REPUBLIC OF UGANDA
MINISTRY OF AGRICULTURE, ANIMAL INDUSTRY AND FISHERIES (MAAIF)
MINISTRY OF WATER AND ENVIRONMENT (MWE)

REPUBLIC OF UGANDA

THE PROJECT ON IRRIGATION SCHEME DEVELOPMENT IN CENTRAL AND EASTERN UGANDA

FINAL REPORT

VOLUME-III ATARI IRRIGATION SCHEME DEVELOPMENT PROJECT (F/S)

FEBRUARY 2017

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

NTC INTERNATIONAL CO., LTD.
PASCO CORPORATION

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THE PROJECT ON IRRIGATION SCHEME DEVELOPMENT IN CENTRAL AND EASTERN UGANDA

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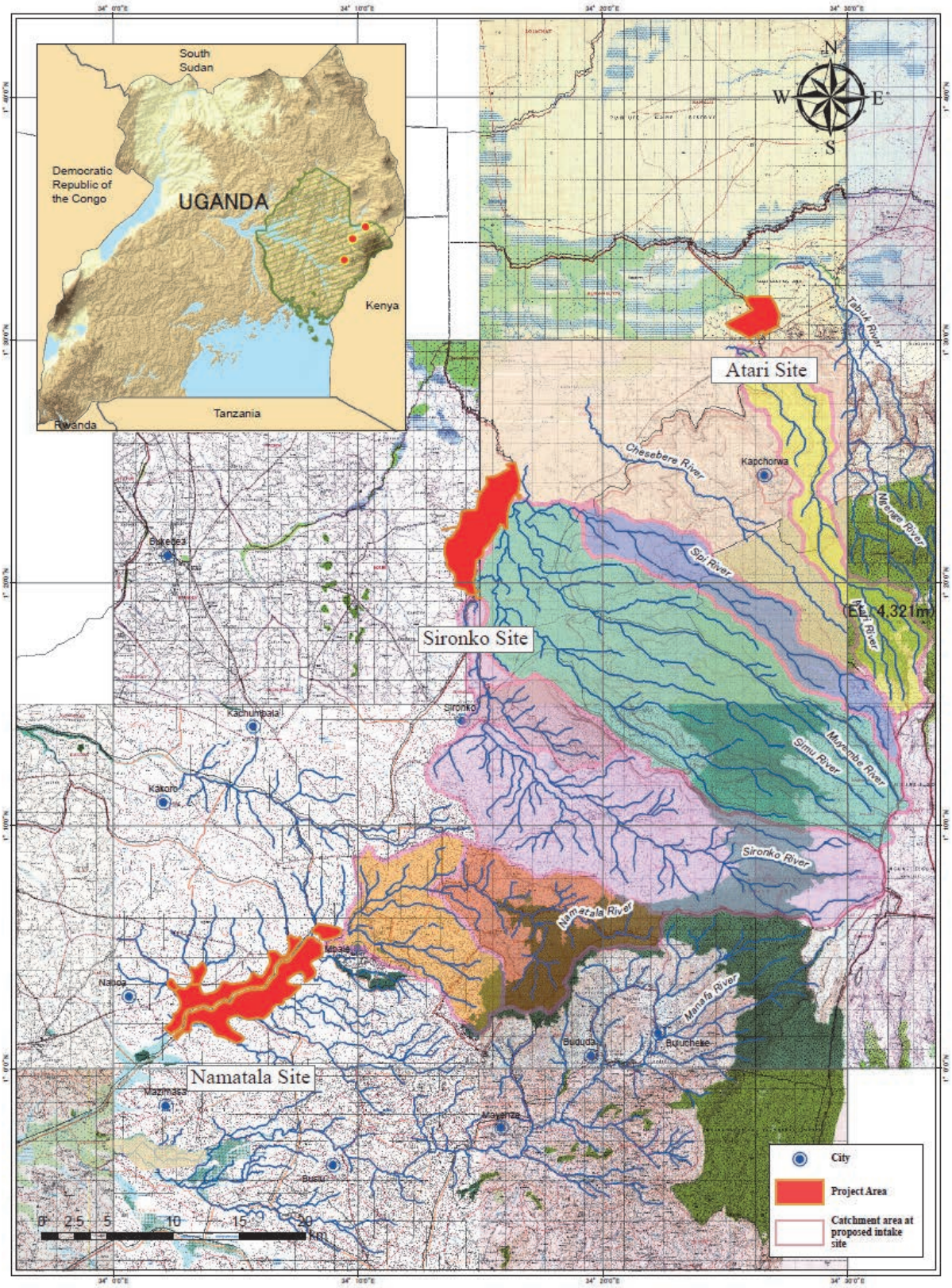


