 0.0225m3/sec×(29.5-9.5)×60×60=1,620.0m3, and the direct run-off is 1,363.0m3. Ratio of the direct run-off becomes [1,363.0m3/{(0.0248m×(8.8×1,000,000)m2)}]×100=0.60%.

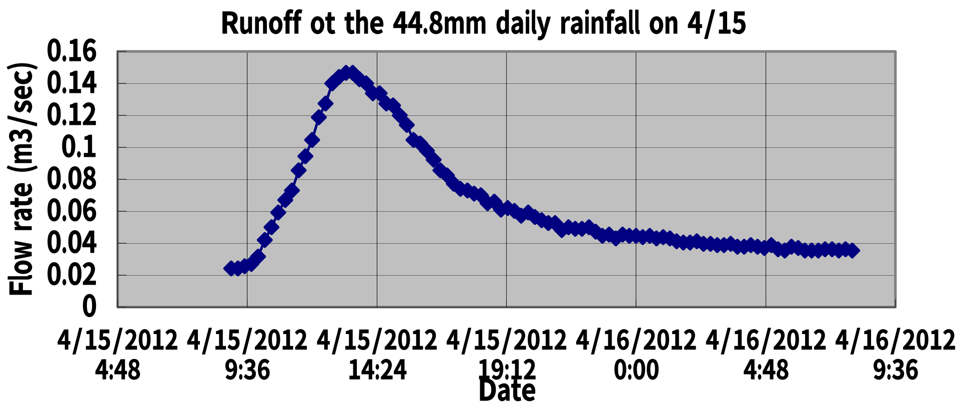
⑧ Run-off to the total rainfall of 11mm from 5th of April to 6th of April





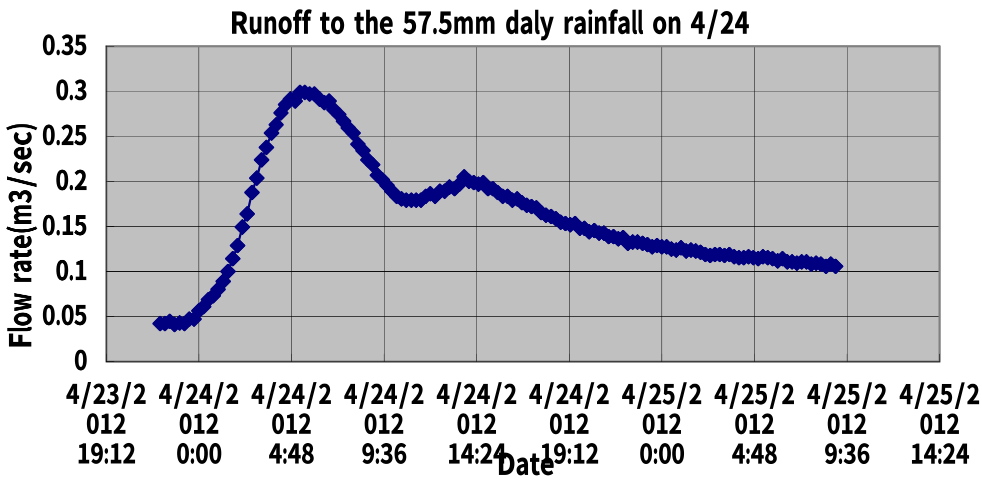
Run-off affected by this rainfall is estimated to arise from 21:30 on 4/5 to 19:00 on 4/6; then the accumulative flow rate during this period becomes 1,343.4m3. The basic flow rate during this period is estimated to be 0.014 m3/sec; then the accumulative basic flow rate is 0.014m3/sec×(19.0+24.0-21.5)×60×60＝1,083.6m3, and the direct run-off is 259.8m3. Ratio of the direct run-off becomes [259.8m3/{(0.011m×(8.8×1,000,000)m2)}]×100=0.25%.

⑨ Run-off to the total rainfall of 44.8mm on 15th of April



Run-off affected by this rainfall is estimated to arise from 10:00 on 4/15 to 5:30 on 4/16; then the accumulative flow rate during this period becomes 4,934.7m3. The basic flow rate during this period is estimated to be 0.035 m3/sec; then the accumulative basic flow rate is 0.035m3/sec×(5.5+24.0-10.0)×60×60=2,457m3, and the direct run-off is 2,477.7m3. Ratio of the direct run-off becomes [2,477.7m3/{(0.0448m×(8.8×1,000,000)m2)}]×100=0.63%.

⑩ Run-off to the total rainfall of 57.6mm on 24th of April

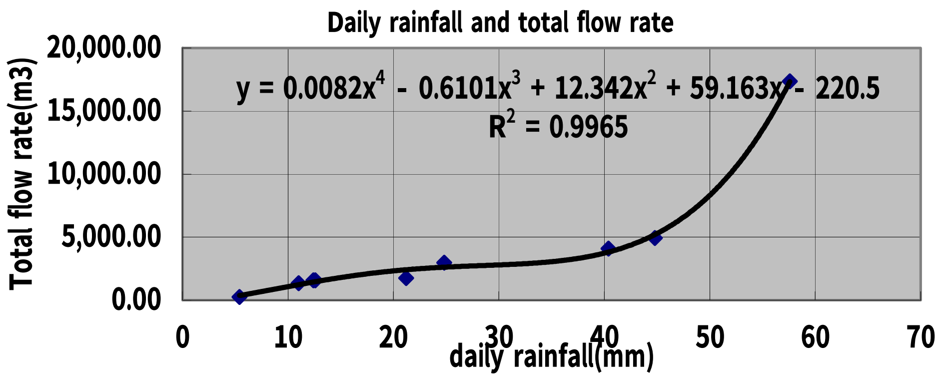


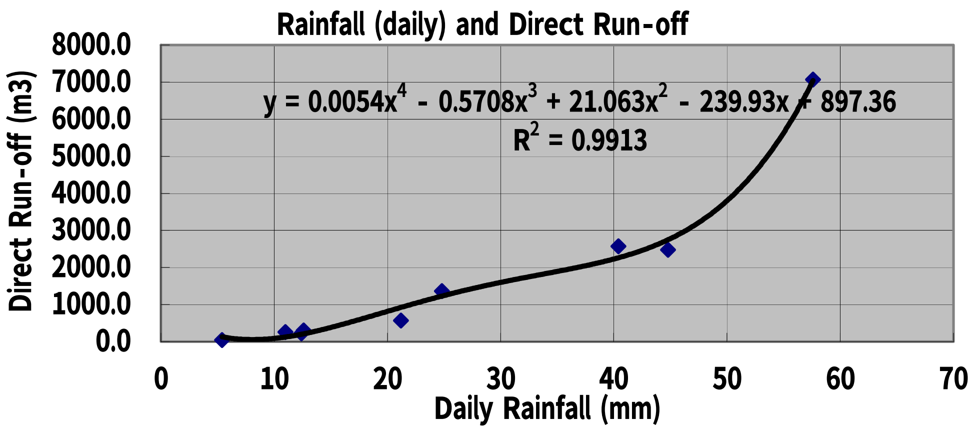
Run-off affected by this rainfall is estimated to arise from 2:00 on 4/24 to 4:00 on 4/25; then the accumulative flow rate during this period becomes 17,361.6m3. The basic flow rate during this period is estimated to be 0.11 m3/sec; then the accumulative basic flow rate is 0.11m3/sec×(4.0+24.0-2.0)×60×60=10,296m3, and the direct run-off is 7,065.6m3. Ratio of the direct run-off becomes [7,065.6m3/{(0.0576m×(8.8×1,000,000)m2)}]×100=1.39%.

⑪ Relationship between daily rainfall and run-off

The study results are summarized as follows.

Date	Daily Rainfall (mm)	Direct Run-off(m3)	Run-off ratio (%)	Total flow rate(m3)
3/4/2012	12.6	299.8	0.27	1,574.20
3/16/2012	40.4	2571.8	0.72	4,101.80
3/25/2012	21.2	565.9	0.30	1,764.70
3/27/2012	12.4	221.6	0.20	1,571.60
3/30/2012	5.4	45.5	0.10	261.50
3/31/2012	24.8	1363.0	0.60	2,983.00
4/5~6/2012	11	259.8	0.25	1,343.40
4/15/2012	44.8	2477.7	0.63	4,934.70
4/24/2012	57.6	7065.6	1.39	17,361.60
3/6/2012	1.2	21.6	0.20	273.60





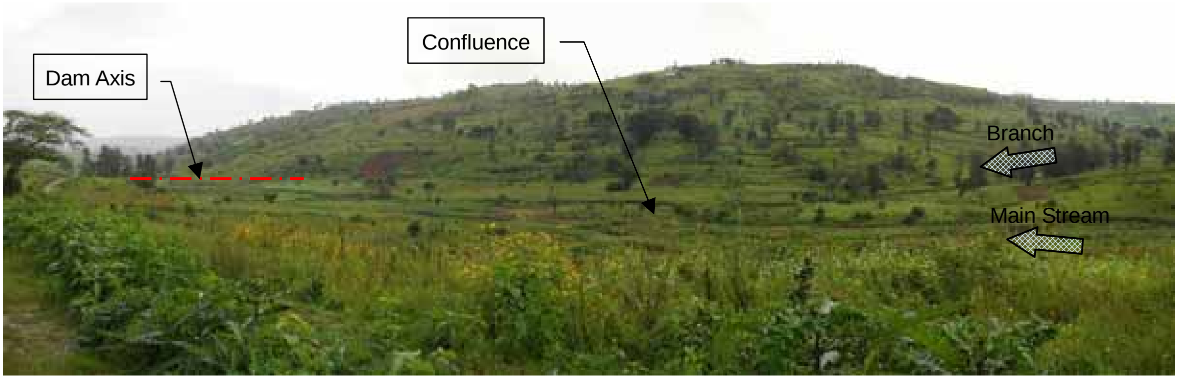
iii) Approximate calculation of the annual flow rate

As a trial, the annual flow rate is calculated through the method of estimating the direct run-off by applying the formula above to the daily rainfall record of 1992 at Kibungo, and then adding the flow rate corresponding to the basic flow. Here, the basic flow rate is assumed to be 0.02m3/sec in the rainy season of March, April, May, September, October and November, and to be 0.015m3/sec in the dry season of December, January, February, June, July and August. The estimated annual flow rate is591,000m3.

Site Inspection of Reservoir Area – Photo Records

1. Panoramic View of Reservoir Area (May 28, '12)

View from Left Bank at Upstream to Reservoir Area



View from left Bank at Midway Point to Reservoir Area

View from Left Bank at Dam Axis to Reservoir Area

2. General View – Flat Area (May 28, '12)

General View in Flat Area (Left: Sweet Potato, Right: Sweet Potato)

General View in Flat Area (Left: Cabbage, Right: Carrot & Sweet Potato)

General View in Flat Area (Left: Cabbage, Right: Chinese Chive)

3. General View – Slope Area (May 28, '12)


General View in Flat Area (Left: Sorghum, Maize & Cassava, Right: Sorghum)


General View in Flat Area (Left: Sorghum, Right: Sorghum & Maize)


General View in Flat Area (Left: Sorghum, Right: Beans)

4. Main Stream #01 (May 28, ’12)

Main Stream #01 – Upstream View

Main Stream #01 – Downstream View

Main Stream #01 – Left Bank View

Main Stream #01 – Right Bank View

5. Main Stream #02 (May 28, '12)

Main Stream #02 – Upstream View

Main Stream #02 – Downstream View

Main Stream #02 – Left Bank View

Main Stream #02 – Right Bank View

6. Main Stream #03 (May 28, '12)

Main Stream #03 – Upstream View

Main Stream #03 – Downstream View

Main Stream #03 – Left Bank View

Main Stream #03 – Right Bank View

7. **Main Stream #04 (May 28, '12)**

Main Stream #04 – Upstream View

Main Stream #04 – Downstream View

Main Stream #04 – Left Bank View

Main Stream #04 – Right Bank View

8. **Branch #01 (May 28, '12)**

Branch #01 – Upstream View

Branch #01 – Downstream View

Branch #01 – Left Bank View

Branch #01 – Right Bank View

9. Branch #02 (May 28, ’12)

Branch #02 – Upstream View

Branch #02 – Downstream View

Branch #02 – Left Bank View

Branch #02 – Right Bank View

10. Confluence (May 28, '12)

Confluence – Upstream View

Confluence – Downstream View

Confluence – Left Bank View

Confluence – Right Bank View

11. Midway Point between Confluence and Dam Axis (May 28, ’12)

Midway Point between Confluence and Dam Axis – Upstream View

Midway Point between Confluence and Dam Axis – Downstream View

Midway Point between Confluence and Dam Axis – Left Bank View

Midway Point between Confluence and Dam Axis – Right Bank View

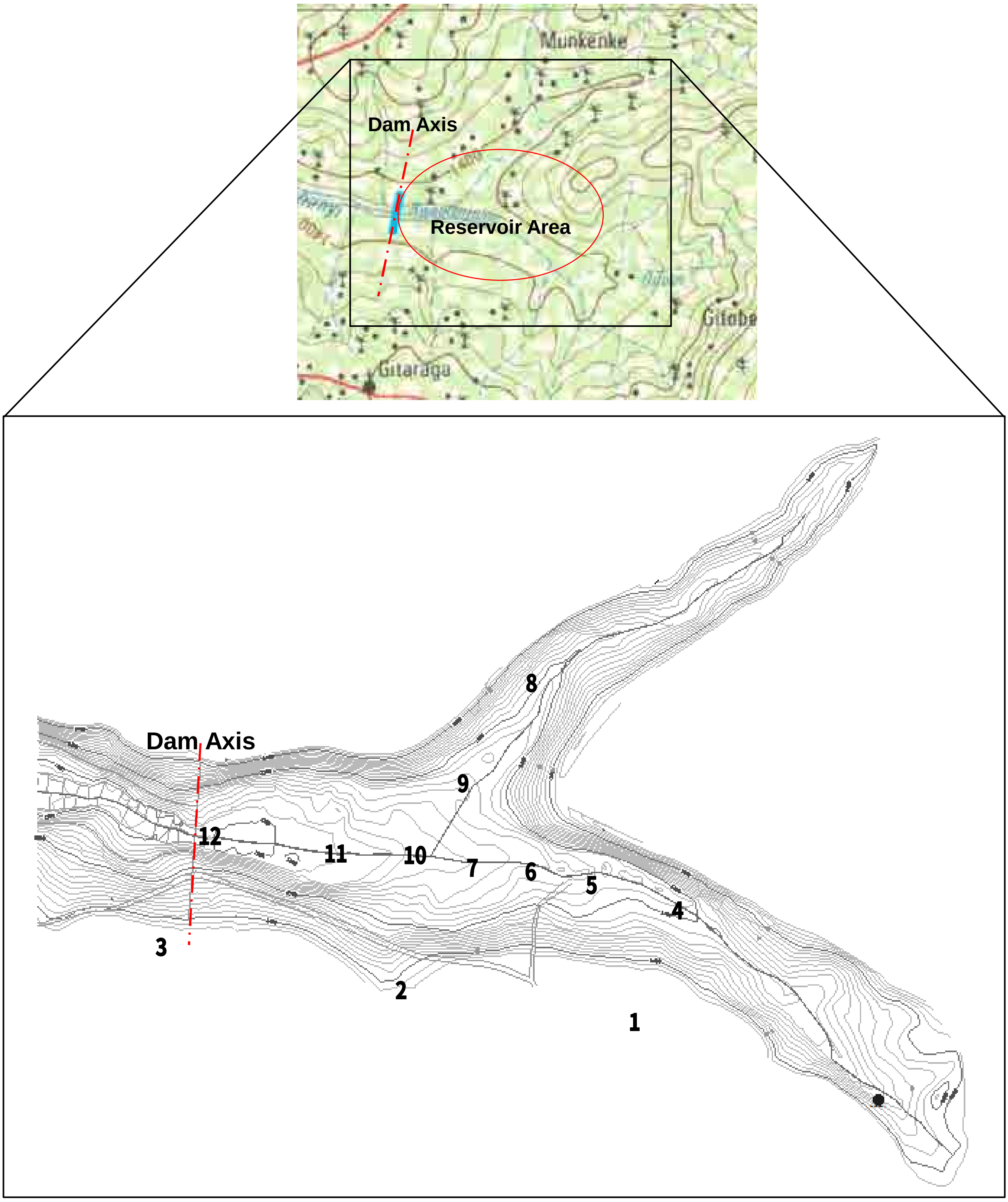
12. Dam Axis (May 28, ’12)

Dam Axis – Upstream View

Dam Axis – Downstream View

Dam Axis – Left Bank View

Dam Axis – Right Bank View



Legend

1 Left Bank at Upstream
2 Left Bank at Midway Point
3 Left Bank at Dam Axis
4 Main Stream #01
5 Main Stream #02
6 Main Stream #03
7 Main Stream #04
8 Branch #01
9 Branch #02
10 Confluence
11 Midway Point bet. Confluence and Dam Axis
12 Dam Axis

Annex-5. Bill of quantities and Approximate cost estimation

(a) Bill of quantities

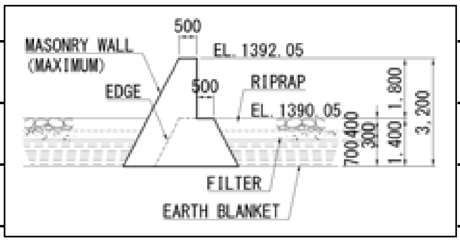
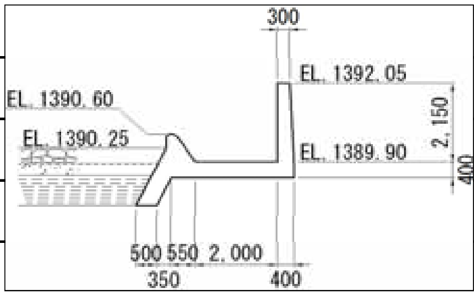
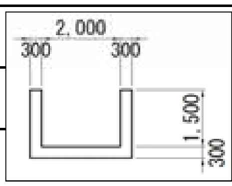
ⅰ) Temporary work and general work

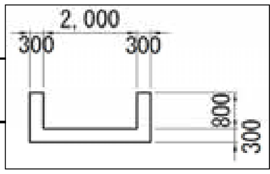
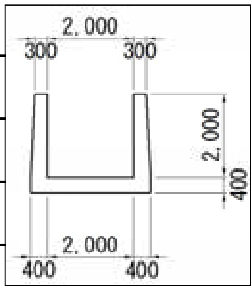
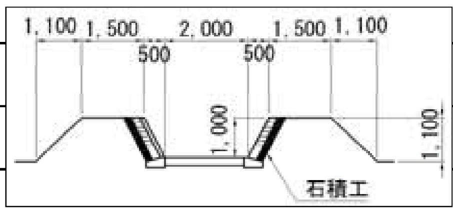
Description	Calculation				Uinit	Quantity
ⅰ-1 Road maintenance and improvement of dam site						
Protection retaining wall of excavation slope	H=1.5m wet stone masonry		=	1000	m	1,000
Drain development	triple soil-cement lining		=	2,500	m	2,500
Roadbed development	recompression of cut-and-cover (t=1m)	1.0×8.0×500.0	=	4,000	m^3	4,000
Subbase development	cement improved soil (t=40cm)	0.4×8.0×500.0	=	1,600	m^3	1,600
Paving gravel	t=20cm	0.2×8.0×2000.0	=	3,200	m^3	3,200
Vegetation of slope protection		2.0×2000.0	=	4,000	m^2	4,000
ⅰ-2 Temporary for dam						
Dewatering (temporary coffering)		Underwater pump driving			ls	1
Excavation of connecting canal of bottom outlet		2.0×1.0×50.0	=	100	m^3	100
Temporary road				1000	m	1,000
ⅰ-3 General temporary construction						
Preparation of site					ls	1
Site office construction					ls	1
Field test room					ls	1
Clearing and grubbing, deforestation				30000	m^2	30,000

ⅱ) Dam body

Description	Calculation			Uinit	Quantity
ⅱ-1 Main body					
Excavation	7450×1.5	=	11,175	m^3	11175
River bed drain	(1/2×(75+80)×8.5+1/2×(80+25.5)×14)×0.7	=	978	m^3	978
Intercepter	5.8×1.0×30.0+1/2×(5.8+0.0)×(16+30)	=	307	m^3	307
Foot of slope	1.0×1.5×20.0	=	30	m^3	30
Riprap	1/2×(90.0+121.0)×18.15×(1+3^2)^0.5/3×0.6	=	1,211	m^3	1,211
Banking	1/2×6.0×13.55×(182.0+29.0)+1/6×(3.0+2.5)×13.55^2×(182.0+2×29.0) +2.5×6.5×1/2×(79.0+29.0)+2.5×7.5×1/2×(90.0+29.0)-1211				
		=	48,721	m^3	48,721
Vegetation of slope protection	{1/2×(163+78)×15.375+1/2×(80.0+30.0)×12.5}×1.08+2.5×80.0	=	2,943	m^2	2,943
Protection crest	164.0×6.0×0.3	=	295	m^3	295
ⅱ-2 Slope blanket					
Excavation	29221×0.5	=	14,611		14,611
Riprap	1/2×(72.0+83.0+82.0+86.0)×18.15×(1+3^2)^0.5/3×0.6	=	1,854	m^3	1,854
Banking	{1/2×(20.0+16.0)×7.5+1/2×(16.0+12.0)×2.7 +1/2×(12.0+4.0)×3.3}×(60.0+70.0)×1.2-1854	=	29,221	m^3	29,221
Protection crest	(78.0×6.0+75.0×9.0)×0.3	=	343	m^3	343
ⅱ-3 Horizontal blanket					
Excavation	53.0×60.0×1.5+1/2×(2.0+5.0)×3.0	=	4,781	m^3	4,781
Banking	50.0×60.0×2.0	=	6,000	m^3	6,000
Banking (cofferdam)	{1/2×(2.0+5.0)×3.0+1/2×(3.0+5.0)×2.5}×123.0	=	2,522	m^3	2,522

iii) Spillway

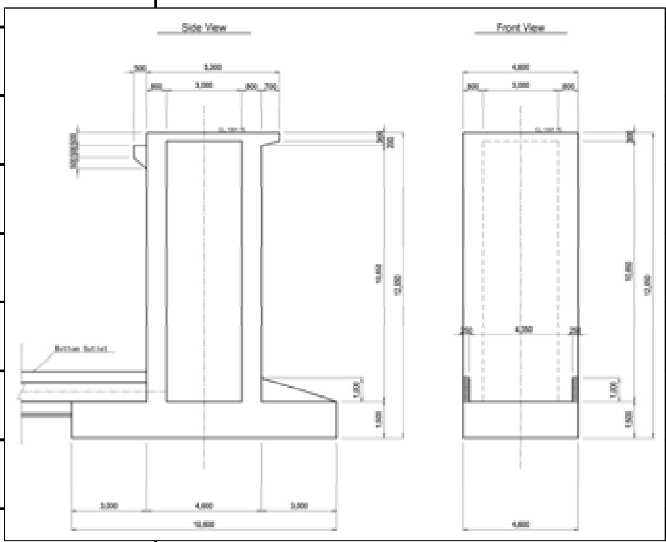
Description	Calculation	Uinit	Quantity
iii-1 Guide portion			
Masonry wall	1/2×{1/2×(1.0+2.4)×1.4+1/2×(0.5+2.1)×3.2+1/2×(0.5+1.2)×1.4} ×20.0×2 = 154.6	m^3	154.6
Earth blanket	2.95×20.0×0.7+1/2×1.5×5.0×0.7×2 = 47.0	m^3	47.0
Riprap filter	3.65×20.0×0.7+1/2×1.5×5.0×0.7×2 = 56.0	m^3	56.0
			
iii-2 Intake portion			
Excavation	4.8×6.0×2.5 = 72.0	m^3	72.0
back-filling	1/2×(1.0+2.25)×(4.8+6.0) = 18.0	m^3	18.0
Reinforced concrete	{0.5×1.1+1/2×(0.9+0.2)×0.7+2.95×0.4}×5.0 +1/2×(0.3+0.4)×2.15×(5.0+2.95) = 16.6	m^3	16.6
Vegetation of slope protection	1.0×5.0 = 5.0	m^2	5.0
			
iii-3 Connecting canal portion			
Excavation	1/2×(4.6+6.6)×2.0×30.0 = 336.0	m^3	336.0
Back-filling	1/2×(1.0+1.8)×1.6×30.0×2 = 134.0	m^3	134.0
Reinforced conceret	(0.3×2.6+0.3×1.5×2)×30.0 = 50.0	m^3	50.0
Vegetation of slope protection	1.0×30.0×2 = 60.0	m^2	60.0
			

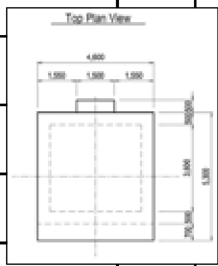
Description	Calculation	Uinit	Quantity
iii-4 Chute portion			
Excavation	1/2×(4.6+4.6+1.5)×1.5×50.0 = 401.0	m^3	401.0
back-filling	1/2×(1.0+1.0+0.9)×0.9×50.0×2 = 131.0	m^3	131.0
Reinforced concrete	(0.3×2.6+0.3×0.8×2)×50.0 = 63.0	m^3	63.0
Vegetation of slope protection	1.0×50.0×2 = 100.0	m^2	100.0
			
iii-5 Stilling basin portion			
Excavation	1/2×(4.6+4.6+1.5)×1.5×5.0 = 40.0	m^3	40.0
back-filling	1/2×(1.0+1.0+1.5)×1.5×5.0×2 = 26.0	m^3	26.0
Reinforced concrete	{0.4×2.8+1/2×(0.3+0.4)×2.0×2}×5.0 = 13.0	m^3	13.0
(chute block)	1/2×0.4×0.2×0.3×3 = 0.04	m^3	0.04
			
iii-6 wasteway portion			
Bank protection (wet stone masonry)	1.0×1.12×30.0×2 = 67.0	m^2	67.0
Bottom protection (wet stone masonry)	2.0×0.3×30.0 = 18.0	m^3	18.0
Back-filling	1/2×(1.2+3.2)×1.1×30.0×2 = 145.0	m^3	145.0
Vegetation of slope protection	(1.1×1.414+1.3)×30.0×2 = 171.0	m^2	171.0
			

iv) Intake facilities

iv-1) Intake Tower

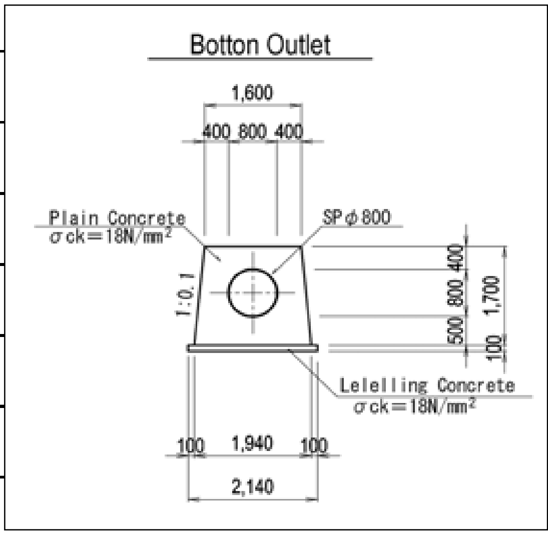
Description	Calculation			Uinit	Quantity
Rainforced concrete (including formwork)	4.6×(5.3-0.7)×(12.65-1.5)	=	235.9		
	-3.0×3.0×10.65	=	-95.9		
	1/2×(0.3+0.5)×0.7×4.6	=	1.3		
	1/2×(0.5+1.0)×0.5×1.5	=	0.6		
	4.6×10.6×1.5	=	73.1		
	2×1/2×1.0×3.0	=	3.0		
	Total		218.0	m^3	218



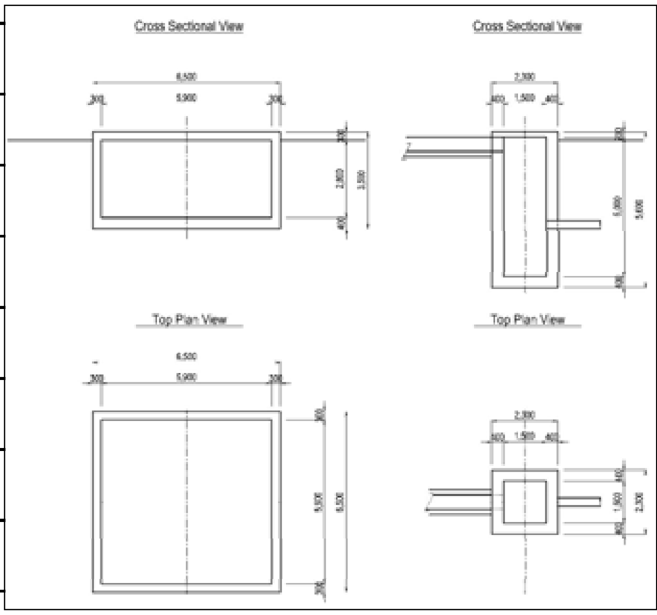


ⅳ-2) Bottom Outlet

Description	Calculation	Uinit	Quantity
Rainforced concrete (including formwork)	1/2×(1.6+1.94)×1.70 = 3.0		
	-π/4×0.8^2 = -0.5		
	2.14×0.1 = 0.2		
	Total 2.7		
	2.7×80.0 = 216.0	m^3	216
Steel pipe φ800		m	80



ⅳ-3) Outlet Valve Chamber

Description	Calculation		Uinit	Quantity
Rainforced concrete (including formwork)	Diversion (1) 2×(6.5×6.5×3.5)	= 295.8		
	2×(-5.9×5.9×2.8)	= -194.9		
	Sub Total	100.9	m^3	
	Diversion (2) 2×(2.3×2.3×5.6)	= 59.2		
	2×(-1.5×1.5×5.0)	= -22.5		
	Sub Total	36.7	m^3	
	Total	138	m^3	138
Needle type valve				
500mm			piece	1
300mm			piece	1
Butterfly type valve				
500mm			piece	1
300mm			piece	3
				

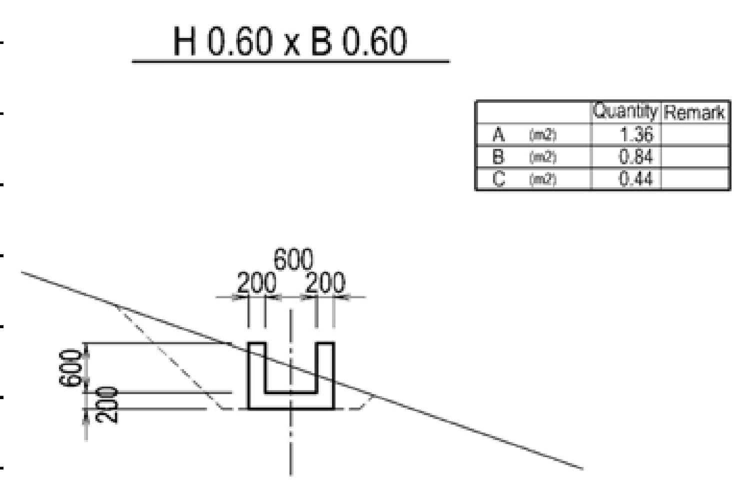
Ⅴ) Irrigation facilities

Ⅴ-1) Pipe Line

Description	Calculation			Uinit	Quantity
Rigth Side Main pipe					
HDPE φ500	50	=	50.0	m	50
Ligth Side Main Pipe					
HDPE φ300	80	=	80.0	m	80
Pressuer Pipe Line					
HDPE φ150	70+150+70+200+130+210+270+300+100+60+140+250+150+60+80+100+110	=	2,450.0	m	2,450
Pump	17	=	17.0	unit	17
Warehouse	17	=	17.0	unit	17
Tertiary					
HDPE φ90	240×(2×75)	=	36,000.0	m	36,000
Water tap	240×6	=	1,440.0	unit	1,440

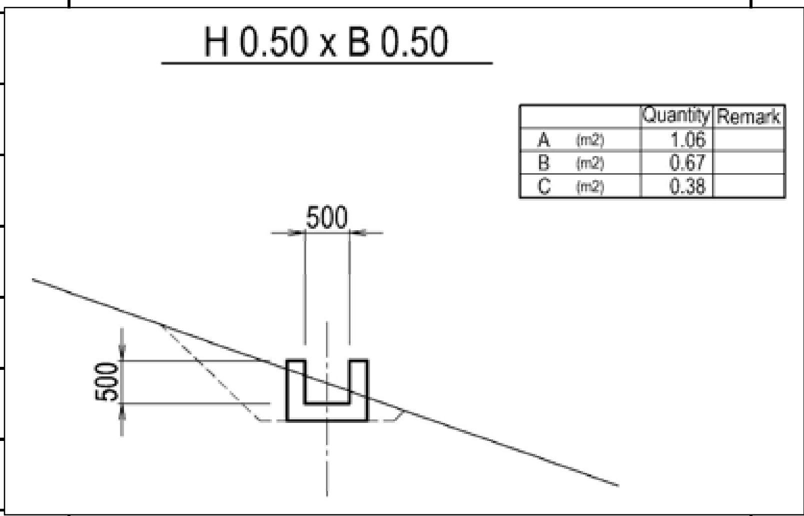
Ⅴ-2) H0.60×B0.60

Description	Calculation			Uinit	Quantity
Structure Length	160+470+420+600+490+320+200	=	2,660	m	2,660
Earth work					
Excavation work	2660×1.36	=	3,618	m^3	3,618
Backfilling work	2660×0.84	=	2,234	m^3	2,234
Canal work					
Wet masonry	2660×0.44	=	1,170	m^3	1,170



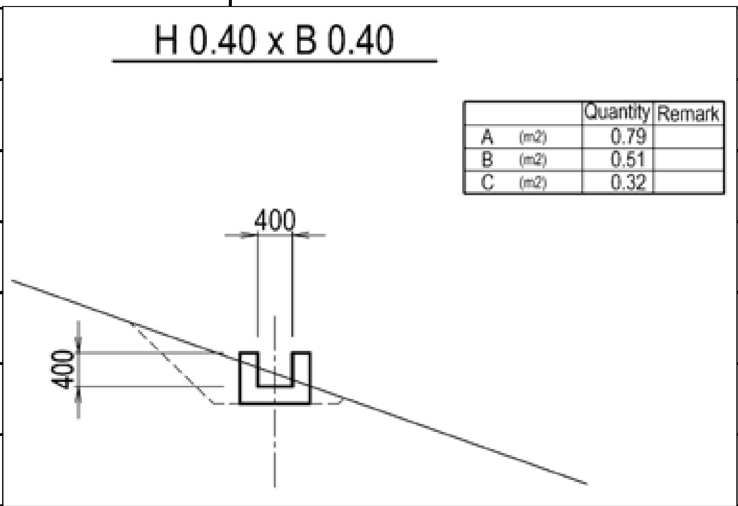
Ⅴ-3) H0.50×B0.50

Description	Calculation			Uinit	Quantity
Structure Length	510+910+1070+2280+1050+510+940	=	7,270	m	7,270
Earth work					
Excavation work	7270×1.06	=	7,706	m^3	7,706
Backfilling work	7270×0.67	=	4,871	m^3	4,871
Canal work					
Wet masonry	7270×0.38	=	2,763	m^3	2,763



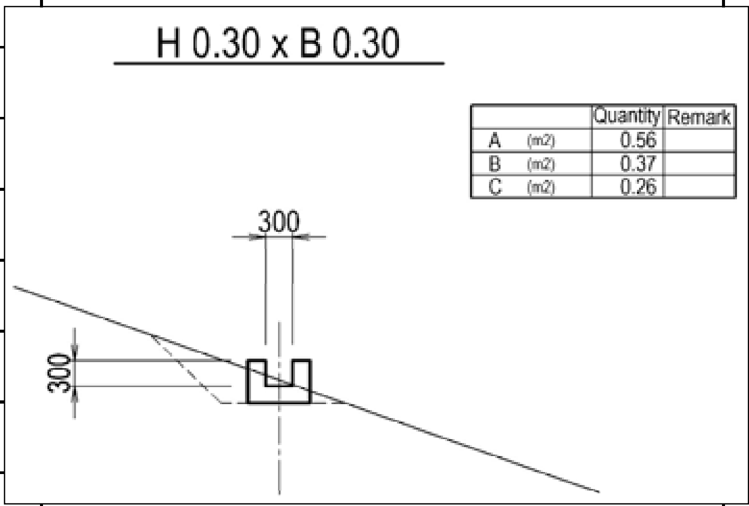
Ⅴ-4) H0.40×B0.40

Description	Calculation		Uinit	Quantity
Structure Length	920+830+950	= 2,700	m	2,700
Earth work				
Excavation work	2700×0.79	= 2,133	m^3	2,133
Backfilling work	2700×0.51	= 1,377	m^3	1,377
Canal work				
Wet masonry	2700×0.32	= 864	m^3	864



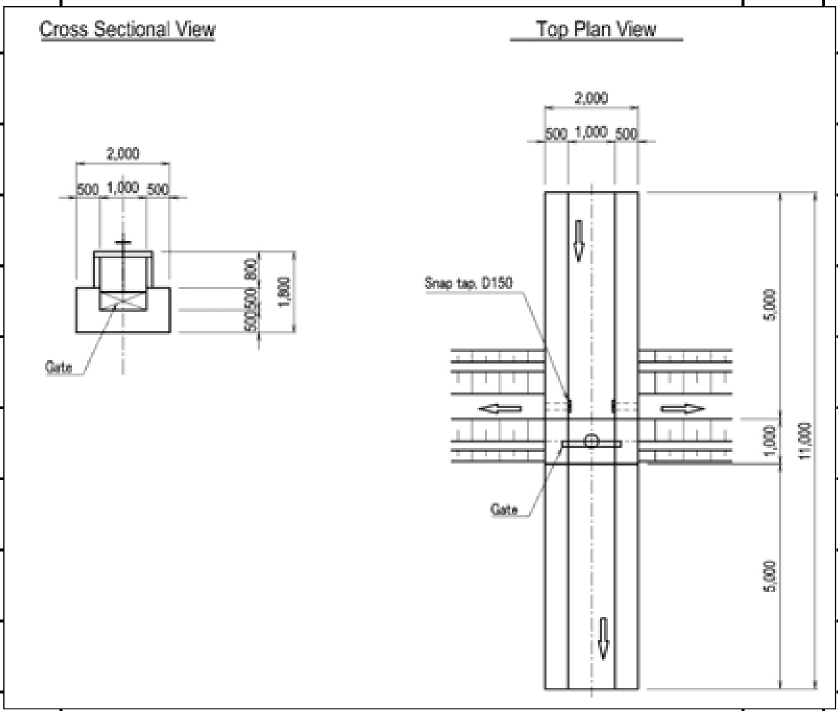
Ⅴ-5) H0.30×B0.30

Description	Calculation	Uinit	Quantity
Structure Length	1590+850+730+390+330+540+320+480+390+11 90+980+470+940+850+900+1010+580+400 = 12,940	m	12,940
Earth work			
Excavation work	12940×0.56 = 7,246	m^3	7,246
Backfilling work	12940×0.37 = 4,788	m^3	4,788
Canal work			
Wet masonry	12940×0.26 = 3,364	m^3	3,364

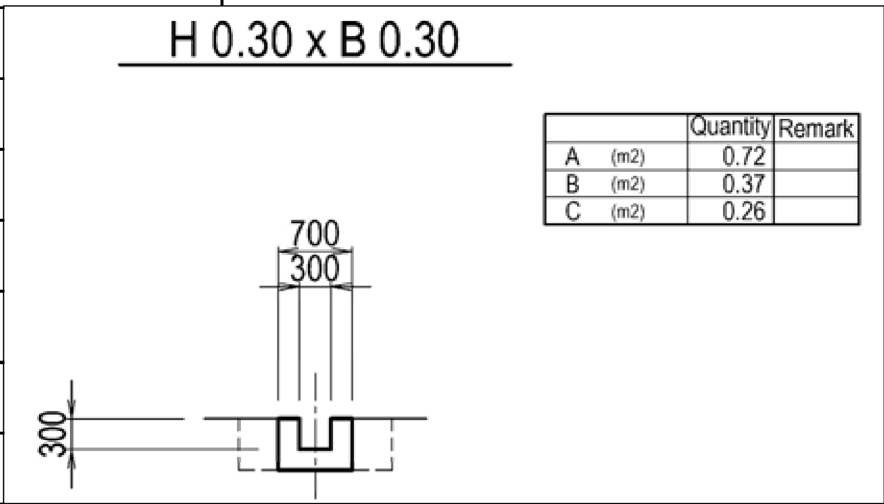


Ⅴ-6) Weir

Description	Calculation			Unit	Quantity
Earth work					
Excavation work	22×3.00×1.00×11.00	=	726	m^3	726
Backfilling work	22×1.00×1.00×11.00	=	242	m^3	242
Weir work					
Wet masonry	22×(2×0.50×1.00+1.00×0.50)	=	33	m^3	33
Gate Steel gate				unit	22
Snap tap	2×22	=	44	unit	44



Description	Calculation	Unit	Quantity
Structure Length	200+60+60+200 Average length 60m = 520	m	520
Earth work			
Excavation work	22×520×0.72 = 8,237	m^3	8,237
Backfilling work	22×520×0.37 = 4,233	m^3	4,233
Canal work			
Wet masonry	22×520×0.26 = 2,974	m^3	2,974
Levee borad	paddy field section 25m×25m 1000m/ha×35ha = 35,000	m	35,000



	Quantity	Remark
A (m2)	0.72	
B (m2)	0.37	
C (m2)	0.26	

(b) Approximate cost estimation

(ⅰ) Summary of approximate cost estimation

Description	Unit	Quantity	Unit Cost (RWF)	Cost (RWF)	Remarks
ⅰ) Temporary work and general work	ls	1.0		467,485,000	
ⅱ) Dam body	ls	1.0		1,099,675,600	
ⅲ) Spillway	ls	1.0		67,042,000	
ⅳ) Intake facilities	ls	1.0		266,256,000	
ⅴ) Irrigation facilities	ls	1.0		2,315,325,000	
ⅵ) Approximate cost estimatio total			RWF	4,215,783,600	indirect construction cost included
			US$	6,968,237	1 US$=605 RWF
			Yen	557,458,988	1 US$=80 Yen

(ⅱ) Approximate cost estimation

Description	Unit	Quantity	Unit Cost (RWF)	Cost (RWF)	Remarks
ⅰ) Temporary work and general work					
Road maintenance and improvement of dam site					
Protection retaining wall of excavation slope	m	1000.0	51,750	51,750,000	Masonry；1.5m×0.3=0.45m3/m×75,000=33,750 Gravel；1.5m×0.3=0.45m3/m×40,000=18,000
Drain development (triple soil-cement lining)	m	2500.0	10,150	25,375,000	Soil-cement；(0.3+0.4×1.414×2)×0.2=0.29m3 0.29×35,000=10,150
Roadbed development (recompression of cut-and-cover)	m^3	4000.0	4,500	18,000,000	
Subbase development (cement improved soil)	m^3	1600.0	21,500	34,400,000	8,500+13,000(cement 50kg/m3)=21,500
Paving gravel	m^3	3200.0	40,000	128,000,000	coarse granular materials
Vegetation of slope protection	m^2	4000.0	1,500	6,000,000	
Sub total				263,525,000	
Temporary for dam					
Dewatering (temporary coffering)	ls			60,000	
Excavation of connecting canal of bottom outlet	m^3	100.0	6,500	650,000	
Temporary road	m	1000.0	147,000	147,000,000	7.0×1.0×1.0×13,000(cement 50kg/m3)=91,000 Gravel；7.0×0.2×1.0×40,000=56,000
Sub total				147,710,000	
General temporary construction					
Preparation of site	ls			7,500,000	
Site office construction	ls			30,000,000	
Field test room	ls			18,000,000	
Clearing and grubbing, deforestation	m^2	30000.0	25	750,000	
Sub total				56,250,000	
Temporary work and general work total				467,485,000	
ⅱ) Dam body					
Excavation	m^3	30657.0	4,500	137,956,500	
River bed drain, Intercepter	m^3	1285.0	30,000	38,550,000	
Foot of slope	m^3	30.0	25,300	759,000	0.3×75000+0.7×4000=25300
Riprap/ filter	m^3	3065.0	40,000	122,600,000	
Banking	m^3	86464.0	7,900	683,065,600	0.15×4500+0.85×8500=7900 （15%;excavation soil、85%;borrow area）
Protection crest (soil-cement)	m^3	638.0	35,000	22,330,000	Cement admixture 100kg/m3
Protection crest (soil-cement)	m^2	2943.0	1,500	4,414,500	
Observatory for dam	ls	1.0		90,000,000	
Dam body total				1,099,675,600	

Description	Unit	Quantity	Unit Cost (RWF)	Cost (RWF)	Remarks
iii) Spillway					
Masonry wall	m^3	156.4	75,000	11,730,000	
Earth blanket	m^3	47.0	8,500	399,500	
Riprap filter	m^3	56.0	40,000	2,240,000	
Excavation	m^3	849.0	4,500	3,820,500	
back-filling	m^3	309.0	5,500	1,699,500	
Reinforced concrete	m^3	142.6	300,000	42,792,000	
Vegetation of slope protection	m^3	165.0	1,500	247,500	
back-filling	m^3	145.0	4,500	652,500	
Bank protection (wet stone masonry)	m^3	67.0	31,500	2,110,500	Masonry；1.0×0.3×75000=22,500 Gravel；1.0×0.3×30,000=9,000
Bottom protection (wet stone masonry)	m^3	18.0	75,000	1,350,000	
Spillway total				67,042,000	
iv) Intake facilities					
Rainforced concrete					
including formwork	m^3	572	300,000	171,600,000	
Steel pipe					
φ800	m	80	500,000	40,000,000	
Needle type valve					
500mm	piece	1	42,000,000	42,000,000	
300mm	piece	1	6,000,000	6,000,000	
Butterfly type valve					
500mm	piece	1	2,972,000	2,972,000	
300mm	piece	3	1,228,000	3,684,000	
Intake facilities total				266,256,000	

Description	Unit	Quantity	Unit Cost (RWF)	Cost (RWF)	Remarks
Ⅴ) Irrigation facilities					
HDPE					
φ500	m	50	140,000	7,000,000	
φ300	m	80	55,000	4,400,000	
φ150	m	2,450	16,000	39,200,000	
Pump	unit	17	18,150,000	308,550,000	
Warehouse	unit	17	3,000,000	51,000,000	
Tertiary					
HDPE φ90	m	36,000	6,000	216,000,000	
Water tap	m	1,440	200,000	288,000,000	
Earth work					
Excavation work	m^3	29,666	3,500	103,831,000	
Backfilling work	m^3	17,745	2,000	35,490,000	
Structure					
Wet masonry	m^3	11,168	75,000	837,600,000	
Gate	unit	22	5,000,000	110,000,000	
Snap tap	unit	44	65,000	2,860,000	
Levee borad	m	35,000	1,500	52,500,000	
Others	ls	1		258,894,000	Above Direct Construction Cost×10%
Irrigation facilities total				2,315,325,000	
ⅵ) Approximate cost estimatio total				4,215,783,600	indirect construction cost included
				6,968,237	1 US$=605 RWF
				557,458,988	1 US$=80 Yen

4-1. Irrigation designing

4-1-1. Planning of water supply

(1) Studying of Available Water Quantity

(a) Estimation of Available River Flow Rate

ⅰ) Methodology

The runoff model that can calculate the daily river flow rates through inputting the daily rainfalls shall be obtained by analyzing the relationship between the rainfall record and the river flow rate record that have been being observed since this February.