Figure 1. Location Map of the Project Area

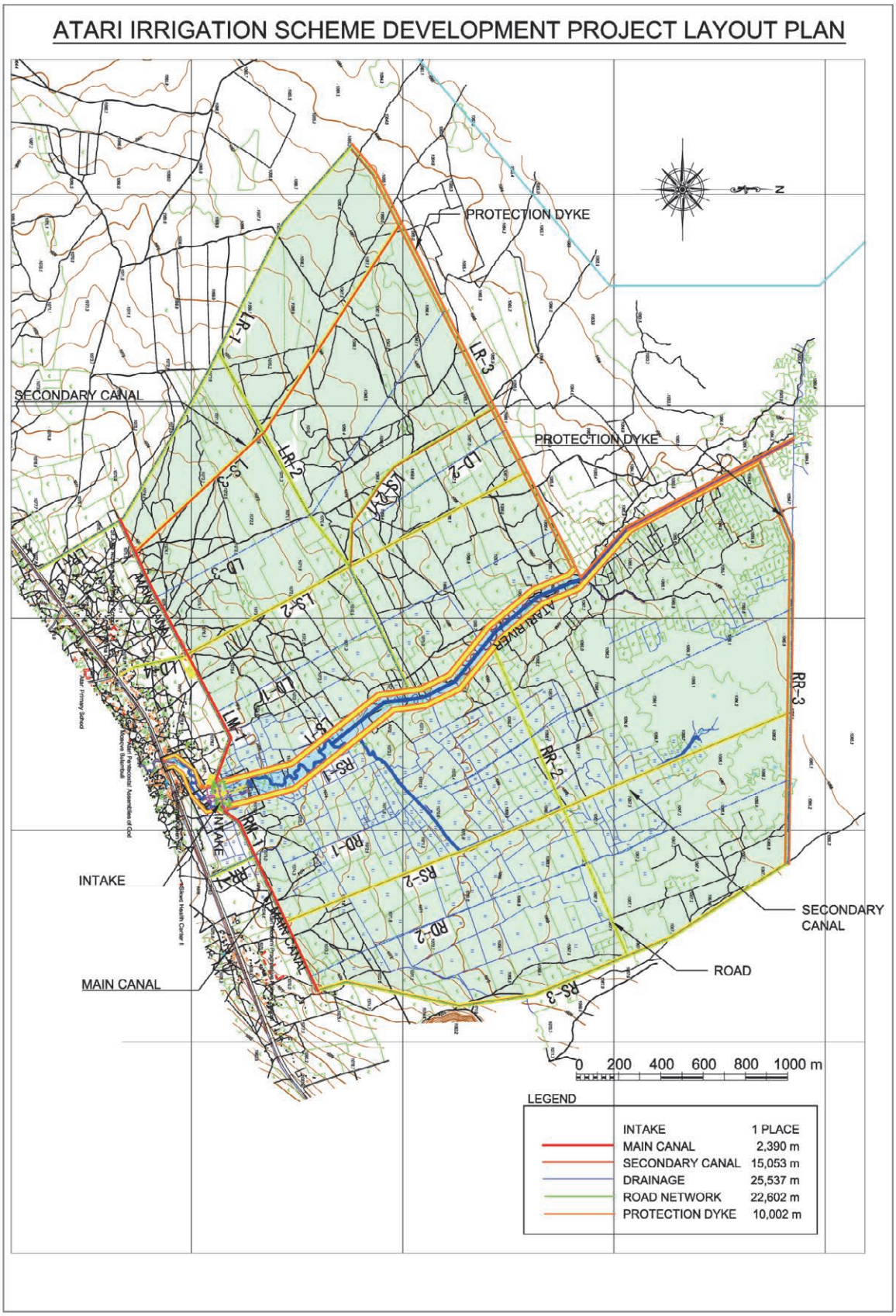


Figure 2. Atari Irrigation Scheme Development Project Layout Plan

Photographs (Atari site)

Overview of Target Area in Atari
This is the view of Atari right bank paddy (background). Aerial view of the area was taken atop Jelalaibei Hill in Kween District. Sesame field is seen in the foreground.

Up-close of Atari Paddy
Paddy cultivation is done between May and September in the left bank. K-5 and Supa are main rice varieties.

The Atari River
View of Atari River Falls from The Elgon Ranges.

The Atari River
View of river upstream of Bulambuli-Moroto Road bridge crossing.

Intake at the Atari River
A general view of the downstream end of the intake at Atari River. The intake was constructed by the NGO, Action Aid. The same intake is shown in the picture to the right.

Intake along the Atari River
This view is upstream of intake. Intake serves only right bank paddy fields in Kween District. The pulley mechanism operating sluice gates is broken. Dimensions of sluice gate = H 1m×W 1.5m×2 gates

Photographs

Diversion Weir at Right Bank Main Canal

The weir is made of logs, bush and shrub material. Weir construction is done by farmers. Visible in the background, near the tree, is the Atari Intake.

Lateral Canal

The canal is of the earth type. The canal is dug by farmers using simple hand tools.

Footbridge

The bridge is made of log. There are several such bridge crossings across canals with top width of more than 1m

Silt Deposition in Target Area

Due to the heavy silt load of the Atari River, silt is deposited in flood plains of the wetland. This is a view of the area after a flood

Downstream of Atari Left Bank

The flow is from the background towards the foreground. Seen in the background are the Elgon ranges

Downstream of Atari area

This is a natural, permanent wetland. Water depth varies between 40-80cm

Photographs

Collected Sand Place
The collected sand place is at Nabukutu Village in Ngenge S/C

Collected Laterite Place
The laterite place is at Chepetere Village in Ngenge S/C

Photo in Air at Atari left bank
The photo was taken by drone in air at downstream in Atari site

Diversion of Atari Left Bank
The flow is from the background towards the foreground. Seen in the background are the Elgon ranges.

Rain Gauge in Kapchorwa District
The rain gage is at Kapchorwa District LGO
It started measuring from 23rd Feb 2015

Weather Station in Atari
The weather station is at Atari Health Centre II
It started measuring from 25th Feb

Executive Summary

1. Introduction

(1) Background of the Study

This Final Report (FR) is prepared by the JICA Study Team (JST) in accordance with the Record of Discussion (R/D) for The Project on Irrigation Scheme Development (PISD) in Central and Eastern Uganda, (hereinafter called "the Study"). The R/D was agreed upon by the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), the Ministry of Water and Environment (MWE), and the Japan International Cooperation Agency (JICA) on 10th February 2014.

(2) Objectives of the Study

Expected goals which will be attained after the completion of the proposed site are:

- ✓ To assure national food security and farmer household income through increased and sustainable irrigated rice production;
- ✓ To build capacity for irrigation and natural resource management among the different stakeholder categories.

(3) Outputs of the Study

The expected outputs of the Study are:

- ✓ Potential sites for Irrigation Development are identified;
- ✓ Feasibility Study (F/S) for prioritized areas is conducted;
- ✓ Stakeholders' capacity of irrigation development, operation, and management is developed.

(4) Scope of the Study

The scope of the Study has two phases. In the first phase (Phase 1), JST conducted a study to develop Irrigation Scheme Development Plan (ISDP) for the respective candidate sites, from June 2014 to March 2015. ISDP was formulated for each site including cost estimation of the project, benefit, and project evaluation. Based on the analysis of ISDP, three priority sites were selected for further study in Phase 2. During the second phase (Phase 2) of the Study - from May 2015 to December 2016 - JST conducted F/S on two (2) of the three (3) selected sites, namely: Sironko/Acomai and Atari site, and Pre-Feasibility Study (Pre-F/S) on Namatala site. Capacity building on irrigation and natural resource management, targeting counterparts (C/Ps) and district officers was also done during the two phases.

2. Results of Phase 1 Study

(1) Selection of the Priority Sites

According to the results of the cross analysis of the 11 candidate sites with quantitative and qualitative factors, the Atari site has been selected for F/S during Phase 2 study as the second highest ranking

among them.

The second Joint Coordination Committee (JCC) meeting was held on 9th December 2014 to confirm the three sites for the next study in Phase 2. The Atari site is named as Atari Irrigation Scheme Development Project (F/S).

3. Results of Phase 2 Study

(1) Preparatory Works for the Selected Priority Sites

(a) Aerial Photograph Survey

Aerial photography survey was done for the 3 selected priority sites, culminating in the development of topographical maps of 1: 5,000 scale with 1m vertical interval contour lines for Atari site.

(b) Observation of hydro-meteorological data

There were no reliable rain gauge stations in the study area. At the Namatala and Sironko Rivers, there were only manual water level gauging stations with results recorded only twice per day. To fill gaps and ensure continuous hydro-meteorological datasets, meteorological stations and automatic water level monitoring gauges were installed at appropriate locations in the study areas.

During Phase 1, the JST estimated the irrigation potential of the area using the observed water level data and converted discharge data - using H-Q curve - prepared by Directorate of Water Resources Management (DWRM) of MWE. During Phase 2, the estimation was done with the data collected from newly installed gauges. Based on the data recorded by the newly installed equipment, the rating H-Q curves were revised and updated. Analysis of the newly acquired data revealed that the previous H-Q curves overestimated the discharges of the Sipi River, which is used for water balance calculation in Atari site. Consequently, the projected irrigable area for Atari site was reduced to about 70 % of the original value.