The Tank Model Method shall be applied as the analysis method considering the following conditions.

・ The target is to estimate the long-term river flow rate such as the annual cumulative river flow rate.
・ The river flow rate in this area is much affected by the degree of saturation in the ground brought from previous rainfalls.
・ The Tank Model Method is appropriate to such analysis conditions.

ⅱ) Examination to the Observation Data

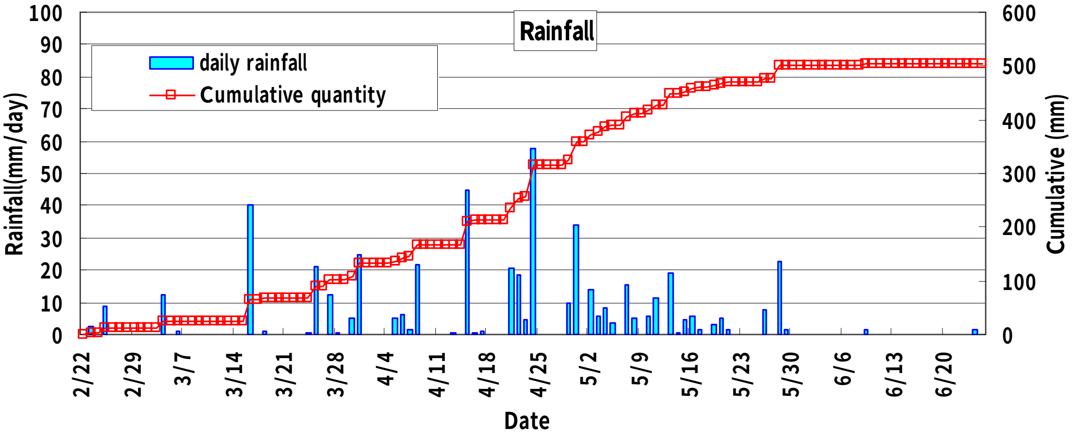
The data that have been being observed shall be summarized in daily records (decade records in runoff's case) and in cumulative records from the beginning of the observation, and shown as the following record diagrams. The observation period is from 22nd of February to 25th of June.

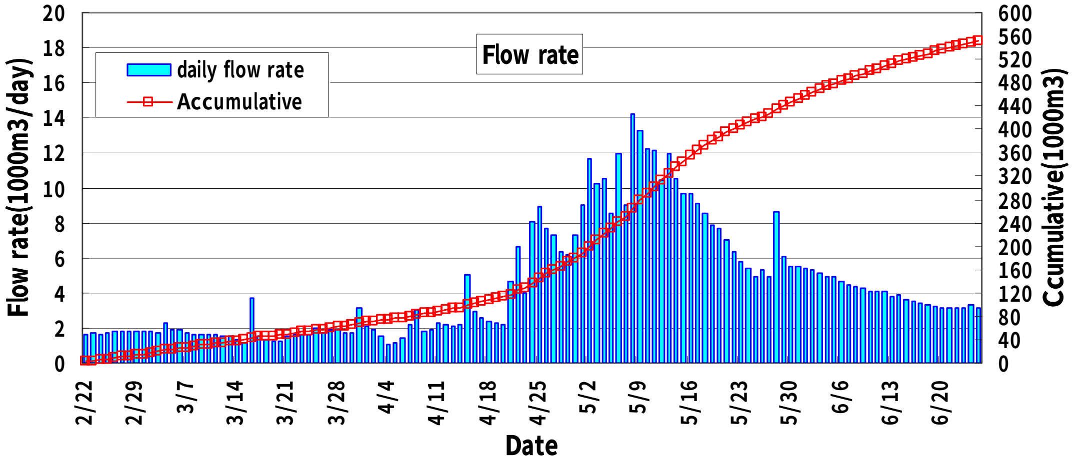
・ Based on these diagrams, followings would be pointed out. As for the runoff ratio that plays an important role in the runoff analysis to the long-term river flow rate, the decade runoff ratio changes from 15 % approximately in February to mid March to 5 % approximately in late March to late April, and keeps an increasing tendency during from the beginning of May to the end of May, then reaches about 40 % in the end at around the end of the rainy season. In June where the rainfall is scarce, the decade runoff ratio diverges due to the denominator of the equation becoming zero.
・ As for the daily river flow rates, they are almost constant to be 2,000 m^3/day approximately since the beginning of the observation, late February, till mid April; and the river flow rate does not respond to the daily rainfall less than 20 mm.
・ The daily river flow rates after considerable precipitations falling in the site at the end of mid April keep the increase tendency, and reach its peak around 10th of May. After showing its peak, the river flow rate keeps decreasing; and the shape of transitional process from increasing to decreasing is almost equilaterally triangular and is similar to the shape of the rainfall's transitional process with about 15 days of shift between their peaks.

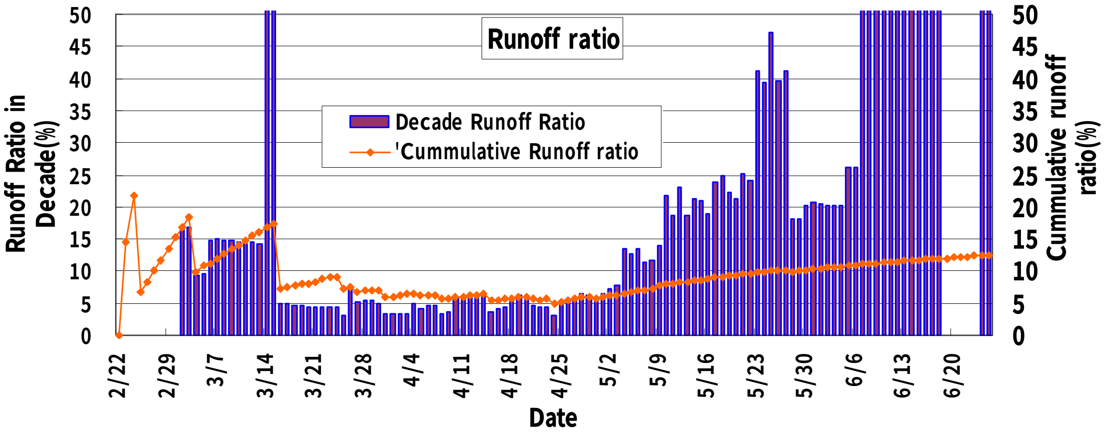
・ The low runoff ratios ranging from 5% to 15% would be caused by the permeable ground surface, precipitations on the dry ground being absorbed and difficult to run off, and the high degree of evapo-traspiration. The continuous river flow rates of 2,000 m^3/day would be the reflection of the base flow.

The increase of the daily river flow rate following the precipitation after late April would be caused by the phenomenon that the runoff ratio increases due to the continuous rainfalls making the ground saturated; and the runoff ratio reaches about 40 % at its peak, and the total runoff ratio of the total river flow rate including the base flow rate to the total rainfall all through the observation period is 12.4 % .

Observation record during 2012/2/22～2012/6/25 (125days)







Examination to the observation record

Period 2012/2/22-2012/5/10	
Correlation factor	0.955
Accumulative flow rate	290 ×1000 m3
Accumulative rainfall	505 mm
Converted flow rate	4,444 ×1000 m3
Runoff ratio	12.4%

(rainfall(mm)×8.8km2)

Fig. 4-1-1-1 Observation records of rainfall & runoff

iii) Building of the Tank Model

a) Evapo-transpiration

In the Tank Model Analysis, the evapo-transpiration from ground surface of the catchment area is taken into account. On the slopes in the catchment area, the main crops planted are the combination of maize or sorghum with beans and banana or coffee as fruit-tree. For the convenient sake of analysis, the pattern of the cropping is assumed to be maize/beans and coffee; and the cultivation ratio is to be maize/beans: 50% and coffee: 50% considering the increase of fruit-tree in future. The decade evapo-transpiration values are shown on Table 4-1-1-1 that are applied to the analysis.

The tanks from which water depth the amount of evapo-transpiration is deducted are the upper (first) tank and the middle (second) tank; only in case of the water depth in the upper tank being not enough, the water depth less than 50 % of the shortage is deducted from the water depth in the middle tank.

Table 4-1-1-1 Evapo-transpiration in decade Unit; mm/day

Mon.	Dec.	Maize (Cultivation: 50%)			Beans (Cultivation: 50%)			Coffee (Cultivation: 50%)			Weighed Mean
1	1				1.86	1.86	1.86	3.38	3.91	3.89	2.79
	2				1.86	1.86	1.86	3.61	3.61	4.18	2.83
	3				1.86	1.86	1.86	3.67	3.67	3.67	2.77
2	1	1.24	1.24	1.24				3.72	3.72	3.72	2.48
	2	1.26	1.26	1.26				3.78	3.78	3.78	2.52
	3	1.30	1.23	1.23				3.70	3.70	3.71	2.48
3	1	2.00	1.26	1.21				3.62	3.62	3.62	2.56
	2	2.87	1.95	1.23				3.53	3.53	3.53	2.77
	3	3.65	2.77	1.90				3.37	3.37	3.37	3.07
4	1	4.25	3.51	2.68				3.20	3.20	3.20	3.34
	2	4.15	4.03	3.32				3.04	3.04	3.04	3.44
	3	4.08	4.08	3.96				2.99	2.99	2.99	3.52
5	1	4.01	4.01	4.01				2.98	2.94	2.94	3.48
	2	3.94	3.94	3.94				2.99	2.92	2.89	3.44
	3	3.43	3.89	3.89				3.03	2.96	2.89	3.35
6	1	2.42	3.34	3.84				3.06	3.00	2.93	3.10
	2	1.49	2.39	3.29				3.09	3.03	2.96	2.71
	3	1.54	1.54	2.47				3.26	3.20	3.13	2.52
7	1	1.55	1.55	1.55				3.32	3.30	3.24	2.42
	2	1.55	1.55	1.55				3.40	3.40	3.38	2.47
	3	1.55	1.55	1.55				3.91	3.91	3.92	2.73
8	1				1.87	1.87	1.87	4.53	4.53	4.55	3.20
	2				1.87	1.87	1.87	5.05	5.05	5.06	3.46
	3				1.87	1.87	1.87	4.95	4.96	4.97	3.42
9	1				1.87	1.87	1.87	4.83	4.83	4.84	3.35
	2				1.85	1.85	1.85	4.77	4.77	4.78	3.31
	3				2.53	1.86	1.86	4.79	4.79	4.81	3.44
10	1				3.83	2.57	1.89	4.88	4.88	4.90	3.83
	2				5.15	3.85	2.60	4.93	4.94	4.95	4.40
	3				4.21	4.69	3.55	4.50	4.50	4.51	4.33
11	1				4.58	4.54	4.16	3.96	3.96	3.97	4.20
	2				4.08	4.04	4.02	3.52	3.52	3.53	3.79
	3				4.00	3.97	3.96	3.47	3.47	3.48	3.73
12	1				3.01	3.86	3.86	3.38	3.38	3.39	3.48
	2				1.64	2.88	3.70	3.26	3.26	3.70	3.07
	3					1.78	3.06	3.50	3.55	3.56	2.58

b) Constant of the tank model

The constants shown in the illustration above are decided through trial calculations aiming to obtain the correlation coefficient between observed values and calculated ones higher than 90 % and to get approximately same values of runoff rate/ratio between the observed and the calculated. The following diagrams show the final result of these trial calculations with the correlation coefficient of 0.961 and the same runoff rate/ratio of 552,000 m3/12.4 %.

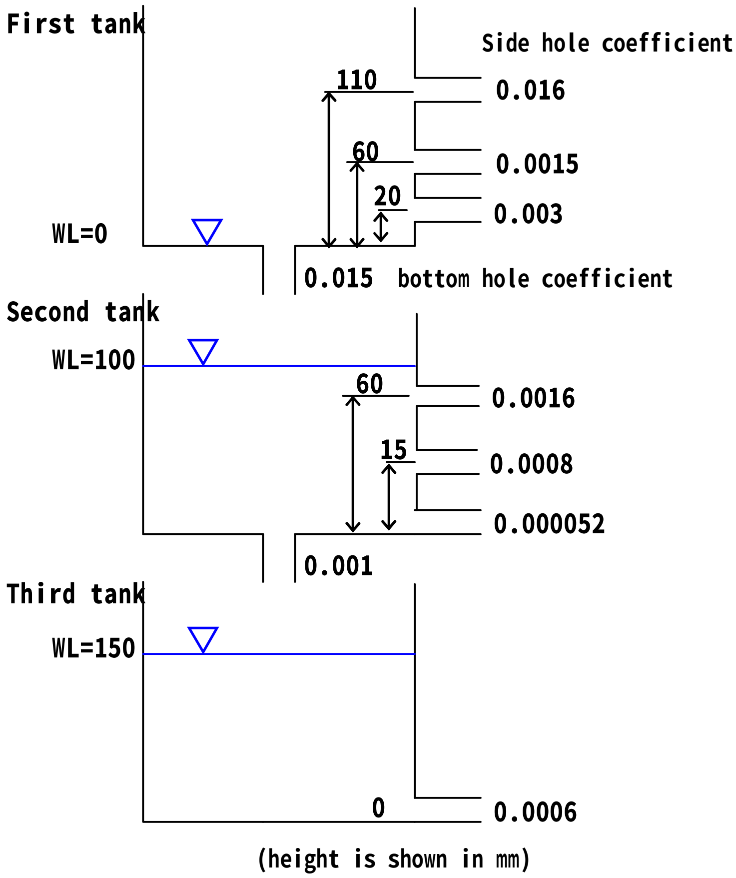
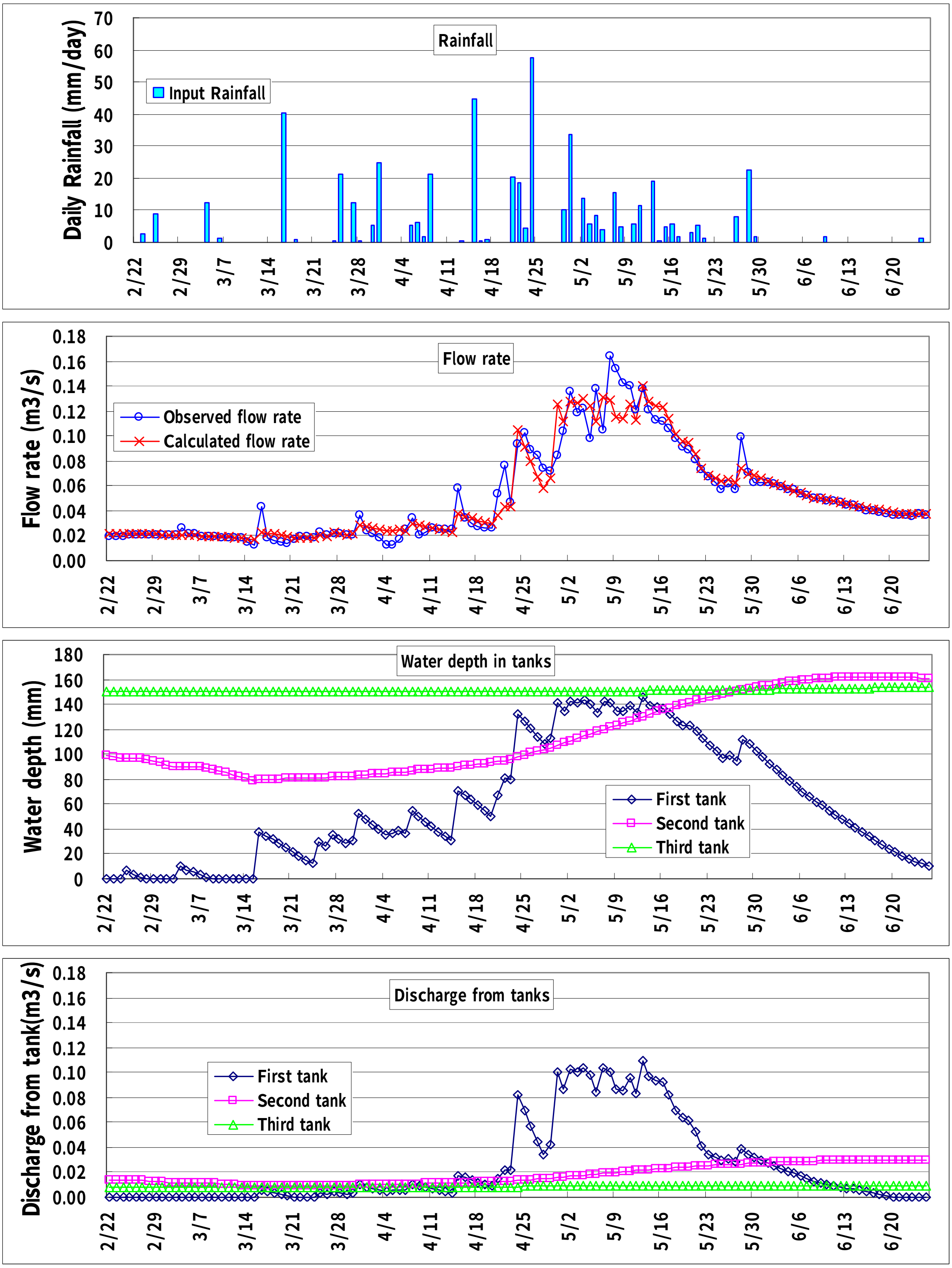


Fig. 4-1-1-2 Conceptual diagram of tank model



Model Quality

Period 2012/2/22-2012/6/25			
Coleration coefficient	0.961	Runnoff ratio	
Cummulative, calculated	552,000m3	Calculated	12.4%
Cummulative, observed	552,000m3	Observed	12.4%
Cummulative rainfall	505mm		

Fig. 4-1-1-3 Comparison of runoff between calculated value and observed value

ⅳ) Estimation of the cumulative quantity of annual river flow rate

The daily rainfall record of Gahororo Weather Station is applied to the analysis based on the following view points.

- Short distance to the dam site
- Daily rainfall record of 34 years from 1960 to 1993
- KIBUNGO Weather Station is also close to the dam site and has the daily rainfall records of 63 years from 1931 to 1994; but these records lack of the recent ones from 1981 to 1989. It is appropriate to adopt Gahororo Station with recent records considering the tendency of the annual rainfall decreasing in these years.

Fig. 4-1-1-4 Location map of the dam site and GAHORORO weather station

The tank model built through the process in the previous section can produce the daily river flow rates corresponding to the each daily rainfall record of 34 years from 1960 to 1993. The following table and figures show the estimated quantity of annual river flow rate that is the accumulation of these daily values.

In addition, the calculation of each year, which starts on 1st of January, is treated to start from the initial water depth conditions of the first tank with 0 mm, of the second tank with 100 mm and of the third tank with 150 mm to avoid the expansion of error through sequential calculation covering 34 years.

Table 4-1-1-2 Results of tank model analysis

Year	Annual flow rate (m3)	Annual rainfall (mm)	Runoff ratio (%)	Wet year ranking	Dry year ranking	
1960	1,467	1,133	14.7	10	25	
1961	1,616	1,320	13.9	6	29	
1962	787	1,067	8.4	26	9	
1963	1,368	1,183	13.1	12	23	
1964	896	1,094	9.3	22	13	
1965	1,536	1,304	13.4	8	27	
1966	1,663	1,366	13.8	5	30	Rainfall record modified
1967	372	856	4.9	34	1	
1968	2,483	1,349	20.9	1	34	
1969	1,049	1,095	10.9	16	19	
1970	894	1,134	9.0	23	12	
1971	670	984	7.7	29	6	
1972	921	1,147	9.1	21	14	
1973	634	918	7.8	30	5	
1974	722	1,002	8.2	27	8	
1975	526	1,022	5.8	32	3	
1976	888	1,145	8.8	24	11	
1977	1,335	1,166	13.0	13	22	
1978	1,608	1,268	14.4	7	28	
1979	2,470	1,269	22.1	2	33	
1980	706	883	9.1	28	7	including missing data
1981	1,253	1,124	12.7	14	21	
1982	832	637	14.9	25	10	including missing data
1983	455	822	6.3	33	2	including missing data
1984	926	1,077	9.8	20	15	
1985	2,458	1,349	20.7	3	32	
1986	1,232	1,046	13.4	15	20	including missing data
1987	1,008	1,161	9.9	18	17	including missing data
1988	1,524	1,306	13.3	9	26	
1989	1,410	1,270	12.6	11	24	
1990	1,867	1,283	16.5	4	31	
1991	970	1,100	10.0	19	16	
1992	571	994	6.5	31	4	
1993	1,014	927	12.4	17	18	
平均	1,158	1,105	11.5			
最小	372	637	4.9			
最大	2,483	1,366	22.1			

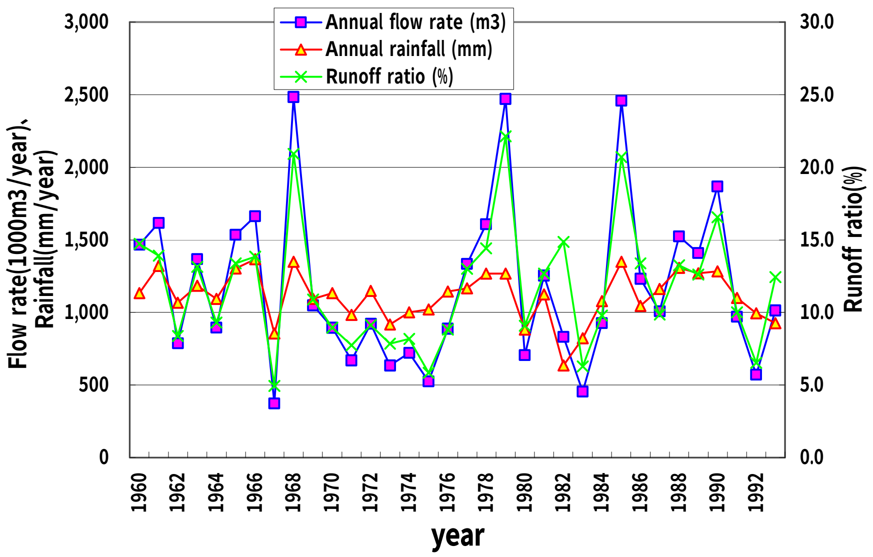


Fig. 4-1-1-5 Results of tank model analysis

V) Base year and the available annual river flow rate

The probability occurrence is examined to the annual river flow rates obtained by the Tank Model Analysis; and the dry year with the probability occurrence of 3/10 approximately is adopted as the base year, which is as same as in Nyanza-23 of the LWH Project, and the annual river flow rate of this year is considered to be the available quantity.

Based on the calculation results shown below, the available quantity is considered to be 893,000 m^3 that corresponds to the three (3) year probability occurrence and the year 1970 the annual value of which is 894,000 m^3 is to be the base year in the irrigation planning. Therefore, 1970 is adopted as the base year and the river flow rate of 894,000m3 is considered to be the base flow rate for planning.

Table 4-1-1-3 Results of provable rainfall (1)

Data number in 10% range at both edges of distributon N/10	Constant of lower limit b
3	24.4

	xl Max	xs Min	xg $\log_{10}xg = \sum \log_{10}xi$	$xl \cdot xs - xg^2$	2xg-(xl+xs)	bs $xl \cdot xs - xg^2$ /2xg-(xl+xs)	b Mean bs
	2,482.660	371.805	1097.9099	-282341.66	-658.64	428.67	428.7
	2,470.078	525.779	1097.9099	93308.36	-800.04	-116.63	156.0
	2,458.152	571.413	1097.9099	199213.67	-833.75	-238.94	24.4
	1,867.161	633.948	1097.9099	-21723.66	-305.29	71.16	36.1
	1,615.768	669.985	1097.9099	-122865.82	-89.93	1366.19	302.1
	1,607.844	722.215	1097.9099	-44196.97	-134.24	329.24	306.6
	1,535.836	787.150	1097.9099	3526.82	-127.17	-27.73	258.9
	1,524.268	888.335	1097.9099	148653.52	-216.78	-685.73	140.8
	1,466.800	893.767	1097.9099	105571.48	-164.75	-640.81	53.9
	1,409.541	896.197	1097.9099	57820.46	-109.92	-526.03	-4.1

standard deviation Sx	1/a
0.20444	0.29443

Unit ×1000 m3/yea

occurrence period of year T year	ξ	1/a· ξ	mean(Y) +1/a· ξ	x+b	Probability prediction to the occurrence x
1	0.0000	0.0000	3.0406	1097.9	1097.910
2	0.0000	0.0000	3.0406	1097.9	1097.910
3	0.3045	0.0897	2.9509	893.1	893.124
4	0.4769	0.1404	2.9002	794.6	794.605
5	0.5951	0.1752	2.8653	733.4	733.414
6	0.6858	0.2019	2.8386	689.7	689.675
7	0.7547	0.2222	2.8184	658.2	658.200
8	0.8134	0.2395	2.8011	632.5	632.521
9	0.8634	0.2542	2.7864	611.4	611.439
10	0.9062	0.2668	2.7738	594.0	593.952

Table 4-1-1-3 Results of provable rainfall (2)

Ranking	YEAR	xi	Fn(%)	$log_{10}xi$	xi+b	Y= log(xi+b)	Y^2	x^2	x^3	ξ	$period_1$	$period_2$	$ξ_1$	$ξ_2$	Repeat period (year)
1	1967	371.805	96.55	2.57031	371.805	2.57031	6.60652	138,238.705	51,397,794.8	1.5971	83	84	1.5950	1.5982	83.7
2	1975	525.779	93.10	2.72080	525.779	2.72080	7.40277	276,443.305	145,348,018.1	1.0860	16	17	1.0848	1.1065	16.1
3	1992	571.413	89.66	2.75695	571.413	2.75695	7.60077	326,512.682	186,573,552.4	0.9633	11	12	0.9442	0.9780	11.6
4	1973	633.948	86.21	2.80205	633.948	2.80205	7.85150	401,889.885	254,777,231.6	0.8101	7	8	0.7547	0.8134	7.9
5	1971	669.985	82.76	2.82607	669.985	2.82607	7.98664	448,880.047	300,742,947.2	0.7285	6	7	0.6858	0.7547	6.6
6	1974	722.215	79.31	2.85867	722.215	2.85867	8.17197	521,594.571	376,703,446.8	0.6178	5	6	0.5951	0.6858	5.3
7	1962	787.150	75.86	2.89606	787.150	2.89606	8.38715	619,604.523	487,721,464.0	0.4908	4	5	0.4769	0.5951	4.1
8	1976	888.335	72.41	2.94858	888.335	2.94858	8.69410	789,138.245	701,018,755.4	0.3124	3	4	0.3045	0.4769	3.0
9	1970	893.767	68.97	2.95122	893.767	2.95122	8.70972	798,819.468	713,958,487.5	0.3034	2	3	0.0000	0.3045	3.0
10	1964	896.197	65.52	2.95240	896.197	2.95240	8.71669	803,169.703	719,798,564.9	0.2994	2	3	0.0000	0.3045	3.0
11	1972	920.984	62.07	2.96425	920.984	2.96425	8.78679	848,211.487	781,189,188.8	0.2592	2	3	0.0000	0.3045	2.9
12	1984	925.900	58.62	2.96656	925.900	2.96656	8.80050	857,291.356	793,766,319.3	0.2513	2	3	0.0000	0.3045	2.8
13	1991	969.775	55.17	2.98667	969.775	2.98667	8.92020	940,463.250	912,037,603.2	0.1830	2	3	0.0000	0.3045	2.6
14	1993	1014.209	51.72	3.00613	1,014.209	3.00613	9.03680	1,028,620.377	1,043,236,288.3	0.1170	2	3	0.0000	0.3045	2.4
15	1969	1049.379	48.28	3.02093	1,049.379	3.02093	9.12603	1,101,196.072	1,155,571,921.4	0.0667	2	3	0.0000	0.3045	2.2
16	1981	1253.001	44.83	3.09795	1,253.001	3.09795	9.59730	1,570,012.463	1,967,227,785.4	-0.1949	1	2	0.0000	0.0000	1.0
17	1977	1334.529	41.38	3.12533	1,334.529	3.12533	9.76768	1,780,967.580	2,376,752,836.0	-0.2879	1	2	0.0000	0.0000	1.0
18	1963	1367.824	37.93	3.13603	1,367.824	3.13603	9.83469	1,870,941.895	2,559,118,816.1	-0.3242	1	2	0.0000	0.0000	1.0
19	1989	1409.541	34.48	3.14908	1,409.541	3.14908	9.91669	1,986,804.921	2,800,482,354.1	-0.3685	1	2	0.0000	0.0000	1.0
20	1960	1466.800	31.03	3.16637	1,466.800	3.16637	10.02591	2,151,502.909	3,155,824,958.0	-0.4273	1	2	0.0000	0.0000	1.0
21	1988	1524.268	27.59	3.18306	1,524.268	3.18306	10.13188	2,323,392.206	3,541,471,835.7	-0.4840	1	2	0.0000	0.0000	1.0
22	1965	1535.836	24.14	3.18634	1,535.836	3.18634	10.15279	2,358,793.262	3,622,720,409.2	-0.4951	1	2	0.0000	0.0000	1.0
23	1978	1607.844	20.69	3.20624	1,607.844	3.20624	10.28000	2,585,162.666	4,156,538,553.3	-0.5627	1	2	0.0000	0.0000	1.0
24	1961	1615.768	17.24	3.20838	1,615.768	3.20838	10.29370	2,610,705.493	4,218,293,796.9	-0.5699	1	2	0.0000	0.0000	1.0
25	1990	1867.161	13.79	3.27118	1,867.161	3.27118	10.70063	3,486,288.983	6,509,461,686.7	-0.7833	1	2	0.0000	0.0000	1.0
26	1985	2458.152	10.34	3.39061	2,458.152	3.39061	11.49623	6,042,512.338	14,853,415,119.3	-1.1889	1	2	0.0000	0.0000	1.0
27	1979	2470.078	6.90	3.39271	2,470.078	3.39271	11.51049	6,101,285.198	15,070,650,181.6	-1.1960	1	2	0.0000	0.0000	1.0
28	1968	2482.660	3.45	3.39492	2,482.660	3.39492	11.52546	6,163,600.037	15,302,122,475.5	-1.2035	1	2	0.0000	0.0000	1.0

(3) Irrigation Planning

(a) Irrigation Water Requirement

Irrigation water requirement is calculated based on cropping pattern & acreage, which are studied in "*4-2. Farming Management Plan*", and meteorological data as follows:

i) Conditions of Study

1) Cropping Pattern

Cropping pattern & acreage, which is recommended to be introduced to command area of Ngoma 22, are shown in will be introduced to Ngoma-22 area and it acreage is shown in the following figure and table:

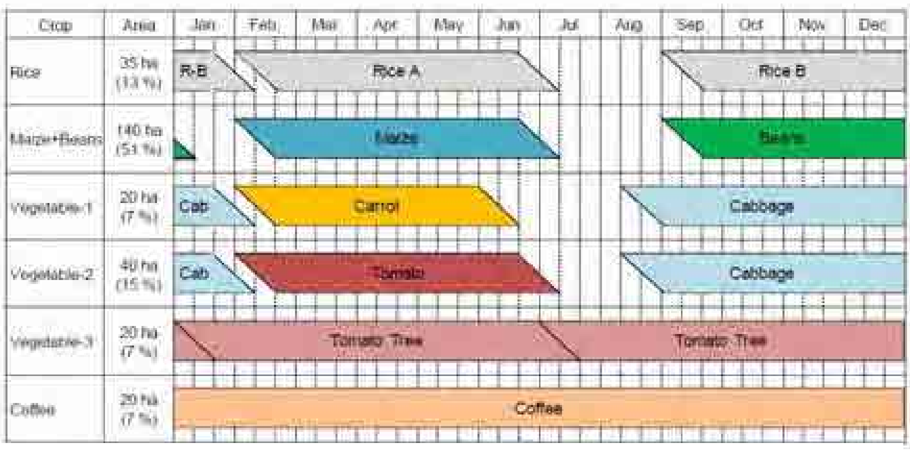


Fig. 4-1-1-20 Cropping Pattern & Acreage of Ngoma-22 (Planed)

Table 4-1-1-11 Cropping Pattern & Acreage of Ngoma-22 (Planed)

Crop		Cropping Acreage	Remarks
Rice Paddy		35 ha (13 %)	
Upland Cropping	Maize + Beans	140 ha (51 %)	
	Vegetable-1	20 ha (7 %)	Carrot + Cabbage
	Vegetable-2	40 ha (15 %)	Tomato + Cabbage
	Vegetable-3	20 ha (7 %)	Tomato Tree
	Coffee	20 ha (7 %)	
	Sub-total	240 ha (87 %)	
Total		275 ha (100 %)	

2) Meteorological Data

In this study, rainfall and temperature observed at Gahororo station, the nearest weather station by command area of Ngoma 22, are adopted for calculation of irrigation water requirement. And other meteorological data, such as relative humidity, wind velocity and sunshine hours observed at Kigali national airport station are adopted since these data are not observed at Gahororo station.

Table 4-1-1-12 Meteorological Data

	Rainfall (mm)	Min.Temp. (℃)	Max.Temp (℃)	Humidity (%)	Wind (km/day)	Sunshine (hrs.)	Radiation (MJ/m^2/day)	RET (mm/day)
Jan.	188.2	10.0	25.3	77	324	6.1	18.6	4.01
Feb.	70.7	9.8	26.4	77	297	6.2	19.2	4.20
Mar.	91.8	10.3	26.6	77	257	4.9	17.2	3.93
Apr.	152.6	10.0	25.4	84	188	5.2	17.0	3.38
May	104.9	10.3	24.3	82	206	5.6	16.5	3.21
Jun.	4.5	11.1	25.6	84	197	5.4	15.6	3.09
Jul.	5.7	10.9	26.3	77	222	4.7	14.9	3.39
Aug.	53.5	9.9	26.8	64	292	7.7	20.2	4.79
Sep.	20.7	10.6	28.4	72	307	6.0	18.6	4.62
Oct.	118.4	9.5	27.5	74	336	6.7	19.9	4.68
Nov.	161.7	10.0	26.0	83	24	4.7	16.4	3.51
Dec.	161.6	10.4	23.8	85	226	5.4	17.3	3.26
Total/Ave.	1,134.3	10.2	26.0	78	258	5.7	17.6	3.84

Notes

*1) Rainfall: Gahororo Station (Rurenge Sector, Ngoma District), 1970.01-12
*2) Minimum Temperature: Gahororo Station, 1970.01-12
*3) Maximum Temperature: Gahororo Station, 1970.01, 1974.02-04, 1970.05-12
*4) Humidity, Wind, and Sunshine: Kigali Station, 1974.01-12
*5)Radiation and RET (Reference Evapotranspiration) is calculated by CROPWAT8.0 based on other data.

ii) Study of Irrigation Water Requirement

1) Unit Irrigation Water Requirement (UIWR)

Unit irrigation water requirement (UIWR) is the quantity of water necessary for crop growth, and expressed in millimeters (mm). It is calculated by CROPWAT8.0, which is a decision support tool developed by the Land Water Development Division of FAO (Food and Agriculture Organization), based on meteorology, soil and crop data.

The results of computation of unit irrigation water requirement (UIWR) are shown in (Table 4-1-1-15) and (Table 4-1-1-16).

2) Net Irrigation Water Requirement (NIWR)

Net irrigation water requirement (NIWR) is the quantity of water for crop growth taking into account cropping acreage, and expressed in cubic-meters (m^3). It is calculated based on UIWR and cropping acreage as follows:

NIWR (m^3) = UIWR (mm) / 1,000 (mm/m) * cropping acreage (ha) * 10,000 (m^2/ha)

The results of computation of net irrigation water requirement (NIWR) are shown in (Table 4-1-1-17).

3) Gross Irrigation Water Requirement (GIWR)

Gross irrigation water requirement (GIWR) is the quantity of water to be applied in reality taking into account water losses, and expressed in cubic-meters (m^3). It is calculated based on NIWR, irrigation efficiency (E) and wetting area coefficient (Kw) and as follows:

GIWR (m^3) = NIWR (m^3) / E (%) * Kw (%)

Irrigation Efficiency (E)

In order to express which percentage of irrigation water is used efficiently and which percentage of is lost, the term irrigation efficiency (E) is used. Irrigation efficiency is subdivided in to conveyance efficiency (Ec) and field application efficiency (Ea) as follows:

E = Ec * Ea

Conveyance efficiency (Ec) presents the efficiency of water transport in canals. It mainly depends on the length of the canals, the soil type or permeability of the canal banks and the condition of canals as shown in the following table:

Table 4-1-1-13 Conveyance Efficiency (Ec)

Description			Conveyance Efficiency (Ec)			
Canal Type			Earthen Canals			**Lined Canals**
Soil Type			Sand	Loam	Clay	-
Canal Length	Long	(> 2,000m)	60 %	70 %	80 %	**95 %**
	Medium	(200- 2,000m)	70 %	75 %	85 %	**95 %**
	Short	(< 200m)	80 %	85 %	90 %	**95 %**

(Irrigation Scheduling, Training Manual No.4, Irrigation Water Management, FAO 1989)

Field application efficiency (Ea) presents the efficiency of water application in the field. It mainly depends on the irrigation method and the level of farmer discipline as shown in the following table:

Table 4-1-1-14 Field Application Efficiency (Ea)

Irrigation Methods	Field Application Efficiency (Ea)
Surface Irrigation (Border, Furrow, Basin)	60 %
Sprinkler Irrigation	75 %
Drip Irrigation	**90 %**

(Irrigation Scheduling, Training Manual No.4, Irrigation Water Management, FAO 1989)

In this study, 95 % is applied as conveyance efficiency (Ec) since stone masonry and pipeline is adopted for main & lateral canal and secondary canal respectively. In addition, 90 % is applied as field application efficiency since hose irrigation method is adopted as on-firm irrigation system.

Therefore, irrigation efficiency is estimated as follows:

E = Ec * Ea = 95 % * 90 % = 85 %

Wetting Area Coefficient

The shape of wet area in a field is different and it depends on the irrigation method and the arrangement of emitters of irrigation system and so on. The ratio of wet area to whole area is expressed by wetting area coefficient (Kw).

According to ”Manual on Design Standard of Efficient Irrigation System and On-farm Irrigation Management” provided by JICA study team for “Project on Development of Efficient Irrigation Techniques and Extension in Syria (DEITEX)” conducted in Syria for three (3) years since March 2005, wetting area coefficient (Kw) is defined as follows:

- Surface and Sprinkler Irrigation
  : Surface and sprinkler irrigation method create whle wet area, and Kw of those is 100 %.

- GR Irrigation (Drip Tube Irrigation)
  : GR irrigation method forms the partial wet zones with a certain width along the drip tubes, and Kw of it varies from 70 to 100 %.

- Micro Irrigation (Micro Emitter, Micro Sprinkler)

: Micro irrigation method forms the isolated wet area around crop plants, and Kw of it varies from 40 to 70 % in accordance with spacing of the crop plants, specification of the emitters and soil type as well.

Since hose irrigation method is adopted as on-firm irrigation system in this study, wetting area coefficient (Kw) for micro irrigation method is applied since hose irrigation method is adopted. Therefore, in this study, comparative study is conducted in four (4) cases, such as Kw = 40, 50, 60 and 70 %.

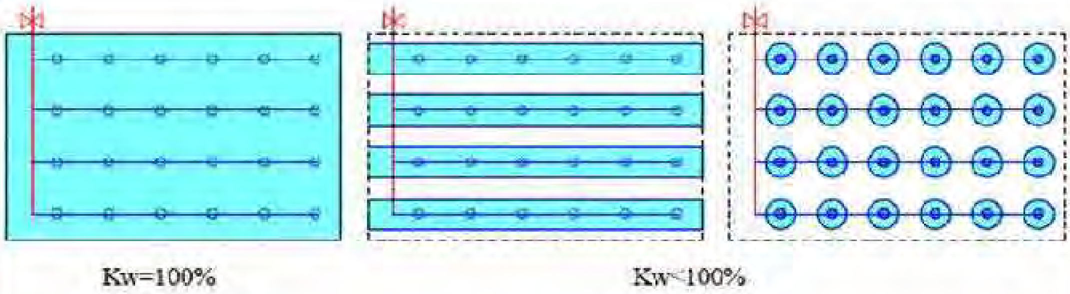


Table 4.5 Wetting area coefficient Kw

Irrigation method	Kw (%)	Remarks
Surface irrigation	100	
Sprinkler irrigation	100	
GR irrigation	70-100	GR : Drip tube
Micro irrigation	40–70	Micro emitter, Micro sprinkler

The results of computation of gross irrigation water requirement (GIWR) are shown in (Table 4-1-1-1~4-1-1-21).

Table 4-1-1-15 Unit Irrigation Water Requirement (per Crop)

Unit Irrigation Water Requirement (per Crop)

(Units: mm/dec)

Rice Paddy

Month	Decade	Days	Rice A 1st.Plant	Rice A 2nd.Plant	Rice A 3rd.Plant	Rice A Average	Rice B 1st.Plant	Rice B 2nd.Plant	Rice B 3rd.Plant	Rice B Average
Jan.	1st.	10	0.0			**0.0**	0.0	0.0	1.3	**0.4**
	2nd.	10	101.6	0.0		**33.9**	0.0	0.0	0.0	**0.0**
	3rd.	11	182.7	106.8	0.0	**96.5**		0.0	9.5	**3.2**
Feb.	1st.	10	19.6	208.2	120.0	**115.9**			3.0	**1.0**
	2nd.	10	29.3	29.3	218.0	**92.2**				**0.0**
	3rd.	8	16.2	16.2	16.2	**16.2**				**0.0**
Mar.	1st.	10	21.0	20.5	20.5	**20.7**				**0.0**
	2nd.	10	20.0	18.6	18.1	**18.9**				**0.0**
	3rd.	11	19.2	17.8	16.3	**17.8**				**0.0**
Apr.	1st.	10	7.0	5.9	4.6	**5.8**				**0.0**
	2nd.	10	0.0	0.0	0.0	**0.0**				**0.0**
	3rd.	10	3.3	3.3	3.0	**3.2**				**0.0**
May	1st.	10	6.0	6.0	6.0	**6.0**				**0.0**
	2nd.	10	7.6	7.6	7.5	**7.6**				**0.0**
	3rd.	11	19.3	21.0	21.0	**20.4**				**0.0**
Jun.	1st.	10	29.1	32.2	33.9	**31.7**				**0.0**
	2nd.	10	29.8	32.9	36.0	**32.9**				**0.0**
	3rd.	10		30.5	33.8	**21.4**				**0.0**
Jul.	1st.	10			30.8	**10.3**				**0.0**
	2nd.	10				**0.0**				**0.0**
	3rd.	11				**0.0**				**0.0**
Aug.	1st.	10				**0.0**	0.0			**0.0**
	2nd.	10				**0.0**	129.7	0.0		**43.2**
	3rd.	11				**0.0**	231.2	138.3	0.0	**123.2**
Sep.	1st.	10				**0.0**	44.9	234.4	145.2	**141.5**
	2nd.	10				**0.0**	49.1	49.1	238.5	**112.2**
	3rd.	10				**0.0**	39.3	39.3	39.3	**39.3**
Oct.	1st.	10				**0.0**	27.9	26.8	26.8	**27.2**
	2nd.	10				**0.0**	21.2	19.2	18.2	**19.5**
	3rd.	11				**0.0**	21.4	19.4	17.6	**19.5**
Nov.	1st.	10				**0.0**	9.3	8.0	6.6	**8.0**
	2nd.	10				**0.0**	1.2	0.9	0.0	**0.7**
	3rd.	10				**0.0**	0.9	0.7	0.8	**0.8**
Dec.	1st.	10				**0.0**	0.9	0.8	0.9	**0.9**
	2nd.	10				**0.0**	0.0	0.0	0.0	**0.0**
	3rd.	11				**0.0**	3.4	5.7	5.9	**5.0**
Annual IWR (mm/yr.)			*511.7*	*556.8*	*585.7*	***551.4***	*580.4*	*542.6*	*513.6*	***545.5***
Max. IWR (mm/dec.)						***115.9***				***141.5***

Upland Cropping

Month	Decade	Days	Maize 1st.Plant	Maize 2nd.Plant	Maize 3rd.Plant	Maize Average	Beans 1st.Plant	Beans 2nd.Plant	Beans 3rd.Plant	Beans Average	Carrot 1st.Plant	Carrot 2nd.Plant	Carrot 3rd.Plant	Carrot Average
Jan.	1st.	10				**0.0**			0.0	**0.0**				**0.0**
	2nd.	10				**0.0**				**0.0**				**0.0**
	3rd.	11				**0.0**				**0.0**				**0.0**
Feb.	1st.	10	0.0			**0.0**				**0.0**	3.1			**1.0**
	2nd.	10	0.0	0.0		**0.0**				**0.0**	12.5	12.5		**8.3**
	3rd.	8	0.0	0.0	0.0	**0.0**				**0.0**	4.9	3.0	3.0	**3.6**
Mar.	1st.	10	0.0	0.0	0.0	**0.0**				**0.0**	11.1	6.2	4.4	**7.2**
	2nd.	10	3.6	0.0	0.0	**1.2**				**0.0**	13.8	8.9	4.1	**8.9**
	3rd.	11	10.6	1.0	0.0	**3.9**				**0.0**	14.5	11.4	6.3	**10.7**
Apr.	1st.	10	6.2	0.0	0.0	**2.1**				**0.0**	1.8	1.6	0.0	**1.1**
	2nd.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**
	3rd.	10	3.5	3.4	2.2	**3.0**				**0.0**	0.0	0.0	0.0	**0.0**
May	1st.	10	6.2	6.2	6.1	**6.2**				**0.0**	1.0	0.9	0.9	**0.9**
	2nd.	10	7.8	7.7	7.7	**7.7**				**0.0**	1.9	2.6	2.5	**2.3**
	3rd.	11	16.1	21.2	21.1	**19.5**				**0.0**	12.9	14.7	15.5	**14.4**
Jun.	1st.	10	19.9	29.1	34.1	**27.7**				**0.0**		26.6	28.2	**18.3**
	2nd.	10	14.9	23.9	32.9	**23.9**				**0.0**			30.5	**10.2**
	3rd.	10		15.1	24.4	**13.2**				**0.0**				**0.0**
Jul.	1st.	10			15.0	**5.0**				**0.0**				**0.0**
	2nd.	10				**0.0**				**0.0**				**0.0**
	3rd.	11				**0.0**				**0.0**				**0.0**
Aug.	1st.	10				**0.0**				**0.0**				**0.0**
	2nd.	10				**0.0**				**0.0**				**0.0**
	3rd.	11				**0.0**				**0.0**				**0.0**
Sep.	1st.	10				**0.0**	12.1			**4.0**				**0.0**
	2nd.	10				**0.0**	16.8	16.8		**11.2**				**0.0**
	3rd.	10				**0.0**	13.5	6.8	6.8	**9.0**				**0.0**
Oct.	1st.	10				**0.0**	13.2	0.5	0.0	**4.6**				**0.0**
	2nd.	10				**0.0**	17.0	4.0	0.0	**7.0**				**0.0**
	3rd.	11				**0.0**	21.0	15.3	2.8	**13.0**				**0.0**
Nov.	1st.	10				**0.0**	7.8	7.3	3.6	**6.2**				**0.0**
	2nd.	10				**0.0**	0.0	0.0	0.0	**0.0**				**0.0**
	3rd.	10				**0.0**	0.0	0.0	0.0	**0.0**				**0.0**
Dec.	1st.	10				**0.0**	0.0	0.0	0.0	**0.0**				**0.0**
	2nd.	10				**0.0**	0.0	0.0	0.0	**0.0**				**0.0**
	3rd.	11				**0.0**		0.0	0.0	**0.0**				**0.0**
Annual IWR (mm/yr.)			*88.8*	*107.6*	*143.5*	***113.3***	*101.4*	*50.7*	*13.2*	***55.1***	*77.5*	*88.4*	*95.4*	***87.1***
Max. IWR (mm/dec.)						***27.7***				***13.0***				***18.3***