(c) Acceptance by the Community

On 28th July 2015, at the commencement of Phase 2 study, there was sudden opposition to PISD by communities in the study area. It became increasingly demanding to achieve agreement to PISD among the communities in the study area given their suspicions about the project and the worry that PISD was a ploy to grab their land. The situation was flared up by the spread of false information, and misinterpretation.

In order to resolve the standoff, the following strategy was executed;

Initially, i) The C/Ps (MAAIF and MWE) formulate a PISD Task Force Team (PTAF) to work together with JST to resume the Study. PTAF, together with JST established ii) PISD District Coordination Committee (PDCC) within the related districts and iii) PISD Area Coordination Committee (PACC) at the study area level including representatives from among expected target beneficiaries from the area.

Secondly, in order to disseminate precise and factual information to the communities, PTAF, PDCC, and JST organized workshops to educate the communities through information materials such as project brief, project map, project benefits, FAQ, among others. For the smooth implementation of the activity, several workshops and sensitization meetings were organised in every village of the target study area.

Finally, the communities understood and agreed to the resumption of PISD in investigations. To formalise the breakthrough, an agreement was signed between the communities and the Local Government.

(2) Major Works during Phase 2

(a) Environmental and Social Considerations

During Phase 1 of the Study, the environmental categorization was B. However, since the F/S sites were located near the Ramsar Convention area, the Category A under JICA guidelines was adopted for the Phase 2 study. It was necessary to consult with JICA's Advisory Committee for Environment and Social Considerations and obtain advice and guidance on the environmental and social considerations to reflect in Phase 2 of the Study.

In line with the environmental legal system in Uganda, an Environment Impact Assessment (EIA) was carried out as part of the F/S of Atari and Sironko sites. Also, Draft Abbreviated Resettlement Action Plan (DARAP) and Community-based Wetland Management Plan (CWMP) was prepared as part of F/S. Information of DARAP will serve as baseline data for a future Resettlement Action Plan (RAP). The Study shall not deviate significantly from the WB's safeguard policy on involuntary resettlement.

Additionally, as the result of EIA, an Environmental Impact Statement (EIS) was submitted to the National Environmental Management Authority of Uganda (NEMA). NEMA will review the EIS to evaluate the sufficiency of the relevant mitigation measures corresponding to the likely negative impacts of the project, and after that, it will grant approval with or, without modification, suggestion, if any. Regarding advice from the Advisory Committee of Japan suggested monitoring points for an environmental condition that should be performed by Government of Uganda (GoU) and it was included in the monitoring plan.

(b) Landowner Boundary Survey

As the issue of land, ownership is sensitive to the community and important to land-related development intervention, Landowner Boundary Survey (LABOS) was conducted in the presence of related landowners on both Atari, and Sironko sites in the area delineated as the irrigation development area. The results of land boundaries were disclosed to the community members and landowners to reflect their objections and revise the boundary. Ultimately, signatures of confirmation from the convinced landowners were obtained from 99% of the total owners.

(c) Preparation of Guideline for Irrigation Development Procedure in Wetlands

JST together with C/Ps have conducted F/S to promote wise-use of wetlands for irrigation agriculture on the basis of discussion and exchange of opinions with stakeholders and community members step-by-step through many types of the meeting; such as sensitization meeting, stakeholder meeting, public meeting, and top level meeting with Minister. During the F/S, JST and C/Ps encountered constraints and challenges that stemmed from legal grounds. The objective of this guideline is to extract lessons learnt from PISD experiences and provide suggestive procedures that other projects can apply in executing middle-large scale irrigation projects in wetlands.

"The Guideline for Irrigation Development Procedure in the Wetland in Uganda" was prepared for expected further development of medium to large-scale irrigation schemes in Uganda.

(3) Results of Phase 2 Study in Atari Site (F/S)

(a) Present Condition

Administratively, the project area lies in two neighbouring parishes namely: Buwebere Parish in Bunambutye Sub-County (S/C), Bulambuli District and Sikwa Parish in Ngenge S/C, Kween District. The Atari area is a sub-catchment of the Awoja catchment, which is one of the 11 catchments of the Lake Kyoga Water Management Zone (KWMZ). The Atari River Basin, covering 9.24 km^2, is found in the districts of Bulambuli and Kween, with the Atari River being the natural and administrative boundary between the two districts. The results of LABOS show that there were 688 plots with 479 landowners in the Atari site.

The area lies on an alluvial plain with sediment from rivers. Vertisols are dominant in the area, followed by Luvisols. The water resource for this area is the Atari River with a catchment area of 103 km^2.

In general, there are two cropping seasons in a year, depending on bimodal rainfall pattern. The 1st cropping season is from March to July, and the 2nd stretches from August to December. Lowland Paddy is cultivated on 63 ha and 190 ha during the 1st and 2nd seasons, respectively. Upland crops such as maize and cassava are cultivated on 219 ha and 131 ha in the 1st and second season, correspondingly.

In the area, 27 % participate in groups. Most groups charge membership fee though it is a paltry amount. The popular functions of existing groups are credit and saving and labour exchange, which infers that people expect access to funds and labour through groups.

(b) Development Plan

A most available and optimum development plan was adopted for the site based on the comparison of some possible alternatives for the irrigation development plan, from the following points: i) alignment and design of the flood protection dyke ii) optimum development scale, and iii) area of the development plan. The comparison study showed the optimum development scale was "the

maximum development area with all paddy field in one season, which included the upland crop project area converted from the paddy area" with irrigation development area of 680 ha.

Since the project area is located near the Ramsar Convention wetland area, the river is to be reverted to its original course to ensure the preservation of natural forest, vegetation and other features of nature and maintenance of the water body in the Ramsar Convention area.

The flood protection dyke has the function of preventing accumulation of sediment in the river. As a buffer zone with 30 m width was designed considering both flood discharge and necessary the distance for trapping the sediment.

(c) Water Resource Plan

The estimation of water balance indicated the irrigable area under a 5-year return period drought taking rainfall, river maintenance flow, domestic water requirement, and livestock water requirement into consideration. The maximum intake water discharge was estimated at 2.04 m^3/sec

The analysis of peak flood discharge for the Atari River was done by applying unit hydrograph analysis. Flood Design Discharge at the proposed intake was estimated as 38 m3/sec under the 10-year probability.

(d) Facility Plan

The design provided an irrigation and drainage scheme development plan in the same manner as that of the Sironko/Acomai site. The location of the proposed new head works is around 140 m upstream of existing intake. It is proposed to irrigate both the right-hand area of Kween District and left-hand area of Bulambuli District.

(e) Plan of Management, Operation and Management Organisation

The JST proposed a Management, Operation and Maintenance (O&M) structure to be organized by the Central and Local Government. It is meant to support the farmers' organisation, composed of both WUA and farmers' cooperative, in increasing crop production through irrigation water supply and drainage works.

The 6th JCC agreed as follows: i) The implementation agencies of the project will be MAAIF and MWE, and ii) MAIIF the executive agency for PISD.

(f) Estimation of Project Costs Project and Project Evaluation

A summary of the results of the F/S, including cost, benefit, project evaluation, and O&M costs among others is shown in Table 2.

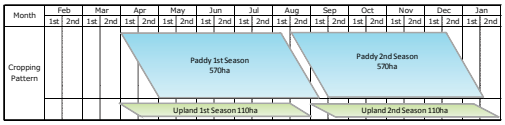
(g) Environmental and Social Considerations

One of the concerns on the local environment is whether the irrigation project would have a severe

impact on the Ramsar Convention wetland area, including the Lake Opeta-Bisina wetland system which is located downstream of the Atari River. Examinations made to determine the degree of impact through the EIA study, and the Study generally, reveals the impact will not be severe as evidenced by the reasons below:

- ✓ The volume of water supply from the Atari River to the Lake Opeta-Bisina wetland system is estimated quite low compared to the catchment areas and the volume of intake for irrigation
- ✓ The concentration of ammonia nitrogen (NH4-N) in the Lake Opeta-Bisina system is already high since livestock farming is run around the system;
- ✓ Although fertilizers will be used for the irrigation project, the level of fertilizers in the backflow water from the irrigation area to the Atari River is estimated low compared to the difference of catchment areas. Also, in case of the fertilizer flowing in the system, the high level of NH4-N at the mouth of the Lake Opeta would not be affected to increase the level It is feasible to avoid excessive use of fertilizers and ban the use of agrichemicals by employing sufficient farming management, and such management is a part of the project menu;
- ✓ Since the proposed irrigation area is located at 11.4 km of distance from the Ramsar Convention wetland area, impacts to the farmers and fisher folks are not anticipated because of no direct touches to the wetland (e.g. encroachment or farming in the Ramsar wetland); and
- ✓ The Lake Opeta-Bisina wetland system is rich in the ecosystem and designated as a bird conservation area, serious impacts are not anticipated on aspects of water volume and quality and human-induced action.

Table 2 Summary Table of Atari Irrigation Scheme Development Project (F/S)

No.	Items	Sub-items	Atari Site	Remarks
1	**Present Land Use (ha)**		(ha)	
	Irrigated Rice Field		240	
	Irrigated Upland Field			
	Upland Field		280	
	Total		520	
2	**Population**			
	Administration	Population of District related to Bukedea District		2020 Projection based on 2014 Kolir sub-county
		Bulambuli Distric	4,147	Bukhalu/Bunambutye
		Kween District	2,386	Ngenge sub-county
		Total	6,533	
		Number of households	**1,289**	
3	**Irrigation Area (Net Area) (ha)**		(ha)	
	Existing Irrigation Area			
	- Paddy Field		240	
	- Upland Crop		280	
	- Others		160	
	Total		680	
	Projected Irrigation Area (ha)		680	
	First Crop		May-August	
	- Paddy Field		570	
	- Upland Crop		110	
	Total		680	
	Second Crop		Sep.-Dec	
	- Paddy Field		570	
	- Upland Crop		110	
	Total		680	
	Cropping Calendar			
	Atari Site			
	Irrigation Factor			
	Irrigation Efficiency	Paddy Field	0.6	
	Design Year (1/5 year draught)	Year	2004	
	Design Capacity of Intake (m3/sec)	Maximum Intake	2.24	
	Design Year Annual Average intake (m3/sec)		0.57	
	Design Year Annual Average intake (1000 m3)		13,485	

4 Facility

Intake Facility (Place)	1
Main Canal Length (km)	2.4
Secondary Canal Length (km)	15.1
Main Farm Ditch (km)	10.0
Supplemental Farm Ditch (km)	38.2
On-farm Development (ha)	330.0
Drainage Canal (km)	25.5
Flood Protection Dyke (km)	10.0
Maintenance Road Length (km)	22.6

5 Annual Crop Production

			Unit Production (ton/ha)
Annual Crop Production (without-project) (ton/year)	Paddy	792	3.00
	Upland Crops	1,232	3.50
Annual Crop Production (with-project) (ton/year)	Paddy	5,700	5.00
	Upland Crops	880	4.00
Crop Production (annual increment) (ton/year)	Paddy	4,908	2.00
	Upland Crops	-352	0.50

6 Irrigation Management System

Central Government (MAAIF/MWE)	Number of Staff	2	Initial Stage only
Local Government (District)	Number of Staff	2	for about 10-year
WUA: Central committee and secondary canal units	Number of Management Staff	40	Member of Farmers: Secondary canal unit
	Member of WUA	1,289	Beneficially (Land Owner)

4. Conclusions and Recommendations

4-1 Priority Site for the First Implementation Site

F/S was conducted on Sironko and Atari sites during Phase 2. Based on the results of this Study and selection criteria set for identifying priority site, the first implementation site was proposed by JST and Atari site was selected as a first priority site.

The results were discussed and approved in the sixth JCC Meeting held on 12th October 2016. JCC members have understood the comparative advantages of the Atari site over the Sironko/Acomai site and resolved that it be the priority site for requesting for Japanese Grant Aid together with Technical Assistance for the project support.

JCC noted that PISD and subsequent Atari site should be a model for irrigation scheme development in the country and experiences of the project would be utilized by GoU for other similar projects.

4-2 Important Consideration for Implementation of Atari Site

4-2-1 Conclusion

The proposed Atari Irrigation Scheme Development Project (AISDP), abstracting water from the Atari River has the high potentiality to be developed and is technically and economically feasible. The AISDP is superior and advantageous regarding the project cost per unit area and O&M cost derived from the Study.

It is concluded that the implementation of the proposed project contributes greatly to not the only regional economy but also the national economy regarding increment of rice production as well as poverty reduction through stabilisation and improvement of smallholders' paddy rice production. It may result in the reduction of rice importation and consequently save the country expenditure on foreign currency.

4-2-2 Recommendations

(1) Preparation for the Project Implementation

According to the comparison study for selection of first priority site, Atari site was selected and recommended. Considering the economic viability of the project, implementation is recommended as soon as possible together with technical assistance in the mould of elite experts for irrigation and drainage management dispatched from Japan.

(2) Supporting System for Implementation of the Project

The following supporting system should be provided for implementation of the project.

- ✓ Necessary facilities and equipment for the sustainability and rationalised O&M activities for the project
- ✓ Demonstration farm, facilities, and equipment for sustainability of the project and quick attainment of the project benefit through increasing crop production
- ✓ Extension services for farmers' agricultural production technology by GoU.

(3)Technical Assistance

A technical assistance provides smooth implementation and sustainable maintenance of AISDP as a model site for irrigation schemes in Uganda. It will be necessary to acquire in management technology, O&M of irrigation and drainage systems, organisation management, agricultural technology especially in rice growing, and training of farmers in on-farm development by exclusive specialists in those fields. GoU needs to request Government of Japan (GoJ) implement AISDP and ask for technical assistance in that regard as well.

Regarding JICA Technical Assistance, the following four experts are required;(1) Team Leader for operation and management of irrigation and drainage system, (2) expert in farmers' organization and WUA, (3) expert in rice cultivation technology and (4) coordinator. The short-term experts will be provided and supplemented by GIS database expert for the management of facilities and members of WUA and mechanical engineer for operation and maintenance of farm machinery.