Month	Decade	Days	Cabbage 1st.Plant	Cabbage 2nd.Plant	Cabbage 3rd.Plant	Cabbage Average	Tomato 1st.Plant	Tomato 2nd.Plant	Tomato 3rd.Plant	Tomato Average	Tomato Tree 1st.Plant	Tomato Tree 2nd.Plant	Tomato Tree 3rd.Plant	Tomato Tree Average	Coffee 1st.Plant	Coffee 2nd.Plant	Coffee 3rd.Plant	Coffee Average
Jan.	1st.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
	2nd.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
	3rd.	11	8.2	7.6	9.8	**8.5**				**0.0**	0.0	0.0	0.0	**0.0**	1.6	1.6	1.6	**1.6**
Feb.	1st.	10		4.2	16.9	**7.0**	0.0			**0.0**	6.8	2.0	0.0	**2.9**	11.4	11.4	11.4	**11.4**
	2nd.	10			4.2	**1.4**	8.3	8.3		**5.5**	21.1	16.3	11.4	**16.3**	20.9	20.9	20.9	**20.9**
	3rd.	8				**0.0**	0.0	0.0	0.0	**0.0**	13.2	9.4	5.6	**9.4**	9.6	9.6	9.6	**9.6**
Mar.	1st.	10				**0.0**	2.5	0.4	0.4	**1.1**	21.0	16.3	11.6	**16.3**	12.5	12.5	12.5	**12.5**
	2nd.	10				**0.0**	6.0	0.5	0.0	**2.2**	21.1	18.5	13.9	**17.8**	10.2	10.2	10.2	**10.2**
	3rd.	11				**0.0**	9.2	3.4	0.0	**4.2**	18.9	18.8	16.3	**18.0**	7.5	7.5	7.5	**7.5**
Apr.	1st.	10				**0.0**	2.5	0.0	0.0	**0.8**	5.5	5.4	5.3	**5.4**	0.0	0.0	0.0	**0.0**
	2nd.	10				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
	3rd.	10				**0.0**	1.5	1.5	0.0	**1.0**	1.7	1.6	1.5	**1.6**	0.0	0.0	0.0	**0.0**
May	1st.	10				**0.0**	4.3	4.3	4.2	**4.3**	4.5	4.4	4.3	**4.4**	0.0	0.0	0.0	**0.0**
	2nd.	10				**0.0**	5.9	5.8	5.8	**5.8**	6.1	6.0	5.9	**6.0**	0.0	0.0	0.0	**0.0**
	3rd.	11				**0.0**	16.0	19.1	19.1	**18.1**	19.4	19.3	19.1	**19.3**	11.7	11.0	10.2	**11.0**
Jun.	1st.	10				**0.0**	23.6	29.2	32.3	**28.4**	32.4	32.4	32.3	**32.4**	26.4	25.7	25.0	**25.7**
	2nd.	10				**0.0**	11.6	27.5	33.0	**24.0**	31.7	36.1	36.1	**34.6**	30.9	30.3	29.6	**30.3**
	3rd.	10				**0.0**		11.9	28.1	**13.3**	22.9	32.4	36.9	**30.7**	32.3	31.7	31.0	**31.7**
Jul.	1st.	10				**0.0**			11.9	**4.0**	18.8	23.1	32.6	**24.8**	32.7	32.5	31.9	**32.4**
	2nd.	10				**0.0**				**0.0**	19.8	19.8	24.2	**21.3**	34.0	34.0	33.8	**33.9**
	3rd.	11				**0.0**				**0.0**	22.8	19.8	19.8	**20.8**	37.7	37.8	37.9	**37.8**
Aug.	1st.	10				**0.0**				**0.0**	21.4	16.0	12.6	**16.7**	31.5	31.6	31.7	**31.6**
	2nd.	10	14.5			**4.8**				**0.0**	25.4	19.4	13.5	**19.4**	30.8	30.8	30.9	**30.8**
	3rd.	11	21.6	21.6	3.4	**15.5**				**0.0**	40.1	33.5	27.1	**33.6**	39.1	39.2	39.3	**39.2**
Sep.	1st.	10	26.2	26.2	26.2	**26.2**				**0.0**	48.4	42.7	36.9	**42.7**	41.7	41.7	41.8	**41.7**
	2nd.	10	30.7	30.6	30.6	**30.6**				**0.0**	54.1	52.3	46.7	**51.0**	46.0	46.0	46.1	**46.0**
	3rd.	10	22.6	20.7	20.7	**21.3**				**0.0**	44.3	44.1	42.3	**43.6**	36.1	36.1	36.2	**36.1**
Oct.	1st.	10	12.8	9.9	8.0	**10.2**				**0.0**	32.0	31.7	31.5	**31.7**	23.6	23.6	23.8	**23.7**
	2nd.	10	7.0	4.1	1.1	**4.1**				**0.0**	23.4	23.1	22.9	**23.1**	14.9	14.9	15.1	**15.0**
	3rd.	11	8.5	5.5	2.6	**5.5**				**0.0**	21.7	21.4	21.2	**21.4**	13.2	13.2	13.4	**13.3**
Nov.	1st.	10	0.3	0.0	0.0	**0.1**				**0.0**	8.3	8.1	7.9	**8.1**	1.5	1.6	1.7	**1.6**
	2nd.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.2	0.0	0.0	**0.1**	0.0	0.0	0.0	**0.0**
	3rd.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
Dec.	1st.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
	2nd.	10	0.0	0.0	0.0	**0.0**				**0.0**	0.0	0.0	0.0	**0.0**	0.0	0.0	0.0	**0.0**
	3rd.	11	0.0	0.0	0.3	**0.1**				**0.0**	0.0	0.0	3.7	**1.2**	0.0	0.0	0.0	**0.0**
Annual IWR (mm/yr.)			*152.4*	*130.4*	*123.8*	***135.5***	*91.4*	*111.9*	*134.8*	***112.7***	*226.3*	*242.0*	*257.0*	***574.7***	*557.8*	*555.4*	*553.1*	***555.4***
Max. IWR (mm/dec.)						***30.6***				***28.4***	*380.7*	*331.9*	*286.1*	***51.0***				***46.0***

Notes

*1) Irrigation Water Requirement : Calculated by CROPWAT8 based on cropping pattern for Ngoma22.

Table 4-1-1-16 Unit Irrigation Water Requirement (per Cropping Pattern)

Unit Irrigation Water Requirement (per Cropping Pattern)

(Units: mm/dec)

Month	Decade	Days	Rice Paddy			Upland Cropping											
						Maize + Beans			Vegetable 1			Vegetable 2			Vegetable 3		
			Rice A (Average)	Rice B (Average)	**Total**	Maize (Average)	Beans (Average)	Sub-total	Carrot (Average)	Cabbage (Average)	Sub-total	Tomato (Average)	Cabbage (Average)	Sub-total	Tomato Tree (Average)	Coffee (Average)	**Total**
Jan.	1st.	10	0.0	0.4	**0.4**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	2nd.	10	33.9	0.0	**33.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	3rd.	11	96.5	3.2	**99.7**	0.0	0.0	0.0	0.0	8.5	8.5	0.0	8.5	8.5	0.0	1.6	**18.7**
Feb.	1st.	10	115.9	1.0	**116.9**	0.0	0.0	0.0	1.0	7.0	8.1	0.0	7.0	7.0	2.9	11.4	**29.4**
	2nd.	10	92.2	0.0	**92.2**	0.0	0.0	0.0	8.3	1.4	9.7	5.5	1.4	6.9	16.3	20.9	**53.8**
	3rd.	8	16.2	0.0	**16.2**	0.0	0.0	0.0	3.6	0.0	3.6	0.0	0.0	0.0	9.4	9.6	**22.6**
Mar.	1st.	10	20.7	0.0	**20.7**	0.0	0.0	0.0	7.2	0.0	7.2	1.1	0.0	1.1	16.3	12.5	**37.1**
	2nd.	10	18.9	0.0	**18.9**	1.2	0.0	1.2	8.9	0.0	8.9	2.2	0.0	2.2	17.8	10.2	**40.3**
	3rd.	11	17.8	0.0	**17.8**	3.9	0.0	3.9	10.7	0.0	10.7	4.2	0.0	4.2	18.0	7.5	**44.3**
Apr.	1st.	10	5.8	0.0	**5.8**	2.1	0.0	2.1	1.1	0.0	1.1	0.8	0.0	0.8	5.4	0.0	**9.4**
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	3rd.	10	3.2	0.0	**3.2**	3.0	0.0	3.0	0.0	0.0	0.0	1.0	0.0	1.0	1.6	0.0	**5.6**
May	1st.	10	6.0	0.0	**6.0**	6.2	0.0	6.2	0.9	0.0	0.9	4.3	0.0	4.3	4.4	0.0	**15.8**
	2nd.	10	7.6	0.0	**7.6**	7.7	0.0	7.7	2.3	0.0	2.3	5.8	0.0	5.8	6.0	0.0	**21.9**
	3rd.	11	20.4	0.0	**20.4**	19.5	0.0	19.5	14.4	0.0	14.4	18.1	0.0	18.1	19.3	11.0	**82.1**
Jun.	1st.	10	31.7	0.0	**31.7**	27.7	0.0	27.7	18.3	0.0	18.3	28.4	0.0	28.4	32.4	25.7	**132.4**
	2nd.	10	32.9	0.0	**32.9**	23.9	0.0	23.9	10.2	0.0	10.2	24.0	0.0	24.0	34.6	30.3	**123.0**
	3rd.	10	21.4	0.0	**21.4**	13.2	0.0	13.2	0.0	0.0	0.0	13.3	0.0	13.3	30.7	31.7	**88.9**
Jul.	1st.	10	10.3	0.0	**10.3**	5.0	0.0	5.0	0.0	0.0	0.0	4.0	0.0	4.0	24.8	32.4	**66.2**
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.3	33.9	**55.2**
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.8	37.8	**58.6**
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.7	31.6	**48.3**
	2nd.	10	0.0	43.2	**43.2**	0.0	0.0	0.0	0.0	4.8	4.8	0.0	4.8	4.8	19.4	30.8	**59.9**
	3rd.	11	0.0	123.2	**123.2**	0.0	0.0	0.0	0.0	15.5	15.5	0.0	15.5	15.5	33.6	39.2	**103.8**
Sep.	1st.	10	0.0	141.5	**141.5**	0.0	4.0	4.0	0.0	26.2	26.2	0.0	26.2	26.2	42.7	41.7	**140.8**
	2nd.	10	0.0	112.2	**112.2**	0.0	11.2	11.2	0.0	30.6	30.6	0.0	30.6	30.6	51.0	46.0	**169.5**
	3rd.	10	0.0	39.3	**39.3**	0.0	9.0	9.0	0.0	21.3	21.3	0.0	21.3	21.3	43.6	36.1	**131.4**
Oct.	1st.	10	0.0	27.2	**27.2**	0.0	4.6	4.6	0.0	10.2	10.2	0.0	10.2	10.2	31.7	23.7	**80.4**
	2nd.	10	0.0	19.5	**19.5**	0.0	7.0	7.0	0.0	4.1	4.1	0.0	4.1	4.1	23.1	15.0	**53.2**
	3rd.	11	0.0	19.5	**19.5**	0.0	13.0	13.0	0.0	5.5	5.5	0.0	5.5	5.5	21.4	13.3	**58.8**
Nov.	1st.	10	0.0	8.0	**8.0**	0.0	6.2	6.2	0.0	0.1	0.1	0.0	0.1	0.1	8.1	1.6	**16.1**
	2nd.	10	0.0	0.7	**0.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	**0.1**
	3rd.	10	0.0	0.8	**0.8**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
Dec.	1st.	10	0.0	0.9	**0.9**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
	3rd.	11	0.0	5.0	**5.0**	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	1.2	0.0	**1.4**
Annual IWR (mm/yr.)			*551.4*	*545.5*	***1,096.9***	*113.3*	*55.1*	*168.4*	*87.1*	*135.5*	*222.6*	*112.7*	*135.5*	*248.2*	*574.7*	*555.4*	***1,769.4***
Max. IWR (mm/dec.)			*115.9*	*141.5*	***141.5***	*27.7*	*13.0*	*27.7*	*18.3*	*30.6*	*30.6*	*28.4*	*30.6*	*30.6*	*51.0*	*46.0*	***169.5***

Table 4-1-1-17 Net Irrigation Water Requirement (per Cropping Pattern)

Net Irrigation Water Requirement (per Cropping Pattern)

(Unit: m^3/dec)

Month	Decade	Days	Rice Paddy: Rice A	Rice Paddy: Rice B	Rice Paddy: Total	Maize + Beans: Maize	Maize + Beans: Beans	Maize + Beans: Sub-total	Vegetable 1: Carrot	Vegetable 1: Cabbage	Vegetable 1: Sub-total	Vegetable 2: Tomato	Vegetable 2: Cabbage	Vegetable 2: Sub-total	Vegetable 3: Tomato Tree	Coffee	Upland Cropping Total	Grand Total
			35.0 ha (13 %)			140.0 ha (51 %)			20.0 ha (7 %)			40.0 ha (15 %)			20.0 ha (7 %)	20.0 ha (7 %)	**240.0 ha (87 %)**	275.0 ha (100 %)
Jan.	1st.	10	0.0	151.7	**151.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	151.7
	2nd.	10	11,853.3	0.0	**11,853.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	11,853.3
	3rd.	11	33,775.0	1,108.3	**34,883.3**	0.0	0.0	0.0	0.0	1,706.7	1,706.7	0.0	3,413.3	3,413.3	0.0	320.0	**5,440.0**	40,323.3
Feb.	1st.	10	40,576.7	350.0	**40,926.7**	0.0	0.0	0.0	206.7	1,406.7	1,613.3	0.0	2,813.3	2,813.3	586.7	2,280.0	**7,293.3**	48,220.0
	2nd.	10	32,270.0	0.0	**32,270.0**	0.0	0.0	0.0	1,666.7	280.0	1,946.7	2,213.3	560.0	2,773.3	3,253.3	4,180.0	**12,153.3**	44,423.3
	3rd.	8	5,670.0	0.0	**5,670.0**	0.0	0.0	0.0	726.7	0.0	726.7	0.0	0.0	0.0	1,880.0	1,920.0	**4,526.7**	10,196.7
Mar.	1st.	10	7,233.3	0.0	**7,233.3**	0.0	0.0	0.0	1,446.7	0.0	1,446.7	440.0	0.0	440.0	3,260.0	2,500.0	**7,646.7**	14,880.0
	2nd.	10	6,615.0	0.0	**6,615.0**	1,680.0	0.0	1,680.0	1,786.7	0.0	1,786.7	866.7	0.0	866.7	3,566.7	2,040.0	**9,940.0**	16,555.0
	3rd.	11	6,218.3	0.0	**6,218.3**	5,413.3	0.0	5,413.3	2,146.7	0.0	2,146.7	1,680.0	0.0	1,680.0	3,600.0	1,500.0	**14,340.0**	20,558.3
Apr.	1st.	10	2,041.7	0.0	**2,041.7**	2,893.3	0.0	2,893.3	226.7	0.0	226.7	333.3	0.0	333.3	1,080.0	0.0	**4,533.3**	6,575.0
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	10	1,120.0	0.0	**1,120.0**	4,246.7	0.0	4,246.7	0.0	0.0	0.0	400.0	0.0	400.0	320.0	0.0	**4,966.7**	6,086.7
May	1st.	10	2,100.0	0.0	**2,100.0**	8,633.3	0.0	8,633.3	186.7	0.0	186.7	1,706.7	0.0	1,706.7	880.0	0.0	**11,406.7**	13,506.7
	2nd.	10	2,648.3	0.0	**2,648.3**	10,826.7	0.0	10,826.7	466.7	0.0	466.7	2,333.3	0.0	2,333.3	1,200.0	0.0	**14,826.7**	17,475.0
	3rd.	11	7,151.7	0.0	**7,151.7**	27,253.3	0.0	27,253.3	2,873.3	0.0	2,873.3	7,226.7	0.0	7,226.7	3,853.3	2,193.3	**43,400.0**	50,551.7
Jun.	1st.	10	11,106.7	0.0	**11,106.7**	38,780.0	0.0	38,780.0	3,653.3	0.0	3,653.3	11,346.7	0.0	11,346.7	6,473.3	5,140.0	**65,393.3**	76,500.0
	2nd.	10	11,515.0	0.0	**11,515.0**	33,460.0	0.0	33,460.0	2,033.3	0.0	2,033.3	9,613.3	0.0	9,613.3	6,926.7	6,053.3	**58,086.7**	69,601.7
	3rd.	10	7,501.7	0.0	**7,501.7**	18,433.3	0.0	18,433.3	0.0	0.0	0.0	5,333.3	0.0	5,333.3	6,146.7	6,333.3	**36,246.7**	43,748.3
Jul.	1st.	10	3,593.3	0.0	**3,593.3**	7,000.0	0.0	7,000.0	0.0	0.0	0.0	1,586.7	0.0	1,586.7	4,966.7	6,473.3	**20,026.7**	23,620.0
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,253.3	6,786.7	**11,040.0**	11,040.0
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4,160.0	7,560.0	**11,720.0**	11,720.0
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,333.3	6,320.0	**9,653.3**	9,653.3
	2nd.	10	0.0	15,131.7	**15,131.7**	0.0	0.0	0.0	0.0	966.7	966.7	0.0	1,933.3	1,933.3	3,886.7	6,166.7	**12,953.3**	28,085.0
	3rd.	11	0.0	43,108.3	**43,108.3**	0.0	0.0	0.0	0.0	3,106.7	3,106.7	0.0	6,213.3	6,213.3	6,713.3	7,840.0	**23,873.3**	66,981.7
Sep.	1st.	10	0.0	49,525.0	**49,525.0**	0.0	5,646.7	5,646.7	0.0	5,240.0	5,240.0	0.0	10,480.0	10,480.0	8,533.3	8,346.7	**38,246.7**	87,771.7
	2nd.	10	0.0	39,281.7	**39,281.7**	0.0	15,680.0	15,680.0	0.0	6,126.7	6,126.7	0.0	12,253.3	12,253.3	10,206.7	9,206.7	**53,473.3**	92,755.0
	3rd.	10	0.0	13,755.0	**13,755.0**	0.0	12,646.7	12,646.7	0.0	4,266.7	4,266.7	0.0	8,533.3	8,533.3	8,713.3	7,226.7	**41,386.7**	55,141.7
Oct.	1st.	10	0.0	9,508.3	**9,508.3**	0.0	6,393.3	6,393.3	0.0	2,046.7	2,046.7	0.0	4,093.3	4,093.3	6,346.7	4,733.3	**23,613.3**	33,121.7
	2nd.	10	0.0	6,836.7	**6,836.7**	0.0	9,800.0	9,800.0	0.0	813.3	813.3	0.0	1,626.7	1,626.7	4,626.7	2,993.3	**19,860.0**	26,696.7
	3rd.	11	0.0	6,813.3	**6,813.3**	0.0	18,246.7	18,246.7	0.0	1,106.7	1,106.7	0.0	2,213.3	2,213.3	4,286.7	2,653.3	**28,506.7**	35,320.0
Nov.	1st.	10	0.0	2,788.3	**2,788.3**	0.0	8,726.7	8,726.7	0.0	20.0	20.0	0.0	40.0	40.0	1,620.0	320.0	**10,726.7**	13,515.0
	2nd.	10	0.0	245.0	**245.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.3	0.0	**13.3**	258.3
	3rd.	10	0.0	280.0	**280.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	280.0
Dec.	1st.	10	0.0	303.3	**303.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	303.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	11	0.0	1,750.0	**1,750.0**	0.0	0.0	0.0	0.0	20.0	20.0	0.0	40.0	40.0	246.7	0.0	**306.7**	2,056.7
Annual IWR (m^3/yr.)			*192,990.0*	*190,936.7*	***383,926.7***	*158,620.0*	*77,140.0*	*235,760.0*	*17,420.0*	*27,106.7*	*44,526.7*	*45,080.0*	*54,213.3*	*99,293.3*	*114,933.3*	*111,086.7*	***605,600.0***	*989,526.7*
Max IWR (m^3/dec.)			*40,576.7*	*49,525.0*	***49,525.0***	*38,780.0*	*18,246.7*	*38,780.0*	*3,653.3*	*6,126.7*	*6,126.7*	*11,346.7*	*12,253.3*	*12,253.3*	*10,206.7*	*9,206.7*	***65,393.3***	*92,755.0*

Notes

*1) Net Irrigation Water Requirement (m^3/dec) = Unit Irrigation Water Requirement (mm/dec) / 1,000 (mm/m) * Cropping Acreage (has) * 10,000 (m^2/ha)

Legend of Table

Crop Combination		
Crop	Crop	Total
Crop Acreage (ha) (Crop Acreage (%))		

Table4-1-1-18 Gross Irrigation Water Requirement (per Cropping Pattern)

Case-1 : Wet Area Coefficient = 40%

Gross Irrigation Water Requirement (per Cropping Pattern)

(Unit: m^3/dec)