(4) Possibility of Upstream Development

Upstream of the Atari site, between the national road and the foot of Mt. Elgon, there is about 500 ha of the flat area, and small-scale pump irrigation is being done within a few areas. In the upstream, river course is deep, and gravity irrigation by the construction of weir will be tough. However, there is some possibility of development with small-scale irrigation scheme by local farmers. In future, the upstream area of the Atari site might be developed by local farmers, and therefore, it will be necessary to check the development progress in the upstream area and negotiate, communicate and cooperate with upstream farmers and adjust water utilization patterns to protect the interests of downstream water users.

Volume-III Atari Irrigation Scheme Development Project (F/S)

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Units and Currency

kg	kilogram
ton	metric ton
hr	hour
mm	millimetre
m	metre
cm	centimetre
km	kilometre
ha	hectare
HP	horsepower
km^2	square kilometre
m^3	cubic metre
MCM	million cubic metres
MW	mega Watt
lit/sec	litter per second
mm/mon	millimetre per month
mm/day	millimetre per day
m/sec	metre per second
m^3/sec	cubic metre per second
ºC	degree Celsius
%	percent
US$	United States Dollar
USh	Ugandan Shilling
¥	Japanese Yen

Exchange rates (as of July 2016)

	USh	US$	¥
USh		0.0003846	0.040
US$	3,300		101.68
¥	25	0.0098348	

Glossary of Acronyms

ACE	Area Cooperative Enterprise
AfDB	African Development Bank
AISDP	Atari Irrigation Scheme Development Project
ALT-L	Alternative Alignment
ALT-P	Alternative Plan
ARAP	Abbreviated Resettlement Action Plan
ASSP	Agriculture Sector Strategic Plan
B/C	Benefit-cost
BZ	Buffer Zone
CAO	Chief Administrative Officer
CBD	Convention on Biological Diversity
CDO	Community Development Officer
CGV	Chief Government Valuer
CITES	Convention on the International Trade in Endangered Species of Wild Flora and Fauna
CMP	Catchment Management Plan
C/P	Counterpart
CWMP	Community-based Wetland Management Plan
DAES	Directorate of Agricultural Extension Service
DAO	District Agriculture Officer
DAP	Diammonium Phosphate
DARAP	Draft Abbreviated Resettlement Action Plan
DCDO	District Community Development Officer
D/D	Detail Design
DDP	District Development Plan
DEM	Digital Elevation Model
DEO	District Environmental officer
DIFACOS	Doho Irrigation Scheme Farmers Cooperative Society
DISO	District Internal Security Officer
DLB	District Land Board
DLG	District Local Government
DLT	District Land Tribunals
DO	Dissolved Oxygen
DOD	Draft Outline Design
DSIP	Sector Development Strategy and Investment Plan
DAIWAP	Department of Agricultural Infrastructure and Water for Agricultural Production
DWAP	District Wetland Action Plan
DWD	Directorate of Water Development
DWO	District Wetland Officer
DWRM	Directorate of Water Resource Management
EIA	Environmental Impact Assessment
EIR	Environmental Impact Review
EIRR	Economic Internal Rate of Return
EIS	Environmental Impact Statement
EIStudy	Environmental Impact Study
EMA	Environmental Monitoring Agent
EMoP	Environmental Monitoring Plan
EMP	Environmental Management Plan
EN	Endangered

ESIA	Environment and Social Impact Assessment
ET	Evapotranspiration
FAO	Food and Agriculture Organization
FAOSTAT	The Food and Agriculture Organization Corporate Statistical Database
FAQ	Frequently Asked Questions
FIEFOC	Farm Income Enhancement and Forest Conservation Project
FMP	Framework Management Plan
FR	Final Report
F/S	Feasibility Study
G/A	Grant Aid
GCP	Ground Control Point
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GISO	Gombolora internal security officer
GNSS	Global Navigation Satellite System
GoU	Government of Uganda
GPS	Global Positioning System
HC	Health Centre
HH	Household
HIV/AIDS	Human Immunodeficiency Virus/Acquired Immune Deficiency Syndrome
H-Q	Height - Quantity Curve
IBA	Important Bird Area
IDB	the Islamic Development Bank
IEE	Initial Environmental Examination
IFC	International Finance Corporation
IMA	Internal Monitoring Agent
IMU	Inertial Measurement Unit
IRR	Internal Rate of Return
ISDP	Irrigation Scheme Development Plan
IUCN	International Union for Conservation of Nature
JCC	Joint Coordinating Committee
JICA	Japan International Cooperation Agency
JST	JICA Study Team
JTC	Joint Technical Committee
Kc	Crop coefficient
LABOS	Landowner Boundary Survey
L/C	Local Consultants
LC	Local Council
LC	Least Concern
LD	Left bank Drainage
LGO	Local Government Office
LS	Left bank Secondary Canal
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MoLHUD	Ministry of Lands, Housing and Urban Development
M/M	Minutes of Meeting
MoFPED	Ministry of Finance, Planning and Economic Development
MoGLSD	Ministry of Gender, Labour and Social Development
MoU	Memorandum of Understanding
MTIC	Ministry of Trade, Industry and Cooperatives
MWE	Ministry of Water and Environment
NAADS	National Agriculture Advisory Service

NaCRRI	National Crops Resources Research Institute
NARO	National Agricultural Research Organization
NBI	Nile River Basin Initiative
NDP	National Development Plan
NEA	National Environment Act
NEMA	National Environment Management Authority
NER	National Environment Regulation
NFA	National Forestry Authority
NGO	Non-Governmental Organization
NIP	National Irrigation Policy
NPV	Net Present Value
NRDS	National Rice Development Strategy
NT	Near Threatened
O&M	Operation and Maintenance
O/D	Outline Design
OJT	On-the-Job Training
OPM	Office of the Prime Minister
PACC	PISD Area Coordination Committee
PAH	Project Affected Household
PAP	Project Affected Person
PDCC	PISD District Coordination Committee
PIA	Planned Irrigation Area
PIE	Project Implementation Entity
PIM	Project Implementation Manual
PISD	Project on Irrigation Scheme Development in Central and Eastern Uganda (This Study)
PISD-FHS	PISD Farm Household Survey
PISD-SES	PISD Socio-economic Survey
PIU	Project Implementation Unit
PLC	Parish Land Committee
Pre-F/S	Pre-Feasibility Study
PRiDe	Promotion of Rice Development (Technical Cooperation by JICA)
PTAF	PISD Task Force Team
PWMPT	Participatory Wetland Management Planning Team
RAP	Resettlement Action Plan
R/D	Record of Discussion
RDC	Resident District Commissioner
RIC	RAP Implementation Committee
RMoP	RAP Monitoring Plan
RTF	RAP Task Force
RTSUs	Regional Technical Support Units
RWH Tank	Rainwater Harvesting Tank
SACCO	Savings and Credit Cooperative Societies
S/C	Sub-county
SCF	Standard Conversion Factor
SEA	Strategic Environment Assessment
SIAD	Sustainable Irrigated Agriculture Development Project
SISDP	Sironko/Acomai Irrigation Scheme Development Project
SRTM	Shuttle Radar Topography Mission
SS	Suspended Solids
SWAP	Sub-county Wetland Action Plan
TLU	Tropical Livestock Unit