Month	Decade	Days	Rice Paddy			Upland Cropping												Grand Total
						Maize + Beans			Vegetable 1			Vegetable 2			Vegetable 3	Coffee	Total	
			Rice A	Rice B	Total	Maize	Beans	Sub-total	Carrot	Cabbage	Sub-total	Tomato	Cabbage	Sub-total	Tomato Tree			
			35.0 ha (13 %)			140.0 ha (51 %)			20.0 ha (7 %)			40.0 ha (15 %)			20.0 ha (7 %)	20.0 ha (7 %)	**240.0 ha (87 %)**	275.0 ha (100 %)
Jan.	1st.	10	0.0	151.7	**151.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	151.7
	2nd.	10	11,853.3	0.0	**11,853.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	11,853.3
	3rd.	11	33,775.0	1,108.3	**34,883.3**	0.0	0.0	0.0	0.0	803.1	803.1	0.0	1,606.3	1,606.3	0.0	150.6	**2,560.0**	37,443.3
Feb.	1st.	10	40,576.7	350.0	**40,926.7**	0.0	0.0	0.0	97.3	662.0	759.2	0.0	1,323.9	1,323.9	276.1	1,072.9	**3,432.2**	44,358.8
	2nd.	10	32,270.0	0.0	**32,270.0**	0.0	0.0	0.0	784.3	131.8	916.1	1,041.6	263.5	1,305.1	1,531.0	1,967.1	**5,719.2**	37,989.2
	3rd.	8	5,670.0	0.0	**5,670.0**	0.0	0.0	0.0	342.0	0.0	342.0	0.0	0.0	0.0	884.7	903.5	**2,130.2**	7,800.2
Mar.	1st.	10	7,233.3	0.0	**7,233.3**	0.0	0.0	0.0	680.8	0.0	680.8	207.1	0.0	207.1	1,534.1	1,176.5	**3,598.4**	10,831.8
	2nd.	10	6,615.0	0.0	**6,615.0**	790.6	0.0	790.6	840.8	0.0	840.8	407.8	0.0	407.8	1,678.4	960.0	**4,677.6**	11,292.6
	3rd.	11	6,218.3	0.0	**6,218.3**	2,547.5	0.0	2,547.5	1,010.2	0.0	1,010.2	790.6	0.0	790.6	1,694.1	705.9	**6,748.2**	12,966.6
Apr.	1st.	10	2,041.7	0.0	**2,041.7**	1,361.6	0.0	1,361.6	106.7	0.0	106.7	156.9	0.0	156.9	508.2	0.0	**2,133.3**	4,175.0
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	10	1,120.0	0.0	**1,120.0**	1,998.4	0.0	1,998.4	0.0	0.0	0.0	188.2	0.0	188.2	150.6	0.0	**2,337.3**	3,457.3
May	1st.	10	2,100.0	0.0	**2,100.0**	4,062.7	0.0	4,062.7	87.8	0.0	87.8	803.1	0.0	803.1	414.1	0.0	**5,367.8**	7,467.8
	2nd.	10	2,648.3	0.0	**2,648.3**	5,094.9	0.0	5,094.9	219.6	0.0	219.6	1,098.0	0.0	1,098.0	564.7	0.0	**6,977.3**	9,625.6
	3rd.	11	7,151.7	0.0	**7,151.7**	12,825.1	0.0	12,825.1	1,352.2	0.0	1,352.2	3,400.8	0.0	3,400.8	1,813.3	1,032.2	**20,423.5**	27,575.2
Jun.	1st.	10	11,106.7	0.0	**11,106.7**	18,249.4	0.0	18,249.4	1,719.2	0.0	1,719.2	5,339.6	0.0	5,339.6	3,046.3	2,418.8	**30,773.3**	41,880.0
	2nd.	10	11,515.0	0.0	**11,515.0**	15,745.9	0.0	15,745.9	956.9	0.0	956.9	4,523.9	0.0	4,523.9	3,259.6	2,848.6	**27,334.9**	38,849.9
	3rd.	10	7,501.7	0.0	**7,501.7**	8,674.5	0.0	8,674.5	0.0	0.0	0.0	2,509.8	0.0	2,509.8	2,892.5	2,980.4	**17,057.3**	24,558.9
Jul.	1st.	10	3,593.3	0.0	**3,593.3**	3,294.1	0.0	3,294.1	0.0	0.0	0.0	746.7	0.0	746.7	2,337.3	3,046.3	**9,424.3**	13,017.6
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,001.6	3,193.7	**5,195.3**	5,195.3
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,957.6	3,557.6	**5,515.3**	5,515.3
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,568.6	2,974.1	**4,542.7**	4,542.7
	2nd.	10	0.0	15,131.7	**15,131.7**	0.0	0.0	0.0	0.0	454.9	454.9	0.0	909.8	909.8	1,829.0	2,902.0	**6,095.7**	21,227.4
	3rd.	11	0.0	43,108.3	**43,108.3**	0.0	0.0	0.0	0.0	1,462.0	1,462.0	0.0	2,923.9	2,923.9	3,159.2	3,689.4	**11,234.5**	54,342.8
Sep.	1st.	10	0.0	49,525.0	**49,525.0**	0.0	2,657.3	2,657.3	0.0	2,465.9	2,465.9	0.0	4,931.8	4,931.8	4,015.7	3,927.8	**17,998.4**	67,523.4
	2nd.	10	0.0	39,281.7	**39,281.7**	0.0	7,378.8	7,378.8	0.0	2,883.1	2,883.1	0.0	5,766.3	5,766.3	4,803.1	4,332.5	**25,163.9**	64,445.6
	3rd.	10	0.0	13,755.0	**13,755.0**	0.0	5,951.4	5,951.4	0.0	2,007.8	2,007.8	0.0	4,015.7	4,015.7	4,100.4	3,400.8	**19,476.1**	33,231.1
Oct.	1st.	10	0.0	9,508.3	**9,508.3**	0.0	3,008.6	3,008.6	0.0	963.1	963.1	0.0	1,926.3	1,926.3	2,986.7	2,227.5	**11,112.2**	20,620.5
	2nd.	10	0.0	6,836.7	**6,836.7**	0.0	4,611.8	4,611.8	0.0	382.7	382.7	0.0	765.5	765.5	2,177.3	1,408.6	**9,345.9**	16,182.5
	3rd.	11	0.0	6,813.3	**6,813.3**	0.0	8,586.7	8,586.7	0.0	520.8	520.8	0.0	1,041.6	1,041.6	2,017.3	1,248.6	**13,414.9**	20,228.2
Nov.	1st.	10	0.0	2,788.3	**2,788.3**	0.0	4,106.7	4,106.7	0.0	9.4	9.4	0.0	18.8	18.8	762.4	150.6	**5,047.8**	7,836.2
	2nd.	10	0.0	245.0	**245.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.3	0.0	**6.3**	251.3
	3rd.	10	0.0	280.0	**280.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	280.0
Dec.	1st.	10	0.0	303.3	**303.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	303.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	11	0.0	1,750.0	**1,750.0**	0.0	0.0	0.0	0.0	9.4	9.4	0.0	18.8	18.8	116.1	0.0	**144.3**	1,894.3
Annual IWR (m^3/yr.)			*192,990.0*	*190,936.7*	***383,926.7***	*74,644.7*	*36,301.2*	*110,945.9*	*8,197.6*	*12,756.1*	*20,953.7*	*21,214.1*	*25,512.2*	*46,726.3*	*54,086.3*	*52,276.1*	***284,988.2***	*668,914.9*
Max IWR (m^3/dec.)			*40,576.7*	*49,525.0*	***49,525.0***	*18,249.4*	*8,586.7*	*18,249.4*	*1,719.2*	*2,883.1*	*2,883.1*	*5,339.6*	*5,766.3*	*5,766.3*	*4,803.1*	*4,332.5*	***30,773.3***	*67,523.4*

Notes

*1) Gross Irrigation Water Requirement (m^3/dec) = Net Irrigation Water Requirement (m^3/dec) / Irrigation Efficiency (%) * Wet Area Coefficient (%)

*2) Irrigation Efficiency	: Rice	100 %	
	: Upland Cropping	85 %	(= 95% (Conveyance Efficiency, "Lined Canal" FAO) * 90% (Field Application Efficiency, "Drip Irrigation" FAO)
*3) Wet Area Coefficient	: Rice	100 %	(= "Surface Irrigation", JICA)
	: Upland Cropping	**40 %**	(= "Micro Irrigation", JICA)

Legend of Table

Crop Combination		
Crop	Crop	Total
Crop Acreage (ha)		
(Crop Acreage (%))		

Table 4-1-1-19 Gross Irrigation Water Requirement (per Cropping Pattern)

Case-2 : Wet Area Coefficient = 50%

Gross Irrigation Water Requirement (per Cropping Pattern)

(Unit: m^3/dec)

Month	Decade	Days	Rice Paddy			Upland Cropping												Grand Total
						Maize + Beans			Vegetable 1			Vegetable 2			Vegetable 3	Coffee	Total	
			Rice A	Rice B	Total	Maize	Beans	Sub-total	Carrot	Cabbage	Sub-total	Tomato	Cabbage	Sub-total	Tomato Tree			
			35.0 ha (13 %)			140.0 ha (51 %)			20.0 ha (7 %)			40.0 ha (15 %)			20.0 ha (7 %)	20.0 ha (7 %)	**240.0 ha (87 %)**	275.0 ha (100 %)
Jan.	1st.	10	0.0	151.7	**151.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	151.7
	2nd.	10	11,853.3	0.0	**11,853.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	11,853.3
	3rd.	11	33,775.0	1,108.3	**34,883.3**	0.0	0.0	0.0	0.0	1,003.9	1,003.9	0.0	2,007.8	2,007.8	0.0	188.2	**3,200.0**	38,083.3
Feb.	1st.	10	40,576.7	350.0	**40,926.7**	0.0	0.0	0.0	121.6	827.5	949.0	0.0	1,654.9	1,654.9	345.1	1,341.2	**4,290.2**	45,216.9
	2nd.	10	32,270.0	0.0	**32,270.0**	0.0	0.0	0.0	980.4	164.7	1,145.1	1,302.0	329.4	1,631.4	1,913.7	2,458.8	**7,149.0**	39,419.0
	3rd.	8	5,670.0	0.0	**5,670.0**	0.0	0.0	0.0	427.5	0.0	427.5	0.0	0.0	0.0	1,105.9	1,129.4	**2,662.7**	8,332.7
Mar.	1st.	10	7,233.3	0.0	**7,233.3**	0.0	0.0	0.0	851.0	0.0	851.0	258.8	0.0	258.8	1,917.6	1,470.6	**4,498.0**	11,731.4
	2nd.	10	6,615.0	0.0	**6,615.0**	988.2	0.0	988.2	1,051.0	0.0	1,051.0	509.8	0.0	509.8	2,098.0	1,200.0	**5,847.1**	12,462.1
	3rd.	11	6,218.3	0.0	**6,218.3**	3,184.3	0.0	3,184.3	1,262.7	0.0	1,262.7	988.2	0.0	988.2	2,117.6	882.4	**8,435.3**	14,653.6
Apr.	1st.	10	2,041.7	0.0	**2,041.7**	1,702.0	0.0	1,702.0	133.3	0.0	133.3	196.1	0.0	196.1	635.3	0.0	**2,666.7**	4,708.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	10	1,120.0	0.0	**1,120.0**	2,498.0	0.0	2,498.0	0.0	0.0	0.0	235.3	0.0	235.3	188.2	0.0	**2,921.6**	4,041.6
May	1st.	10	2,100.0	0.0	**2,100.0**	5,078.4	0.0	5,078.4	109.8	0.0	109.8	1,003.9	0.0	1,003.9	517.6	0.0	**6,709.8**	8,809.8
	2nd.	10	2,648.3	0.0	**2,648.3**	6,368.6	0.0	6,368.6	274.5	0.0	274.5	1,372.5	0.0	1,372.5	705.9	0.0	**8,721.6**	11,369.9
	3rd.	11	7,151.7	0.0	**7,151.7**	16,031.4	0.0	16,031.4	1,690.2	0.0	1,690.2	4,251.0	0.0	4,251.0	2,266.7	1,290.2	**25,529.4**	32,681.1
Jun.	1st.	10	11,106.7	0.0	**11,106.7**	22,811.8	0.0	22,811.8	2,149.0	0.0	2,149.0	6,674.5	0.0	6,674.5	3,807.8	3,023.5	**38,466.7**	49,573.3
	2nd.	10	11,515.0	0.0	**11,515.0**	19,682.4	0.0	19,682.4	1,196.1	0.0	1,196.1	5,654.9	0.0	5,654.9	4,074.5	3,560.8	**34,168.6**	45,683.6
	3rd.	10	7,501.7	0.0	**7,501.7**	10,843.1	0.0	10,843.1	0.0	0.0	0.0	3,137.3	0.0	3,137.3	3,615.7	3,725.5	**21,321.6**	28,823.2
Jul.	1st.	10	3,593.3	0.0	**3,593.3**	4,117.6	0.0	4,117.6	0.0	0.0	0.0	933.3	0.0	933.3	2,921.6	3,807.8	**11,780.4**	15,373.7
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,502.0	3,992.2	**6,494.1**	6,494.1
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,447.1	4,447.1	**6,894.1**	6,894.1
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1,960.8	3,717.6	**5,678.4**	5,678.4
	2nd.	10	0.0	15,131.7	**15,131.7**	0.0	0.0	0.0	0.0	568.6	568.6	0.0	1,137.3	1,137.3	2,286.3	3,627.5	**7,619.6**	22,751.3
	3rd.	11	0.0	43,108.3	**43,108.3**	0.0	0.0	0.0	0.0	1,827.5	1,827.5	0.0	3,654.9	3,654.9	3,949.0	4,611.8	**14,043.1**	57,151.5
Sep.	1st.	10	0.0	49,525.0	**49,525.0**	0.0	3,321.6	3,321.6	0.0	3,082.4	3,082.4	0.0	6,164.7	6,164.7	5,019.6	4,909.8	**22,498.0**	72,023.0
	2nd.	10	0.0	39,281.7	**39,281.7**	0.0	9,223.5	9,223.5	0.0	3,603.9	3,603.9	0.0	7,207.8	7,207.8	6,003.9	5,415.7	**31,454.9**	70,736.6
	3rd.	10	0.0	13,755.0	**13,755.0**	0.0	7,439.2	7,439.2	0.0	2,509.8	2,509.8	0.0	5,019.6	5,019.6	5,125.5	4,251.0	**24,345.1**	38,100.1
Oct.	1st.	10	0.0	9,508.3	**9,508.3**	0.0	3,760.8	3,760.8	0.0	1,203.9	1,203.9	0.0	2,407.8	2,407.8	3,733.3	2,784.3	**13,890.2**	23,398.5
	2nd.	10	0.0	6,836.7	**6,836.7**	0.0	5,764.7	5,764.7	0.0	478.4	478.4	0.0	956.9	956.9	2,721.6	1,760.8	**11,682.4**	18,519.0
	3rd.	11	0.0	6,813.3	**6,813.3**	0.0	10,733.3	10,733.3	0.0	651.0	651.0	0.0	1,302.0	1,302.0	2,521.6	1,560.8	**16,768.6**	23,582.0
Nov.	1st.	10	0.0	2,788.3	**2,788.3**	0.0	5,133.3	5,133.3	0.0	11.8	11.8	0.0	23.5	23.5	952.9	188.2	**6,309.8**	9,098.1
	2nd.	10	0.0	245.0	**245.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.8	0.0	**7.8**	252.8
	3rd.	10	0.0	280.0	**280.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	280.0
Dec.	1st.	10	0.0	303.3	**303.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	303.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	11	0.0	1,750.0	**1,750.0**	0.0	0.0	0.0	0.0	11.8	11.8	0.0	23.5	23.5	145.1	0.0	**180.4**	1,930.4
Annual IWR (m^3/yr.)			*192,990.0*	*190,936.7*	***383,926.7***	*93,305.9*	*45,376.5*	*138,682.4*	*10,247.1*	*15,945.1*	*26,192.2*	*26,517.6*	*31,890.2*	*58,407.8*	*67,607.8*	*65,345.1*	***356,235.3***	*740,162.0*
Max IWR (m^3/dec.)			*40,576.7*	*49,525.0*	***49,525.0***	*22,811.8*	*10,733.3*	*22,811.8*	*2,149.0*	*3,603.9*	*3,603.9*	*6,674.5*	*7,207.8*	*7,207.8*	*6,003.9*	*5,415.7*	***38,466.7***	*72,023.0*

Notes

*1) Gross Irrigation Water Requirement (m^3/dec) = Net Irrigation Water Requirement (m^3/dec) / Irrigation Efficiency (%) * Wet Area Coefficient (%)

*2) Irrigation Efficiency : Rice 100 %

: Upland Cropping 85 % (= 95% (Conveyance Efficiency, "Lined Canal" FAO) * 90% (Field Application Efficiency, "Drip Irrigation" FAO)

*3) Wet Area Coefficient : Rice 100 % (= "Surface Irrigation", JICA)

: Upland Cropping **50 %** (= "Micro Irrigation", JICA)

Legend of Table

Crop Combination		
Crop	Crop	Total
Crop Acreage (ha)		
(Crop Acreage (%))		

Table 4-1-1-20 Gross Irrigation Water Requirement (per Cropping Pattern)

Case-3 : Wet Area Coefficient = 60%

Gross Irrigation Water Requirement (per Cropping Pattern)

(Unit: m^3/dec)

Month	Decade	Days	Rice Paddy			Upland Cropping												Grand Total
						Maize + Beans			Vegetable 1			Vegetable 2			Vegetable 3	Coffee	Total	
			Rice A	Rice B	Total	Maize	Beans	Sub-total	Carrot	Cabbage	Sub-total	Tomato	Cabbage	Sub-total	Tomato Tree			
			35.0 ha (13 %)			140.0 ha (51 %)			20.0 ha (7 %)			40.0 ha (15 %)			20.0 ha (7 %)	20.0 ha (7 %)	**240.0 ha (87 %)**	275.0 ha (100 %)
Jan.	1st.	10	0.0	151.7	**151.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	151.7
	2nd.	10	11,853.3	0.0	**11,853.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	11,853.3
	3rd.	11	33,775.0	1,108.3	**34,883.3**	0.0	0.0	0.0	0.0	1,204.7	1,204.7	0.0	2,409.4	2,409.4	0.0	225.9	**3,840.0**	38,723.3
Feb.	1st.	10	40,576.7	350.0	**40,926.7**	0.0	0.0	0.0	145.9	992.9	1,138.8	0.0	1,985.9	1,985.9	414.1	1,609.4	**5,148.2**	46,074.9
	2nd.	10	32,270.0	0.0	**32,270.0**	0.0	0.0	0.0	1,176.5	197.6	1,374.1	1,562.4	395.3	1,957.6	2,296.5	2,950.6	**8,578.8**	40,848.8
	3rd.	8	5,670.0	0.0	**5,670.0**	0.0	0.0	0.0	512.9	0.0	512.9	0.0	0.0	0.0	1,327.1	1,355.3	**3,195.3**	8,865.3
Mar.	1st.	10	7,233.3	0.0	**7,233.3**	0.0	0.0	0.0	1,021.2	0.0	1,021.2	310.6	0.0	310.6	2,301.2	1,764.7	**5,397.6**	12,631.0
	2nd.	10	6,615.0	0.0	**6,615.0**	1,185.9	0.0	1,185.9	1,261.2	0.0	1,261.2	611.8	0.0	611.8	2,517.6	1,440.0	**7,016.5**	13,631.5
	3rd.	11	6,218.3	0.0	**6,218.3**	3,821.2	0.0	3,821.2	1,515.3	0.0	1,515.3	1,185.9	0.0	1,185.9	2,541.2	1,058.8	**10,122.4**	16,340.7
Apr.	1st.	10	2,041.7	0.0	**2,041.7**	2,042.4	0.0	2,042.4	160.0	0.0	160.0	235.3	0.0	235.3	762.4	0.0	**3,200.0**	5,241.7
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	10	1,120.0	0.0	**1,120.0**	2,997.6	0.0	2,997.6	0.0	0.0	0.0	282.4	0.0	282.4	225.9	0.0	**3,505.9**	4,625.9
May	1st.	10	2,100.0	0.0	**2,100.0**	6,094.1	0.0	6,094.1	131.8	0.0	131.8	1,204.7	0.0	1,204.7	621.2	0.0	**8,051.8**	10,151.8
	2nd.	10	2,648.3	0.0	**2,648.3**	7,642.4	0.0	7,642.4	329.4	0.0	329.4	1,647.1	0.0	1,647.1	847.1	0.0	**10,465.9**	13,114.2
	3rd.	11	7,151.7	0.0	**7,151.7**	19,237.6	0.0	19,237.6	2,028.2	0.0	2,028.2	5,101.2	0.0	5,101.2	2,720.0	1,548.2	**30,635.3**	37,787.0
Jun.	1st.	10	11,106.7	0.0	**11,106.7**	27,374.1	0.0	27,374.1	2,578.8	0.0	2,578.8	8,009.4	0.0	8,009.4	4,569.4	3,628.2	**46,160.0**	57,266.7
	2nd.	10	11,515.0	0.0	**11,515.0**	23,618.8	0.0	23,618.8	1,435.3	0.0	1,435.3	6,785.9	0.0	6,785.9	4,889.4	4,272.9	**41,002.4**	52,517.4
	3rd.	10	7,501.7	0.0	**7,501.7**	13,011.8	0.0	13,011.8	0.0	0.0	0.0	3,764.7	0.0	3,764.7	4,338.8	4,470.6	**25,585.9**	33,087.5
Jul.	1st.	10	3,593.3	0.0	**3,593.3**	4,941.2	0.0	4,941.2	0.0	0.0	0.0	1,120.0	0.0	1,120.0	3,505.9	4,569.4	**14,136.5**	17,729.8
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,002.4	4,790.6	**7,792.9**	7,792.9
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,936.5	5,336.5	**8,272.9**	8,272.9
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,352.9	4,461.2	**6,814.1**	6,814.1
	2nd.	10	0.0	15,131.7	**15,131.7**	0.0	0.0	0.0	0.0	682.4	682.4	0.0	1,364.7	1,364.7	2,743.5	4,352.9	**9,143.5**	24,275.2
	3rd.	11	0.0	43,108.3	**43,108.3**	0.0	0.0	0.0	0.0	2,192.9	2,192.9	0.0	4,385.9	4,385.9	4,738.8	5,534.1	**16,851.8**	59,960.1
Sep.	1st.	10	0.0	49,525.0	**49,525.0**	0.0	3,985.9	3,985.9	0.0	3,698.8	3,698.8	0.0	7,397.6	7,397.6	6,023.5	5,891.8	**26,997.6**	76,522.6
	2nd.	10	0.0	39,281.7	**39,281.7**	0.0	11,068.2	11,068.2	0.0	4,324.7	4,324.7	0.0	8,649.4	8,649.4	7,204.7	6,498.8	**37,745.9**	77,027.5
	3rd.	10	0.0	13,755.0	**13,755.0**	0.0	8,927.1	8,927.1	0.0	3,011.8	3,011.8	0.0	6,023.5	6,023.5	6,150.6	5,101.2	**29,214.1**	42,969.1
Oct.	1st.	10	0.0	9,508.3	**9,508.3**	0.0	4,512.9	4,512.9	0.0	1,444.7	1,444.7	0.0	2,889.4	2,889.4	4,480.0	3,341.2	**16,668.2**	26,176.6
	2nd.	10	0.0	6,836.7	**6,836.7**	0.0	6,917.6	6,917.6	0.0	574.1	574.1	0.0	1,148.2	1,148.2	3,265.9	2,112.9	**14,018.8**	20,855.5
	3rd.	11	0.0	6,813.3	**6,813.3**	0.0	12,880.0	12,880.0	0.0	781.2	781.2	0.0	1,562.4	1,562.4	3,025.9	1,872.9	**20,122.4**	26,935.7
Nov.	1st.	10	0.0	2,788.3	**2,788.3**	0.0	6,160.0	6,160.0	0.0	14.1	14.1	0.0	28.2	28.2	1,143.5	225.9	**7,571.8**	10,360.1
	2nd.	10	0.0	245.0	**245.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.4	0.0	**9.4**	254.4
	3rd.	10	0.0	280.0	**280.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	280.0
Dec.	1st.	10	0.0	303.3	**303.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	303.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	11	0.0	1,750.0	**1,750.0**	0.0	0.0	0.0	0.0	14.1	14.1	0.0	28.2	28.2	174.1	0.0	**216.5**	1,966.5
Annual IWR (m^3/yr.)			*192,990.0*	*190,936.7*	***383,926.7***	*111,967.1*	*54,451.8*	*166,418.8*	*12,296.5*	*19,134.1*	*31,430.6*	*31,821.2*	*38,268.2*	*70,089.4*	*81,129.4*	*78,414.1*	***427,482.4***	*811,409.0*
Max IWR (m^3/dec.)			*40,576.7*	*49,525.0*	***49,525.0***	*27,374.1*	*12,880.0*	*27,374.1*	*2,578.8*	*4,324.7*	*4,324.7*	*8,009.4*	*8,649.4*	*8,649.4*	*7,204.7*	*6,498.8*	***46,160.0***	*77,027.5*

Notes

*1) Gross Irrigation Water Requirement (m^3/dec) = Net Irrigation Water Requirement (m^3/dec) / Irrigation Efficiency (%) * Wet Area Coefficient (%)

*2) Irrigation Efficiency	: Rice	100 %	
	: Upland Cropping	85 %	(= 95% (Conveyance Efficiency, "Lined Canal" FAO) * 90% (Field Application Efficiency, "Drip Irrigation" FAO)
*3) Wet Area Coefficient	: Rice	100 %	(= "Surface Irrigation", JICA)
	: Upland Cropping	**60 %**	(= "Micro Irrigation", JICA)