TOR	Terms of Reference
TSS	Total Suspended Solids
UBOS	Uganda Bureau of Statistics
UCA	Uganda Cooperative Alliance
ULC	Uganda Land Commission
UNFCCC	United Nations Framework Convention on Climate Change
UNMA	Uganda National Meteorology Authority
UNNFE	Uganda National Farmers Federation
URA	Uganda Revenue Authority
USh	Uganda Shilling
WAIASS	World Atlas of Irrigation Agriculture for Sustainability Sciences
WB	World Bank
WfAP	Water for Agricultural Production
WfPD	Water for Production Department
WMD	Wetland Management Department
WSSP	Wetland Sector Strategic Plan
WTO	World Trade Organization
WUA	Water Users' Association
WUC	Water Users' Committee
WUG	Water Users' Group

CHAPTER 1

PRESENT CONDITION OF ATARI SITE

CHAPTER 1 PRESENT CONDITION OF ATARI SITE

1.1 Location and Scope of the Study Area

1.1.1 Background

The volume III report is a part of Feasibility Study (F/S) of Atari Irrigation Scheme Development Project, (hereinafter called as "AISDP"), under the Project on Irrigation Scheme Development (PISD) in Central and Eastern Uganda, (hereinafter called as "the Study"). The Study was conducted in accordance with the Record of Discussion (R/D) as agreed upon by Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Ministry of Water and Environment (MWE) and the Japan International Cooperation Agency (JICA) on 10th February 2014. The Study was conducted by JICA Study Team (JST) with the active cooperation of counterparts (C/Ps), mainly MAAIF, MWE, local government and community members in the Atari site.

Atari site is one of the candidate sites during the Phase 1 (June 2014 to March 2015)of the Study and identified by a team from MAAIF, MWE, and JST for undertaking Feasibility Study (F/S) on irrigation scheme development in Phase 2 (from May 2015 to December 2016).

The study area is situated within Atari River Basin, which is a river-line wetland sustained by the Kelim River and tributaries into part of Bunambutye plains. Precipitation, groundwater flow, and runoff also contribute to the flow of this basin. The Atari River merged into the mainstream of Kelim River after the confluence Tabuk River to Kelim River, which is located in the border area of Kween and Nakapiripirit District. At the confluence of Atari and Kelmin River and beyond after that, the river-line wetland becomes part of the Awoja wetland systems, which later drains into the Lake Opeta.

Generally, the wetland can be categorized as seasonal floodplain at the downstream area of the Atari River, which lies at the edge of the study area. Away from the foot of the study area towards the upstream of the river, the area experiences very little flood water during rainy season. During times of peak rainfall (October to December and April to May), the edge wetland is filled up and sometimes over floods. The flooding problem is exacerbated by silt deposition into the swamp due to the heavy silt-laden the Atari River.

There is huge and continuous soil erosion from the highland (due to mainly poor farming practices) of the district, which leads to degradation of the soil and accumulation of siltation in the plain area. Such situation, in turn, causes raising-up of the river bed and narrowing the river course at the channel downstream and as a result, causes water logging and poor drainage condition over cultivated area. Originally, the Atari River was the boundary between Kween and Bulambuli District. However, the accumulation of siltation combined with a long history of human interference on the river resulted in the change of river course. Presently, the entire volume of river water is flowing through an old

irrigation canal into a lower area of Kween District creating permanent flood area of that part of study area, which lies on the Kween side and in the downstream direction of the Atari River whereas due to such change of river course it is dry at the Bulambuli side.

1.1.2 Location and Administration

Atari project site is found at the boundary between Bulambuli District and Kween District, bordered by the Atari River. It lies approximately between latitude 1°43' north and 1°30' south and longitude 34°27' east and 34°25' west. Administratively, the study area lies in the two neighbouring parishes namely: Buwebere Parish in Bunambutye sub-county (S/C) of Bulambuli District and Sikwa Parish in Ngenge S/C of Kween District. The proposed study area covers about 8 villages in the two parishes, namely: Sikwa, Sosot, and Amukokel, Nganjarishik Village in Sikwa Parish and Bunambale, Bubuya-B, Buwechalo, Bukhaiaki Village in Buwebere Parish. Table 1.1.1 shows the administrative division that covers the Study area. The geological and administrative location of the Study area is shown in Figure 1.1.1 below

Table 1.1.1 Administrative Division of the Study Area

District	Sub-County	Parish	Village in the target area	Remark
Kween	Ngenge	Sikwa	Sikwa, Sosot, Amukokel, Nganjarishik	10 villages in the Parish, Most of the community resides along the road and on hillside of the parish
Bulambuli	Bunambutye	Buwebere	Bunambale, Bubuya-B, Buwechalo, Bukhaiaki	10 villages in the Parish, Most of the community resides along the road and on hillside of the parish

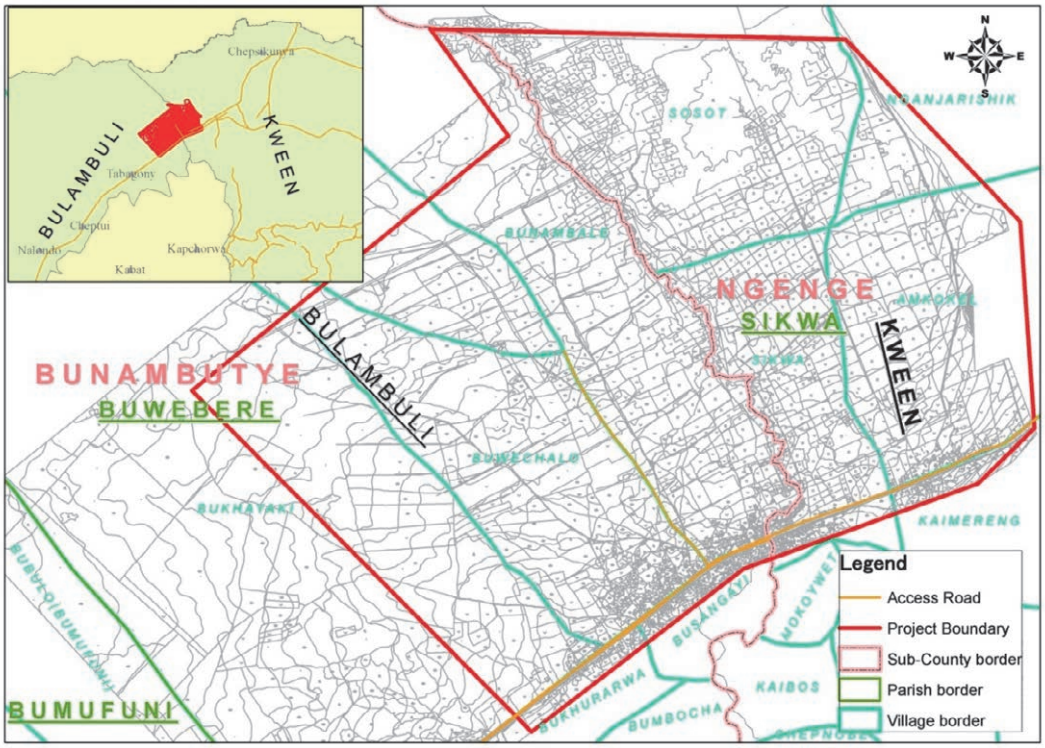


Figure 1.1.1 Location Map of the Study Area inside the Atari River Basin

1.1.3 Scope of the Study Area

The target study area was identified through the result of field investigation in Phase 1 considering social issues. The area bounded shows the target area where it is identified as a study area for F/S of Phase 2, which was approved by the Joint Coordinating Committee (JCC) of the study during the 4th JCC meeting on the 4th October 2015. The area indicated by red hatch mark shows disputed land which is claimed as registered illegally. To avoid social conflict and land issues, Counterparts (C/Ps) and JICA Study Team (hereinafter referred as to JST) decided to exclude this disputed land from the study area and it was discussed and accepted by the Project on Irrigation Scheme Development in Central & Eastern Uganda (PISD) Area Coordination Committee (hereinafter referred as to PACC).

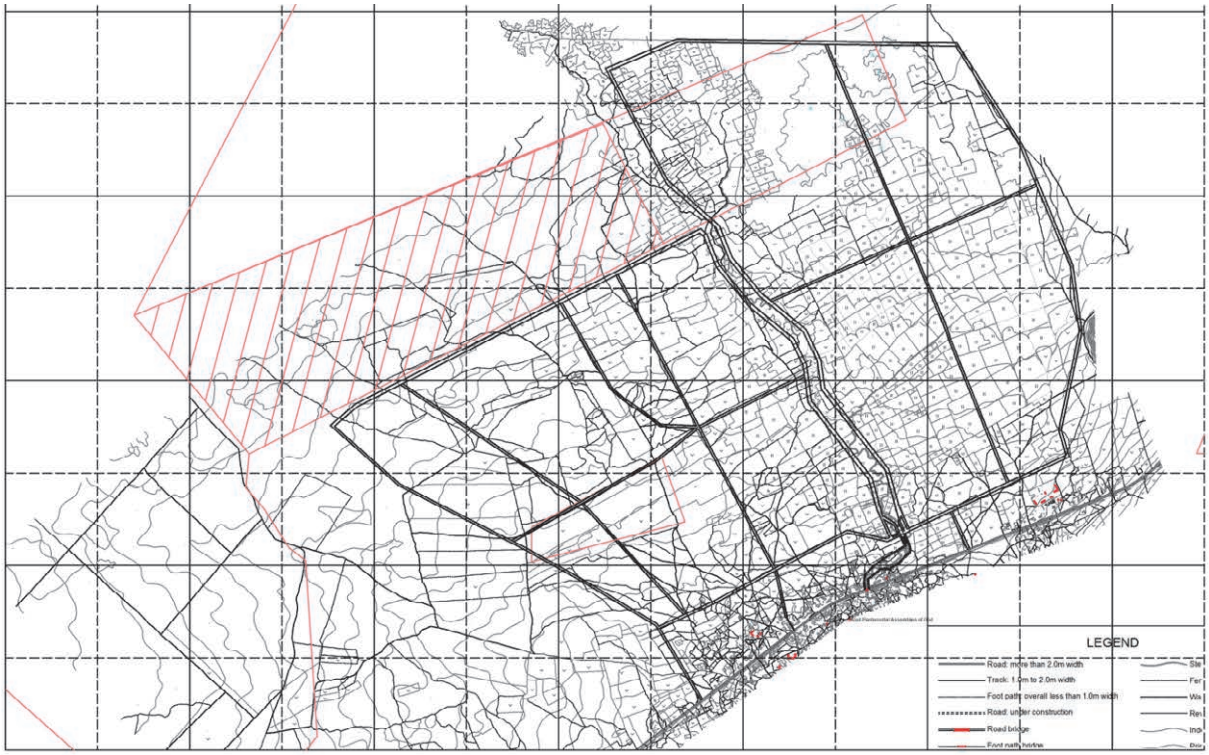


Figure 1.1.2 Study Area in Atari Site

1.2 Socio-economic Condition of the Study Area

1.2.1 Population and Target Beneficiary

(1)Target Beneficiary

The total numbers of people living in the two target parishes are stipulated in Table 1.2.1 below. It was confirmed that there are 479 landowners in the project area according to the result of LABOS (Landowner Boundary Survey). According to the results PISD Farm Household Survey in Phase 2, the percentage of the tenant is around 10 % of total household (HH). Then it is expected 53 HH (=479/0.90*0.10) will be the beneficiaries of the tenant in the project area. Among the population in the two target parishes, these landowners and tenants, totally 532 HH in the project area will be the direct beneficiaries. This population is expected to be the direct beneficiary of the Atari River Basin

Irrigation Scheme Development.

Table 1.2.1 Population in the Study Area

District	Sub-county	Parish	Population per Parish			
			HH	Male	Female	Total
Kween	Ngenge	Sikwa	716	1,181	1,205	2,386
Bulambuli	Bunambutye	Buwebere	573	1,963	2,185	4,147
		Total	1,289	3,144	3,390	6,533

Source: Draft 2014 census (UBOS 2014)

(2)Settlement Pattern

Most of the community in the study area are settled along the Mbale-Moroto main road and on the hilly side of the villages but farm inside the target study area. This situation favours the preparation of scheme layout where all irrigation facilities pass through an area free from any type of settlement. Figure 1.2.1 below shows the settlement pattern in the study area.

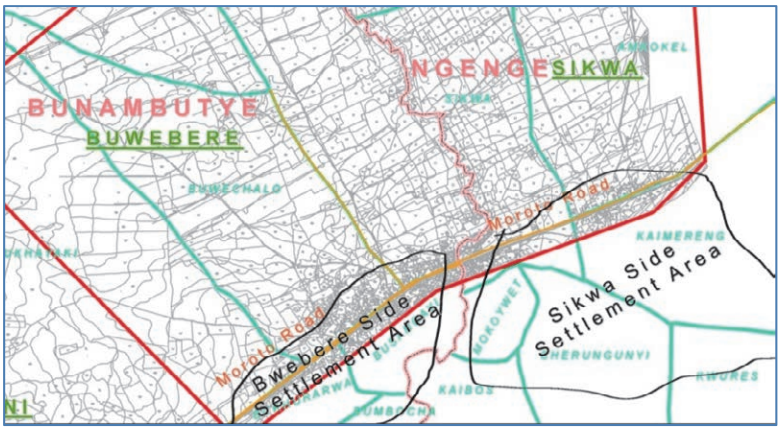


Figure 1.2.1 Settlement Pattern of the Study Area inside the Atari River Basin

1.2.2 Socio-economic Characteristics of the Study Area

Socio-economic characteristics of the study area are presented below based on the Socio-economic Survey (PISD-SES) conducted as a part of the Draft Abbreviated Resettlement Action Plan (DARAP (June 2016)). The DARAP survey focused on the Project Affected Person (PAP) over the sample households of 399 (approximately 3,216 family members). It should be noted that the data presented in this section ((1) Socio-economic characteristics) indicate overall picture of the beneficiaries within the project planning area; whereas in section 1.7 of this chapter, those data presented are capturing specific farm households viewing from lowland rice grower or non-rice grower under the Farm Household Survey1 carried out in July 2015.