Legend of Table

Crop Combination		
Crop	Crop	Total
Crop Acreage (ha)		
(Crop Acreage (%))		

Table 4-1-1-21 Gross Irrigation Water Requirement (per Cropping Pattern)

Case-4 : (Wet Area Coefficient = 70%

Gross Irrigation Water Requirement (per Cropping Pattern)

(Unit: m^3/dec)

Month	Decade	Days	Rice Paddy			Upland Cropping												Grand Total
						Maize + Beans			Vegetable 1			Vegetable 2			Vegetable 3	Coffee	Total	
			Rice A	Rice B	Total	Maize	Beans	Sub-total	Carrot	Cabbage	Sub-total	Tomato	Cabbage	Sub-total	Tomato Tree			
			35.0 ha (13 %)			140.0 ha (51 %)			20.0 ha (7 %)			40.0 ha (15 %)			20.0 ha (7 %)	20.0 ha (7 %)	**240.0 ha (87 %)**	275.0 ha (100 %)
Jan.	1st.	10	0.0	151.7	**151.7**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	151.7
	2nd.	10	11,853.3	0.0	**11,853.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	11,853.3
	3rd.	11	33,775.0	1,108.3	**34,883.3**	0.0	0.0	0.0	0.0	1,405.5	1,405.5	0.0	2,811.0	2,811.0	0.0	263.5	**4,480.0**	39,363.3
Feb.	1st.	10	40,576.7	350.0	**40,926.7**	0.0	0.0	0.0	170.2	1,158.4	1,328.6	0.0	2,316.9	2,316.9	483.1	1,877.6	**6,006.3**	46,932.9
	2nd.	10	32,270.0	0.0	**32,270.0**	0.0	0.0	0.0	1,372.5	230.6	1,603.1	1,822.7	461.2	2,283.9	2,679.2	3,442.4	**10,008.6**	42,278.6
	3rd.	8	5,670.0	0.0	**5,670.0**	0.0	0.0	0.0	598.4	0.0	598.4	0.0	0.0	0.0	1,548.2	1,581.2	**3,727.8**	9,397.8
Mar.	1st.	10	7,233.3	0.0	**7,233.3**	0.0	0.0	0.0	1,191.4	0.0	1,191.4	362.4	0.0	362.4	2,684.7	2,058.8	**6,297.3**	13,530.6
	2nd.	10	6,615.0	0.0	**6,615.0**	1,383.5	0.0	1,383.5	1,471.4	0.0	1,471.4	713.7	0.0	713.7	2,937.3	1,680.0	**8,185.9**	14,800.9
	3rd.	11	6,218.3	0.0	**6,218.3**	4,458.0	0.0	4,458.0	1,767.8	0.0	1,767.8	1,383.5	0.0	1,383.5	2,964.7	1,235.3	**11,809.4**	18,027.7
Apr.	1st.	10	2,041.7	0.0	**2,041.7**	2,382.7	0.0	2,382.7	186.7	0.0	186.7	274.5	0.0	274.5	889.4	0.0	**3,733.3**	5,775.0
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	10	1,120.0	0.0	**1,120.0**	3,497.3	0.0	3,497.3	0.0	0.0	0.0	329.4	0.0	329.4	263.5	0.0	**4,090.2**	5,210.2
May	1st.	10	2,100.0	0.0	**2,100.0**	7,109.8	0.0	7,109.8	153.7	0.0	153.7	1,405.5	0.0	1,405.5	724.7	0.0	**9,393.7**	11,493.7
	2nd.	10	2,648.3	0.0	**2,648.3**	8,916.1	0.0	8,916.1	384.3	0.0	384.3	1,921.6	0.0	1,921.6	988.2	0.0	**12,210.2**	14,858.5
	3rd.	11	7,151.7	0.0	**7,151.7**	22,443.9	0.0	22,443.9	2,366.3	0.0	2,366.3	5,951.4	0.0	5,951.4	3,173.3	1,806.3	**35,741.2**	42,892.8
Jun.	1st.	10	11,106.7	0.0	**11,106.7**	31,936.5	0.0	31,936.5	3,008.6	0.0	3,008.6	9,344.3	0.0	9,344.3	5,331.0	4,232.9	**53,853.3**	64,960.0
	2nd.	10	11,515.0	0.0	**11,515.0**	27,555.3	0.0	27,555.3	1,674.5	0.0	1,674.5	7,916.9	0.0	7,916.9	5,704.3	4,985.1	**47,836.1**	59,351.1
	3rd.	10	7,501.7	0.0	**7,501.7**	15,180.4	0.0	15,180.4	0.0	0.0	0.0	4,392.2	0.0	4,392.2	5,062.0	5,215.7	**29,850.2**	37,351.9
Jul.	1st.	10	3,593.3	0.0	**3,593.3**	5,764.7	0.0	5,764.7	0.0	0.0	0.0	1,306.7	0.0	1,306.7	4,090.2	5,331.0	**16,492.5**	20,085.9
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,502.7	5,589.0	**9,091.8**	9,091.8
	3rd.	11	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3,425.9	6,225.9	**9,651.8**	9,651.8
Aug.	1st.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2,745.1	5,204.7	**7,949.8**	7,949.8
	2nd.	10	0.0	15,131.7	**15,131.7**	0.0	0.0	0.0	0.0	796.1	796.1	0.0	1,592.2	1,592.2	3,200.8	5,078.4	**10,667.5**	25,799.1
	3rd.	11	0.0	43,108.3	**43,108.3**	0.0	0.0	0.0	0.0	2,558.4	2,558.4	0.0	5,116.9	5,116.9	5,528.6	6,456.5	**19,660.4**	62,768.7
Sep.	1st.	10	0.0	49,525.0	**49,525.0**	0.0	4,650.2	4,650.2	0.0	4,315.3	4,315.3	0.0	8,630.6	8,630.6	7,027.5	6,873.7	**31,497.3**	81,022.3
	2nd.	10	0.0	39,281.7	**39,281.7**	0.0	12,912.9	12,912.9	0.0	5,045.5	5,045.5	0.0	10,091.0	10,091.0	8,405.5	7,582.0	**44,036.9**	83,318.5
	3rd.	10	0.0	13,755.0	**13,755.0**	0.0	10,414.9	10,414.9	0.0	3,513.7	3,513.7	0.0	7,027.5	7,027.5	7,175.7	5,951.4	**34,083.1**	47,838.1
Oct.	1st.	10	0.0	9,508.3	**9,508.3**	0.0	5,265.1	5,265.1	0.0	1,685.5	1,685.5	0.0	3,371.0	3,371.0	5,226.7	3,898.0	**19,446.3**	28,954.6
	2nd.	10	0.0	6,836.7	**6,836.7**	0.0	8,070.6	8,070.6	0.0	669.8	669.8	0.0	1,339.6	1,339.6	3,810.2	2,465.1	**16,355.3**	23,192.0
	3rd.	11	0.0	6,813.3	**6,813.3**	0.0	15,026.7	15,026.7	0.0	911.4	911.4	0.0	1,822.7	1,822.7	3,530.2	2,185.1	**23,476.1**	30,289.4
Nov.	1st.	10	0.0	2,788.3	**2,788.3**	0.0	7,186.7	7,186.7	0.0	16.5	16.5	0.0	32.9	32.9	1,334.1	263.5	**8,833.7**	11,622.1
	2nd.	10	0.0	245.0	**245.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0	0.0	**11.0**	256.0
	3rd.	10	0.0	280.0	**280.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	280.0
Dec.	1st.	10	0.0	303.3	**303.3**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	303.3
	2nd.	10	0.0	0.0	**0.0**	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**	0.0
	3rd.	11	0.0	1,750.0	**1,750.0**	0.0	0.0	0.0	0.0	16.5	16.5	0.0	32.9	32.9	203.1	0.0	**252.5**	2,002.5
Annual IWR (m^3/yr.)			*192,990.0*	*190,936.7*	***383,926.7***	*130,628.2*	*63,527.1*	*194,155.3*	*14,345.9*	*22,323.1*	*36,669.0*	*37,124.7*	*44,646.3*	*81,771.0*	*94,651.0*	*91,483.1*	***498,729.4***	*882,656.1*
Max IWR (m^3/dec.)			*40,576.7*	*49,525.0*	***49,525.0***	*31,936.5*	*15,026.7*	*31,936.5*	*3,008.6*	*5,045.5*	*5,045.5*	*9,344.3*	*10,091.0*	*10,091.0*	*8,405.5*	*7,582.0*	***53,853.3***	*83,318.5*

Notes

*1) Gross Irrigation Water Requirement (m^3/dec) = Net Irrigation Water Requirement (m^3/dec) / Irrigation Efficiency (%) * Wet Area Coefficient (%)

*2) Irrigation Efficiency	: Rice	100 %	
	: Upland Cropping	85 %	(= 95% (Conveyance Efficiency, "Lined Canal" FAO) * 90% (Field Application Efficiency, "Drip Irrigation" FAO)
*3) Wet Area Coefficient	: Rice	100 %	(= "Surface Irrigation", JICA)
	: Upland Cropping	**70 %**	(= "Micro Irrigation", JICA)

Legend of Table

Crop Combination		
Crop	Crop	Total
Crop Acreage (ha)		
(Crop Acreage (%))		

(b) Simulation of Water Balance / Study on Active Storage Capacity of Reservoir

Active storage capacity or water utilization capacity of reservoir is calculated by water-balance simulation based on inflow to reservoir and outflow from reservoir every ten (10) days as follows:

ｉ) Conditions of Simulation

1) Inflow to Reservoir

Inflow to reservoir in this simulation is river discharge in base year of 1970 estimated by the tank model method in *“4-1-1. Planning of Water Supply”*, and summarized as shown in (Table 4-1-1-22).”

2) Out flow from Reservoir

Outflow from reservoir consists of irrigation water requirement for rice paddy and upland cropping, and seepage loss as follows:

Irrigation Water Requirement for Rice Paddy

Supply water for rice paddy estimated in “*4-1-1. Planning of Water Supply*” applied as irrigation water requirement for rice paddy, and summarized as shown in(Table 4-1-1-22)

Table 4-1-1-22 Inflow and Supply Water for Rice Paddy

Month	Decade	days	Inflow (m^3)			Supply Water for Rice Paddy (m^3)		
			Decade	Monthly	Cumulative	Decade	Monthly	Cumulative
Jan.	1st.	10	21,595			469		
	2nd.	10	43,927	109,665	109,665	469	1,453	1,453
	3rd.	11	44,143			516		
Feb.	1st.	10	37,257			6,228		
	2nd.	10	40,417	106,232	215,898	6,228	17,438	18,891
	3rd.	8	28,559			4,982		
Mar.	1st.	10	31,307			854		
	2nd.	10	29,033	97,478	313,376	854	2,647	21,538
	3rd.	11	37,139			939		
Apr.	1st.	10	33,398			658		
	2nd.	10	33,160	102,702	416,077	658	1,974	23,512
	3rd.	10	36,144			658		
May	1st.	10	48,003			468		
	2nd.	10	45,660	133,739	549,817	468	1,452	24,964
	3rd.	11	40,077			515		
Jun.	1st.	10	33,656			1,232		
	2nd.	10	30,742	91,537	641,353	1,232	3,695	28,659
	3rd.	10	27,139			1,232		
Jul.	1st.	10	23,852			895		
	2nd.	10	20,719	63,977	705,330	895	2,774	31,433
	3rd.	11	19,405			984		
Aug.	1st.	10	13,923			12,943		
	2nd.	10	10,887	38,502	743,832	12,943	40,122	71,555
	3rd.	11	13,692			14,237		
Sep.	1st.	10	9,935			30,117		
	2nd.	10	9,271	27,513	771,345	30,117	90,350	161,905
	3rd.	10	8,307			30,117		
Oct.	1st.	10	7,701			965		
	2nd.	10	11,698	28,879	800,224	965	2,990	164,895
	3rd.	11	9,480			1,061		
Nov.	1st.	10	11,612			665		
	2nd.	10	10,690	33,237	833,461	665	1,995	166,890
	3rd.	10	10,935			665		
Dec.	1st.	10	15,099			455		
	2nd.	10	17,035	60,306	893,767	455	1,409	168,299
	3rd.	11	28,172			500		
Total			**893,767**	893,767	-	**168,299**	168,299	-

Irrigation Water Requirement for Upland Cropping

Gross irrigation water requirement (GIWR) shown in “(Table 4-1-1-18~4-1-1-21) *Gross Irrigation Water Requirement*” is applied as irrigation water requirement for upland cropping. Annual GIWR for each case (Kw = 40, 50, 60 and 70 %) is summarized as shown in (Table 4-1-1-23).

Table 41-1-23 Annual Irrigation Water Requirement for Upland Cropping

Wetting Area Coefficient Kw (%)	Gross Irrigation Water Requirement GIWR (m^3/year)
40	284,988
50	356,235
60	427,482
70	498,729

Seepage loss from Reservoir

0.05 % of storage volume of reservoir is applied as seepage loss from reservoir.

3) Balance between Rainfall and Evaporation on Reservoir

Rainfall to reservoir and evaporation from reservoir is considered for simulation of water balance, as well as inflow and out flow which mentioned in the above. Water surface area, which is used for calculation for evaporation from reservoir is estimated as 14.96 ha based on H-Q curve at full water surface FWS. 1,390.60 m.

Rainfall to Reservoir (Rd)

Rainfall data observed at Gahororo station in 1970 are applied as rainfall to reservoir.

Evaporation from Reservoir (Eo)

Evaporation from reservoir (Eo) is estimated based on reference Evapotranspiration (ETo) which is calculated by CROWPWAT8.0 and mentioned in (Table 4-1-1-12) and crop coefficient (kc) as follows:

Table 41-1-24 Balance between Rainfall and Evaporation on Reservoir

Crop Coefficient: kc = 1.1 Water Surface Area: A = 14.96 ha (@ FWS.1,390.60m)

Month	Decade	days	Provable Rainfall Rm (mm/month)	Provable Rainfall Rd (mm/decade)	Reference Evapotranspiration ETo (mm/day)	Evaporation Eo = ETo * kc (mm/decade)	Evaporation from Water Surface E = Eo - Rd (mm/decade)	Evaporation from Water Surface **Ev = E * A (m^3/decade)**	Remarks
Jan.	1st.	10	188.2	60.7	4.01	44.1	-16.6	**-2,485**	
	2nd.	10		60.7		44.1	-16.6	**-2,485**	
	3rd.	11		66.8		48.5	-18.3	**-2,735**	
Feb.	1st.	10	70.7	25.3	4.20	46.2	21.0	**3,134**	
	2nd.	10		25.3		46.2	21.0	**3,134**	
	3rd.	8		20.2		37.0	16.8	**2,513**	
Mar.	1st.	10	91.8	29.6	3.93	43.2	13.6	**2,033**	
	2nd.	10		29.6		43.2	13.6	**2,033**	
	3rd.	11		32.6		47.6	15.0	**2,248**	
Apr.	1st.	10	152.6	50.9	3.38	37.2	-13.7	**-2,045**	
	2nd.	10		50.9		37.2	-13.7	**-2,045**	
	3rd.	10		50.9		37.2	-13.7	**-2,045**	
May	1st.	10	104.9	33.8	3.21	35.3	1.5	**219**	
	2nd.	10		33.8		35.3	1.5	**219**	
	3rd.	11		37.2		38.8	1.6	**236**	
Jun.	1st.	10	4.5	1.5	3.09	34.0	32.5	**4,862**	
	2nd.	10		1.5		34.0	32.5	**4,862**	
	3rd.	10		1.5		34.0	32.5	**4,862**	
Jul.	1st.	10	5.7	1.8	3.39	37.3	35.5	**5,305**	
	2nd.	10		1.8		37.3	35.5	**5,305**	
	3rd.	11		2.0		41.0	39.0	**5,831**	
Aug.	1st.	10	53.5	17.3	4.79	52.7	35.4	**5,302**	
	2nd.	10		17.3		52.7	35.4	**5,302**	
	3rd.	11		19.0		58.0	39.0	**5,837**	
Sep.	1st.	10	20.7	6.9	4.62	50.8	43.9	**6,567**	
	2nd.	10		6.9		50.8	43.9	**6,567**	
	3rd.	10		6.9		50.8	43.9	**6,567**	
Oct.	1st.	10	118.4	38.2	4.68	51.5	13.3	**1,991**	
	2nd.	10		38.2		51.5	13.3	**1,991**	
	3rd.	11		42.0		56.6	14.6	**2,182**	
Nov.	1st.	10	161.7	53.9	3.51	38.6	-15.3	**-2,289**	
	2nd.	10		53.9		38.6	-15.3	**-2,289**	
	3rd.	10		53.9		38.6	-15.3	**-2,289**	
Dec.	1st.	10	161.6	52.1	3.26	35.9	-16.2	**-2,428**	
	2nd.	10		52.1		35.9	-16.2	**-2,428**	
	3rd.	11		57.3		39.4	-17.9	**-2,684**	
Total / Average			1,134.3	1,134.3	3.84	1,541.1	407	**60,855**	

Notes

*1) Provable Rainfall : 1970, Gahororo Station, Rurenge Sector, Ngoma District

*2) Reference Evapotranspiration : Calculated from Climate Data (Temperature, Humidity, Wind Velocity, Sunshine Hours) by CROPWAT8

*3) Climate Data / Min. Temp. : 1970, Gahororo Station, Rurenge Sector, Ngoma District

Max. Temp. : 1970 & 1974, Gahororo Station, Rurenge Sector, Ngoma District

Humidity : 1974, Kigali International Airport

Wind Velocity : 1974, Kigali International Airport

Sunshine : 1974, Kigali International Airport

*4) Crop Coefficient : kc from water surface of 1.1 is applied based on FAO Irrigation and drainage paper No. 24.

*5) Water Surface Area : 14.96 ha at Full Water Surface (FWS.) EL. 1,390.60 m is applied.

ⅱ) Results of Simulation

The results of simulation are mentioned in (Table 4-1-1-26~4-1-1-29) and required active storage capacity of reservoir is summarized in (Table 4-1-1-25).

Table 4-1-1-25 Design Active Storage Capacity of Reservoir

Wetting Area Coefficient Kw (%)	Storage Volume of Reservoir (m^3)		
	Cumulative Storage Volume		Balance / Required Active Storage Capacity (3) = (1) - (2)
	Maximum (1)	Minimum (2)	
40	450,000	250,693	199,307
50	440,015	209,926	230,089
60	423,489	139,979	283,510
70	406,963	70,031	**336,931**

As the results of simulation mentioned the above, design active storage capacity of reservoir 450,000 m^3 is sufficient to the required active storage capacity in case of Kw = 70%, most severe conditions of wetting area coefficient.

Active Storage Capacity of Reservoir

Design Capacity 450,000 m^3 > Required Capacity 336,931 m^3

In this case, design discharge or intake volume for rice paddy and upland cropping is calculated as follows:

(See "(Table 4-1-1-30) *Design Discharge / Intake Volume*" for the details

Design Discharge / Intake Volume

Rice Paddy : $Q = 0.0349 m^3/sec$

Upland cropping : $Q = 0.1760 m^3/sec$

Table 4-1-1-26 Simulation of Water Balance / Study on Active Storage Capacity of Reservoir

Case-1: Wetting Area Coefficient Kw = 40 %

Cropping Acreage

Crop		Area	
Rice Paddy		35 ha	13 %
Upland Cropping	Maize+Beans	140 ha	51 %
	Vegitable-1	20 ha	7 %
	Vegetable-2	40 ha	15 %
	Vegetable-3	20 ha	7 %
	Coffee	20 ha	7 %
	Sub-total	240 ha	87 %
Total		275 ha	100 %

Efficiencies

Description		Coefficient	Remarks
Irrigation Efficiency	Rice Paddy	100 %	
	Upland Cropping	85 %	= 95% (Conveyance: Lined Canal) * 90% (Field Application: Drip)
Wetting Area	Rice Paddy	100 %	"Suface Irrigation"
	Upland Cropping	**40 %**	"Micro Irrigation"

Reservoir

Description	EL & Volume	Remarks
Full Water Surface	EL. 1,390.60 m	FWS (Water Surface Area: 14.96 ha)
Dead Water Surface	EL. 1,386.50 m	DWS (Water Surface Area: 8.15 ha)
Bottom of Reservoir	EL. 1,380.00 m	ELbttm
Active Storage Capacity	450,000 m3	between FWS and DWS (H=4.10m)
Dead Water Volume	250,000 m3	between DWS and ELbttm (H=6.50m)

Results of Water Balance Study

Month	Decade	days	Inflow (m^3) ①	Outflow (m^3): Rice Supply Water ②	Outflow (m^3): Upland Crop Irrigation Water Requirement ③	Outflow (m^3): Seepage Loss ④	Outflow (m^3): Evaporation from W. Surface ⑤	Outflow (m^3): Total ⑥=Σ②-⑤	Balance between In & Outflow (m^3) ⑦=①-⑥	**Cumulative Storage Volume of Reservoir (m^3) ⑧**	Remarks
										0	
Jan.	1st.	10	21,595	469	0	11	-2,485	-2,005	23,600	23,600	
	2nd.	10	43,927	469	0	22	-2,485	-1,994	45,921	69,522	
	3rd.	11	44,143	516	2,560	22	-2,735	363	43,781	113,302	
Feb.	1st.	10	37,257	6,228	3,432	19	3,134	12,813	24,444	137,746	
	2nd.	10	40,417	6,228	5,719	20	3,134	15,101	25,316	163,062	
	3rd.	8	28,559	4,982	2,130	14	2,513	9,639	18,919	181,981	
Mar.	1st.	10	31,307	854	3,598	16	2,033	6,501	24,805	206,786	
	2nd.	10	29,033	854	4,678	15	2,033	7,580	21,453	228,240	
	3rd.	11	37,139	939	6,748	19	2,248	9,954	27,184	255,424	
Apr.	1st.	10	33,398	658	2,133	17	-2,045	763	32,634	288,058	
	2nd.	10	33,160	658	0	17	-2,045	-1,370	34,530	322,588	
	3rd.	10	36,144	658	2,337	18	-2,045	968	35,176	357,764	
May	1st.	10	48,003	468	5,368	24	219	6,079	41,923	399,687	
	2nd.	10	45,660	468	6,977	23	219	7,688	37,972	437,660	
	3rd.	11	40,077	515	20,424	20	236	21,195	18,882	**450,000**	**Max.**
Jun.	1st.	10	33,656	1,232	30,773	17	4,862	36,884	-3,229	446,772	
	2nd.	10	30,742	1,232	27,335	15	4,862	33,444	-2,701	444,070	
	3rd.	10	27,139	1,232	17,057	14	4,862	23,165	3,974	448,044	
Jul.	1st.	10	23,852	895	9,424	12	5,305	15,636	8,216	450,000	
	2nd.	10	20,719	895	5,195	10	5,305	11,405	9,314	450,000	
	3rd.	11	19,405	984	5,515	10	5,831	12,341	7,064	450,000	
Aug.	1st.	10	13,923	12,943	4,543	7	5,302	22,794	-8,871	441,129	
	2nd.	10	10,887	12,943	6,096	5	5,302	24,345	-13,458	427,671	
	3rd.	11	13,692	14,237	11,235	7	5,837	31,315	-17,623	410,047	
Sep.	1st.	10	9,935	30,117	17,998	5	6,567	54,687	-44,752	365,295	
	2nd.	10	9,271	30,117	25,164	5	6,567	61,853	-52,582	312,713	
	3rd.	10	8,307	30,117	19,476	4	6,567	56,164	-47,857	264,857	
Oct.	1st.	10	7,701	965	11,112	4	1,991	14,072	-6,371	258,486	
	2nd.	10	11,698	965	9,346	6	1,991	12,307	-610	257,876	
	3rd.	11	9,480	1,061	13,415	5	2,182	16,663	-7,183	**250,693**	**Min.**
Nov.	1st.	10	11,612	665	5,048	6	-2,289	3,430	8,182	258,875	
	2nd.	10	10,690	665	6	5	-2,289	-1,613	12,303	271,179	
	3rd.	10	10,935	665	0	5	-2,289	-1,619	12,554	283,732	
Dec.	1st.	10	15,099	455	0	8	-2,428	-1,965	17,065	300,797	
	2nd.	10	17,035	455	0	9	-2,428	-1,964	19,000	319,797	
	3rd.	11	28,172	500	144	14	-2,684	-2,026	30,197	349,995	
Total			**893,767**	168,299	284,988	450	60,855	**514,592**	379,175	-	-
									Max. - Min. =	**199,307**	

Notes

*1) Seepage loss from dam body of 0.05 % of storage volume is assumed.

*2) Evaporation from water surface is estimated based on balance of rainfall and evaporation with kc of 1.1 from FAO Irrigation and Drainage Paper No.24.
(See Table "Evaporation from Water Surface of Reservoir, Ngoma 22" for reference.)

*3) Water Supply for Rice Paddy — 168,299 m3/yr.

*4) Cumu. Storage Volume : Start at DWS.1,386.50m — 0 m3 (Effective Dam Storage Volume)

Table 4-1-1-27 Simulation of Water Balance / Study on Active Storage Capacity of Reservoir
Case-2: Wetting Area Coefficient Kw = 50 %

Cropping Acreage

Crop		Area	
Rice Paddy		35 ha	13 %
Upland Cropping	Maize+Beans	140 ha	51 %
	Vegitable-1	20 ha	7 %
	Vegetable-2	40 ha	15 %
	Vegetable-3	20 ha	7 %
	Coffee	20 ha	7 %
	Sub-total	240 ha	87 %
Total		275 ha	100 %

Efficiencies

Description		Coefficient	Remarks
Irrigation Efficiency	Rice Paddy	100 %	
	Upland Cropping	85 %	= 95% (Conveyance: Lined Canal) * 90% (Field Application: Drip)
Wetting Area	Rice Paddy	100 %	"Suface Irrigation"
	Upland Cropping	**50 %**	"Micro Irrigation"

Reservoir

Description	EL & Volume	Remarks
Full Water Surface	EL. 1,390.60 m	FWS (Water Surface Area: 14.96 ha)
Dead Water Surface	EL. 1,386.50 m	DWS (Water Surface Area: 8.15 ha)
Bottom of Reservoir	EL. 1,380.00 m	ELbttm
Active Storage Capacity	450,000 m3	between FWS and DWS (H=4.10m)
Dead Water Volume	250,000 m3	between DWS and ELbttm (H=6.50m)

Results of Water Balance Study

Month	Decade	days	Inflow (m^3) ①	Outflow (m^3): Rice Supply Water ②	Outflow: Upland Crop Irrigation Water Requirement ③	Outflow: Seepage Loss ④	Outflow: Evaporation from W. Surface ⑤	Outflow: Total ⑥=Σ②-⑤	Balance between In & Outflow (m^3) ⑦=①-⑥	Cumulative Storage Volume of Reservoir (m^3) ⑧	Remarks
										0	
Jan.	1st.	10	21,595	469	0	11	-2,485	-2,005	23,600	23,600	
	2nd.	10	43,927	469	0	22	-2,485	-1,994	45,921	69,522	
	3rd.	11	44,143	516	3,200	22	-2,735	1,003	43,141	112,662	
Feb.	1st.	10	37,257	6,228	4,290	19	3,134	13,671	23,586	136,248	
	2nd.	10	40,417	6,228	7,149	20	3,134	16,531	23,886	160,134	
	3rd.	8	28,559	4,982	2,663	14	2,513	10,172	18,386	178,521	
Mar.	1st.	10	31,307	854	4,498	16	2,033	7,401	23,906	202,426	
	2nd.	10	29,033	854	5,847	15	2,033	8,749	20,284	222,710	
	3rd.	11	37,139	939	8,435	19	2,248	11,642	25,497	248,207	
Apr.	1st.	10	33,398	658	2,667	17	-2,045	1,297	32,101	280,309	
	2nd.	10	33,160	658	0	17	-2,045	-1,370	34,530	314,838	
	3rd.	10	36,144	658	2,922	18	-2,045	1,553	34,592	349,430	
May	1st.	10	48,003	468	6,710	24	219	7,421	40,581	390,011	
	2nd.	10	45,660	468	8,722	23	219	9,432	36,228	426,239	
	3rd.	11	40,077	515	25,529	20	236	26,301	13,776	**440,015**	**Max.**
Jun.	1st.	10	33,656	1,232	38,467	17	4,862	44,577	-10,922	429,093	
	2nd.	10	30,742	1,232	34,169	15	4,862	40,277	-9,535	419,558	
	3rd.	10	27,139	1,232	21,322	14	4,862	27,429	-290	419,268	
Jul.	1st.	10	23,852	895	11,780	12	5,305	17,992	5,860	425,128	
	2nd.	10	20,719	895	6,494	10	5,305	12,704	8,015	433,144	
	3rd.	11	19,405	984	6,894	10	5,831	13,719	5,685	438,829	
Aug.	1st.	10	13,923	12,943	5,678	7	5,302	23,930	-10,007	428,822	
	2nd.	10	10,887	12,943	7,620	5	5,302	25,869	-14,982	413,840	
	3rd.	11	13,692	14,237	14,043	7	5,837	34,124	-20,432	393,408	
Sep.	1st.	10	9,935	30,117	22,498	5	6,567	59,187	-49,252	344,157	
	2nd.	10	9,271	30,117	31,455	5	6,567	68,144	-58,873	285,284	
	3rd.	10	8,307	30,117	24,345	4	6,567	61,033	-52,726	232,558	
Oct.	1st.	10	7,701	965	13,890	4	1,991	16,850	-9,149	223,409	
	2nd.	10	11,698	965	11,682	6	1,991	14,644	-2,946	220,463	
	3rd.	11	9,480	1,061	16,769	5	2,182	20,017	-10,537	**209,926**	**Min.**
Nov.	1st.	10	11,612	665	6,310	6	-2,289	4,692	6,920	216,847	
	2nd.	10	10,690	665	8	5	-2,289	-1,611	12,302	229,148	
	3rd.	10	10,935	665	0	5	-2,289	-1,619	12,554	241,702	
Dec.	1st.	10	15,099	455	0	8	-2,428	-1,965	17,065	258,767	
	2nd.	10	17,035	455	0	9	-2,428	-1,964	19,000	277,767	
	3rd.	11	28,172	500	180	14	-2,684	-1,990	30,161	307,928	
Total			**893,767**	168,299	356,235	450	60,855	**585,839**	307,928	-	-
									Max. - Min. =	**230,089**	

Notes

*1) Seepage loss from dam body of 0.05 % of storage volume is assumed.

*2) Evaporation from water surface is estimated based on balance of rainfall and evaporation with kc of 1.1 from FAO Irrigation and Drainage Paper No.24.
(See Table "Evaporation from Water Surface of Reservoir, Ngoma 22" for reference.)

*3) Water Supply for Rice Paddy 168,299 m3/yr.

*4) Cumu. Storage Volume : Start at DWS.1,386.50m 0 m3 (Effective Dam Storage Volume)

Table 4-1-1-28 Simulation of Water Balance / Study on Active Storage Capacity of Reservoir

Case-3: Wetting Area Coefficient Kw = 60 %

Cropping Acreage

Crop		Area	
Rice Paddy		35 ha	13 %
Upland Cropping	Maize+Beans	140 ha	51 %
	Vegitable-1	20 ha	7 %
	Vegetable-2	40 ha	15 %
	Vegetable-3	20 ha	7 %
	Coffee	20 ha	7 %
	Sub-total	240 ha	87 %
Total		275 ha	100 %

Efficiencies

Description		Coefficient	Remarks
Irrigation Efficiency	Rice Paddy	100 %	
	Upland Cropping	85 %	= 95% (Conveyance: Lined Canal) * 90% (Field Application: Drip)
Wetting Area	Rice Paddy	100 %	"Suface Irrigation"
	Upland Cropping	**60 %**	"Micro Irrigation"

Reservoir

Description	EL & Volume	Remarks
Full Water Surface	EL. 1,390.60 m	FWS (Water Surface Area: 14.96 ha)
Dead Water Surface	EL. 1,386.50 m	DWS (Water Surface Area: 8.15 ha)
Bottom of Reservoir	EL. 1,380.00 m	ELbttm
Active Storage Capacity	450,000 m3	between FWS and DWS (H=4.10m)
Dead Water Volume	250,000 m3	between DWS and ELbttm (H=6.50m)

Results of Water Balance Study

Month	Decade	days	Inflow (m^3) ①	Outflow (m^3) Rice Supply Water ②	Upland Crop Irrigation Water Requirement ③	Seepage Loss ④	Evaporation from W. Surface ⑤	Total ⑥=Σ②-⑤	Balance between In & Outflow (m^3) ⑦=①-⑥	Cumulative Storage Volume of Reservoir (m^3) ⑧	Remarks
										0	
Jan.	1st.	10	21,595	469	0	11	-2,485	-2,005	23,600	23,600	
	2nd.	10	43,927	469	0	22	-2,485	-1,994	45,921	69,522	
	3rd.	11	44,143	516	3,840	22	-2,735	1,643	42,501	112,022	
Feb.	1st.	10	37,257	6,228	5,148	19	3,134	14,529	22,728	134,750	
	2nd.	10	40,417	6,228	8,579	20	3,134	17,961	22,456	157,206	
	3rd.	8	28,559	4,982	3,195	14	2,513	10,705	17,854	175,060	
Mar.	1st.	10	31,307	854	5,398	16	2,033	8,301	23,006	198,066	
	2nd.	10	29,033	854	7,016	15	2,033	9,918	19,114	217,181	
	3rd.	11	37,139	939	10,122	19	2,248	13,329	23,810	240,991	
Apr.	1st.	10	33,398	658	3,200	17	-2,045	1,830	31,568	272,559	
	2nd.	10	33,160	658	0	17	-2,045	-1,370	34,530	307,088	
	3rd.	10	36,144	658	3,506	18	-2,045	2,137	34,007	341,096	
May	1st.	10	48,003	468	8,052	24	219	8,763	39,239	380,335	
	2nd.	10	45,660	468	10,466	23	219	11,176	34,484	414,819	
	3rd.	11	40,077	515	30,635	20	236	31,407	8,670	**423,489**	**Max.**
Jun.	1st.	10	33,656	1,232	46,160	17	4,862	52,271	-18,615	404,874	
	2nd.	10	30,742	1,232	41,002	15	4,862	47,111	-16,369	388,505	
	3rd.	10	27,139	1,232	25,586	14	4,862	31,694	-4,554	383,951	
Jul.	1st.	10	23,852	895	14,136	12	5,305	20,348	3,504	387,455	
	2nd.	10	20,719	895	7,793	10	5,305	14,003	6,717	394,171	
	3rd.	11	19,405	984	8,273	10	5,831	15,098	4,307	398,478	
Aug.	1st.	10	13,923	12,943	6,814	7	5,302	25,066	-11,143	387,335	
	2nd.	10	10,887	12,943	9,144	5	5,302	27,393	-16,506	370,829	
	3rd.	11	13,692	14,237	16,852	7	5,837	36,933	-23,241	347,589	
Sep.	1st.	10	9,935	30,117	26,998	5	6,567	63,686	-53,751	293,837	
	2nd.	10	9,271	30,117	37,746	5	6,567	74,435	-65,164	228,673	
	3rd.	10	8,307	30,117	29,214	4	6,567	65,902	-57,595	171,079	
Oct.	1st.	10	7,701	965	16,668	4	1,991	19,628	-11,927	159,152	
	2nd.	10	11,698	965	14,019	6	1,991	16,980	-5,283	153,869	
	3rd.	11	9,480	1,061	20,122	5	2,182	23,370	-13,890	**139,979**	**Min.**
Nov.	1st.	10	11,612	665	7,572	6	-2,289	5,954	5,658	145,637	
	2nd.	10	10,690	665	9	5	-2,289	-1,610	12,300	157,937	
	3rd.	10	10,935	665	0	5	-2,289	-1,619	12,554	170,491	
Dec.	1st.	10	15,099	455	0	8	-2,428	-1,965	17,065	187,556	
	2nd.	10	17,035	455	0	9	-2,428	-1,964	19,000	206,556	
	3rd.	11	28,172	500	216	14	-2,684	-1,954	30,125	236,681	
Total			**893,767**	168,299	427,482	450	60,855	**657,086**	236,681	-	-
									Max. - Min. =	**283,510**	

Notes

*1) Seepage loss from dam body of 0.05 % of storage volume is assumed.

*2) Evaporation from water surface is estimated based on balance of rainfall and evaporation with kc of 1.1 from FAO Irrigation and Drainage Paper No.24.
(See Table "Evaporation from Water Surface of Reservoir, Ngoma 22" for reference.)

*3) Water Supply for Rice Paddy — 168,299 m3/yr.

*4) Cumu. Storage Volume : Start at DWS.1,386.50m — 0 m3 (Effective Dam Storage Volume)

Table 4-1-1-29 Simulation of Water Balance / Study on Active Storage Capacity of Reservoir
Case-4: Wetting Area Coefficient Kw = 70 %

Cropping Acreage

Crop		Area	
Rice Paddy		35 ha	13 %
Upland Cropping	Maize+Beans	140 ha	51 %
	Vegitable-1	20 ha	7 %
	Vegetable-2	40 ha	15 %
	Vegetable-3	20 ha	7 %
	Coffee	20 ha	7 %
	Sub-total	240 ha	87 %
Total		275 ha	100 %

Efficiencies

Description		Coefficient	Remarks
Irrigation Efficiency	Rice Paddy	100 %	
	Upland Cropping	85 %	= 95% (Conveyance: Lined Canal) * 90% (Field Application: Drip)
Wetting Area	Rice Paddy	100 %	"Surface Irrigation"
	Upland Cropping	**70 %**	"Micro Irrigation"

Reservoir

Description	EL & Volume	Remarks
Full Water Surface	EL. 1,390.60 m	FWS (Water Surface Area: 14.96 ha)
Dead Water Surface	EL. 1,386.50 m	DWS (Water Surface Area: 8.15 ha)
Bottom of Reservoir	EL. 1,380.00 m	ELbttm
Active Storage Capacity	450,000 m3	between FWS and DWS (H=4.10m)
Dead Water Volume	250,000 m3	between DWS and ELbttm (H=6.50m)

Results of Water Balance Study

Month	Decade	days	Inflow (m^3) ①	Outflow (m^3): Rice Supply Water ②	Outflow: Upland Crop Irrigation Water Requirement ③	Outflow: Seepage Loss ④	Outflow: Evaporation from W. Surface ⑤	Outflow: Total ⑥=Σ②-⑤	Balance between In & Outflow (m^3) ⑦=①-⑥	**Cumulative Storage Volume of Reservoir (m^3)** ⑧	Remarks
										0	
Jan.	1st.	10	21,595	469	0	11	-2,485	-2,005	23,600	23,600	
	2nd.	10	43,927	469	0	22	-2,485	-1,994	45,921	69,522	
	3rd.	11	44,143	516	4,480	22	-2,735	2,283	41,861	111,382	
Feb.	1st.	10	37,257	6,228	6,006	19	3,134	15,387	21,870	133,252	
	2nd.	10	40,417	6,228	10,009	20	3,134	19,390	21,026	154,278	
	3rd.	8	28,559	4,982	3,728	14	2,513	11,237	17,321	171,600	
Mar.	1st.	10	31,307	854	6,297	16	2,033	9,200	22,107	193,706	
	2nd.	10	29,033	854	8,186	15	2,033	11,088	17,945	211,651	
	3rd.	11	37,139	939	11,809	19	2,248	15,016	22,123	233,775	
Apr.	1st.	10	33,398	658	3,733	17	-2,045	2,363	31,034	264,809	
	2nd.	10	33,160	658	0	17	-2,045	-1,370	34,530	299,338	
	3rd.	10	36,144	658	4,090	18	-2,045	2,721	33,423	332,762	
May	1st.	10	48,003	468	9,394	24	219	10,105	37,897	370,659	
	2nd.	10	45,660	468	12,210	23	219	12,921	32,739	403,398	
	3rd.	11	40,077	515	35,741	20	236	36,512	3,564	**406,963**	**Max.**
Jun.	1st.	10	33,656	1,232	53,853	17	4,862	59,964	-26,309	380,654	
	2nd.	10	30,742	1,232	47,836	15	4,862	53,945	-23,203	357,452	
	3rd.	10	27,139	1,232	29,850	14	4,862	35,958	-8,819	348,633	
Jul.	1st.	10	23,852	895	16,493	12	5,305	22,704	1,148	349,781	
	2nd.	10	20,719	895	9,092	10	5,305	15,302	5,418	355,199	
	3rd.	11	19,405	984	9,652	10	5,831	16,477	2,928	358,126	
Aug.	1st.	10	13,923	12,943	7,950	7	5,302	26,201	-12,278	345,848	
	2nd.	10	10,887	12,943	10,667	5	5,302	28,917	-18,030	327,818	
	3rd.	11	13,692	14,237	19,660	7	5,837	39,741	-26,049	301,769	
Sep.	1st.	10	9,935	30,117	31,497	5	6,567	68,186	-58,251	243,518	
	2nd.	10	9,271	30,117	44,037	5	6,567	80,726	-71,455	172,063	
	3rd.	10	8,307	30,117	34,083	4	6,567	70,771	-62,464	109,599	
Oct.	1st.	10	7,701	965	19,446	4	1,991	22,406	-14,705	94,895	
	2nd.	10	11,698	965	16,355	6	1,991	19,317	-7,619	87,275	
	3rd.	11	9,480	1,061	23,476	5	2,182	26,724	-17,244	**70,031**	**Min.**
Nov.	1st.	10	11,612	665	8,834	6	-2,289	7,216	4,396	74,428	
	2nd.	10	10,690	665	11	5	-2,289	-1,608	12,298	86,726	
	3rd.	10	10,935	665	0	5	-2,289	-1,619	12,554	99,280	
Dec.	1st.	10	15,099	455	0	8	-2,428	-1,965	17,065	116,345	
	2nd.	10	17,035	455	0	9	-2,428	-1,964	19,000	135,345	
	3rd.	11	28,172	500	253	14	-2,684	-1,917	30,089	165,434	
Total			**893,767**	168,299	498,729	450	60,855	728,333	165,434	-	-
									Max. - Min. =	**336,931**	

Notes

*1) Seepage loss from dam body of 0.05 % of storage volume is assumed.

*2) Evaporation from water surface is estimated based on balance of rainfall and evaporation with kc of 1.1 from FAO Irrigation and Drainage Paper No.24.
(See Table "Evaporation from Water Surface of Reservoir, Ngoma 22" for reference.)

*3) Water Supply for Rice Paddy 168,299 m3/yr.

*4) Cumu. Storage Volume : Start at DWS.1,386.50m 0 m3 (Effective Dam Storage Volume)

Table 4-1-1-30 Design Discharge / Intake Volume

Cropping Acreage

Crop		Area	
Rice Paddy		35	13%
Upland Cropping	Maize+Beans	140	51%
	Vegitable-1	20	7%
	Vegetable-2	40	15%
	Vegetable-3	20	7%
	Coffee	20	7%
	Sub-total	240	87%
Total		275	100%

Operation Hours

Crop	Operation Hours	Remarks
Rice Paddy	24 hrs	
Upland Cropping	8.5 hrs	

Efficiencies

Description		Coefficient	Remarks
Irrigation Efficiency	Rice Paddy	100 %	-
	Upland Cropping	85 %	-
Wetting Area Coefficient	Rice Paddy	100 %	"Suface Irrigation"
	Upland Cropping	70 %	"Micro Irrigation"

Design Discharge

Month	Decade	Days	Rice Paddy		Upland Cropping		Grand Total		Remarks
			Supply Water (m^3/dec)	Discharge Volume (m^3/sec)	GIWR (m^3/dec)	Discharge Volume (m^3/sec)	GIWR (m^3/dec)	Discharge Volume (m^3/sec)	
Jan.	1st.	10	469	0.0005	0	0.0000	469	0.0005	
	2nd.	10	469	0.0005	0	0.0000	469	0.0005	
	3rd.	11	516	0.0005	4,480	0.0133	4,996	0.0139	
Feb.	1st.	10	6,228	0.0072	6,006	0.0196	12,234	0.0268	
	2nd.	10	6,228	0.0072	10,009	0.0327	16,236	0.0399	
	3rd.	8	4,982	0.0072	3,728	0.0152	8,710	0.0224	
Mar.	1st.	10	854	0.0010	6,297	0.0206	7,151	0.0216	
	2nd.	10	854	0.0010	8,186	0.0268	9,040	0.0277	
	3rd.	11	939	0.0010	11,809	0.0351	12,749	0.0361	
Apr.	1st.	10	658	0.0008	3,733	0.0122	4,391	0.0130	
	2nd.	10	658	0.0008	0	0.0000	658	0.0008	
	3rd.	10	658	0.0008	4,090	0.0134	4,748	0.0141	
May	1st.	10	468	0.0005	9,394	0.0307	9,862	0.0312	
	2nd.	10	468	0.0005	12,210	0.0399	12,679	0.0404	
	3rd.	11	515	0.0005	35,741	0.1062	36,256	0.1067	
Jun.	1st.	10	1,232	0.0014	53,853	**0.1760**	55,085	0.1774	
	2nd.	10	1,232	0.0014	47,836	0.1563	49,068	0.1578	
	3rd.	10	1,232	0.0014	29,850	0.0975	31,082	0.0990	
Jul.	1st.	10	895	0.0010	16,493	0.0539	17,387	0.0549	
	2nd.	10	895	0.0010	9,092	0.0297	9,987	0.0307	
	3rd.	11	984	0.0010	9,652	0.0287	10,636	0.0297	
Aug.	1st.	10	12,943	0.0150	7,950	0.0260	20,892	0.0410	
	2nd.	10	12,943	0.0150	10,667	0.0349	23,610	0.0498	
	3rd.	11	14,237	0.0150	19,660	0.0584	33,897	0.0734	
Sep.	1st.	10	30,117	**0.0349**	31,497	0.1029	61,614	0.1378	
	2nd.	10	30,117	0.0349	44,037	0.1439	74,154	**0.1788**	
	3rd.	10	30,117	0.0349	34,083	0.1114	64,200	0.1462	
Oct.	1st.	10	965	0.0011	19,446	0.0635	20,411	0.0647	
	2nd.	10	965	0.0011	16,355	0.0534	17,320	0.0546	
	3rd.	11	1,061	0.0011	23,476	0.0697	24,537	0.0709	
Nov.	1st.	10	665	0.0008	8,834	0.0289	9,499	0.0296	
	2nd.	10	665	0.0008	11	0.0000	676	0.0008	
	3rd.	10	665	0.0008	0	0.0000	665	0.0008	
Dec.	1st.	10	455	0.0005	0	0.0000	455	0.0005	
	2nd.	10	455	0.0005	0	0.0000	455	0.0005	
	3rd.	11	500	0.0005	253	0.0008	753	0.0013	
Annual			*168,299.0*	-	*498,729.4*	-	*667,028.4*	-	-
Maximum			*30,116.7*	***0.0349***	*53,853.3*	***0.1760***	*74,153.5*	***0.1788***	-

Notes

*1) GIWR (m^3/dec) : Gross Irrigation Water Requirement

*2) Discharge Volume (m^3/sec) = GIWR (m^3/dec) / dec (days) / (3,600 (sec/hr) * Operation Hours (hrs))