[1] The Farm Household Survey aimed to draw farm-households' intension over development and relevant farm practical information based on the samples collected by "Snowball sampling"; pooling small initial informants to nominate, through their social networks, other participants who meet the eligibility criteria and could potentially contribute to a specific area of question technically. Total sample number was 63 for Atari. There were several blocks set within the project planning area by zoning according to land use and dominant farm practicing (i.e., lowland rice versus upland crop dominant). Therefore, data from the Farm Household Survey is also presented in section 1.7 to provide broad and fair picture of the household in context with current farming activities.

(1)Average Size of the Affected Households

The average household in the districts of Bulambuli and Kween comprised of 9 and above persons living within a single household which is higher than the national average 5.02. Results from the project districts of Bulambuli (17.6 %) and Kween (18.5 %) show 9 and above persons living within a single household, 5-6 persons at (6.9 %) and (13.5 %) and 7-8 people at (8.1 %) and (12.5 %) in Bulambuli and Kween Districts respectively [valid respondents: 394].

(2)Gender Distribution of Household Heads and Marital Status by Gender

Results from the census survey in the study area established that there were more male respondents (79.1 %) among affected households in comparison to females respondents (20.9 %).Further analysis of gender distribution in "project affected" households indicated that this trend was consistent in both the districts of Bulambuli (male 31.5 %) and (7.0 % female) and Kween (male 47.6 %) and (13.8 %) Female [valid respondents: 398].

For marital status in the study area in Atari area in the districts of Bulambuli and Kween reveals that the majority were married (80.4 %) and these comprised of (75.7 %) male and female (4.7 %). Results also indicate that there are more female-headed households that were divorced (2.1 %) and widowed (9.7 %) in comparison to the male-headed households which had 1.0 % divorced and 0.3 % widowed respondents [valid respondents: 383].

(3)Age Group

Age is one of the important factors in socio-economic analysis and mitigation of project impacts as it helps to measure the dependency ratio in affected households in a given study area. More so, age can be used as a proxy indicator to establish the need physiological status and healthcare needs of a given population. Primary data shows that the majority of household heads are (25.7 %) 36-45 years of age followed by, (23.4 %) 46-55 and (21.4 %) 56 and above years [valid respondents: 397].

(4)Occupations

Like the majority of areas in Uganda, the vast majority of people in the study areas are engaged in farming (77.8 %) as the main source of livelihood for the household heads. Other forms are shown in the table below.

Table 1.2.2 Occupations of Household Heads

Primary Occupation	Percentage	Number
Farming	77.8	374
Formal Employment	2.5	12
Casual labour	8.3	40
Retail Trading	7.3	35
Service provision (salon, transport)	0.6	3
Student	1.9	9

Fishing	0.4	2
Brick making	0.4	2
Other	0.8	4
Total (mechanic, lodge-service etc.)	100	481

Source: Primary data [effective respondents 481 for multiple answers]

(5)Crops Grown in the Study Area

Results from the survey indicate that rice (53 %) was the most commonly grown crop in the Atari study area in the districts of Kween and Bulambuli. A significant number (31 %) also acknowledged growing another crop. Respondents who reported growing other crops were found to have a variety of them ranging from food crops like maize(96.2 %), beans (91.4 %) sweet potatoes (34 %), cassava (50.1 %) and Bananas (59.0 %), vegetables (89.2 %) [valid respondents: 495 for multiple answers].

(6)Livestock

Livestock farming is also practised within the study area but on a small scale with most households not keeping many animals. The most common livestock are poultry (85.9 %) goats (66.0 %) cattle (59.8 %), sheep (5.2 %) and pigs (4.9 %). According to respondents, very little income is got from selling livestock and this is mainly because they are reared at a small scale.

(7)Fishing

More still, fishing was listed as a secondary economic activity in the study area. This is carried out in open water sources and provides an important source of livelihood and food security for many people in the project. According to the field survey, most respondents (85 %) indicated that they get most of the fish from the river while (15 %) get their fish from the inland pond in the study area [valid respondents: 60].

(8)Levels of Income

Information was collected from households on incomes from farming and other sources. Results from the field reveal that (25.1 %) respondents earned between USh. 500,001- 1,000,000 from their respective occupations especially agriculture. Detailed distribution is shown in below.

Table 1.2.3 Average Monthly Income Levels of Potentially Affected Households

Average Monthly Income (USh)	Percentage	Number
Below 100,000	10.3	41
100,001 – 200,000	16.2	65
200,001 – 300,000	9.4	38
300,001 – 400,000	7.7	30
400,001 – 500,000	12.2	49
500,001 – 1,000,000	25.1	100
1,000,001 – 1,500,000	10.8	43
Over 1,500,000	8.3	33

Source: Primary data

(9)Ethnicity and Religion

Ethnic composition of potentially affected households in the study area was heterogeneous indicates that most people are Bamasaba (54.3 %), Sabiny (31.8 %), Banyole (5.5 %) and Itesots (5.2 %). There were also small ethnic groups such as the Bagwere (1.2 %) and Basoga (0.5 %). Data above shows that the study area is also inhabited mainly by migratory tribes (1.6 %) because of factors such as farming, marriage; these included the Banyankole, Nubians, Bagisu and Swahili.

(10)Health

Health has a unique classification of health centres, from Health Centre I (HC I) to Heath Centre IV (HC IV), with HC I being the lowest level. Higher-level health facilities tend to serve larger populations and are more autonomous. Typically, HC IIIs are constructed at sub-county levels and HC IV at the county level. In the project districts of Bulambuli and Kween most of the people lived in close proximity with HC II (80.8 %).

(11)Level of Education

Basic education improves the capacity of people to diversify assets and activities, access information on agriculture and other forms of livelihoods which are essential elements in sustaining their lives. Field results of the education level of potentially affected households reveal that the majority of respondents had attained primary education (57.3 %), 22 % had attained ordinary level education and only (11.9 %) had never gone to school. It is important to take into consideration this low level of literacy in the study area as it can affect the project implementation. Additionally, the way information is presented for informative and/or discussion purposes should be geared towards more visual/oral means rather than written communications.

(12)Access to Education Services

That majority of project affected people live close to primary schools within the area. Many of the respondents live within 100 m (34.3 %), 100 - 500 m (37.8 %) 1-1.5km (17.8 %), and over 5 km (10) from the primary schools [valid respondents: 370]. However, most households are very far from secondary schools 86.4 % which are over 5 km. This may resultantly negatively affect secondary school enrolment and attendance in the study area [valid respondents: 317].

(13)Sources of Water in the Study Area

In the entire project affected areas, there was a combination of both ground and surface water sources. Within the Project Affected Households (PAHs), the commonest sources of water for domestic use include communal boreholes (65.1 %) followed by river/lakes (24.2 %) and rain water (9.9 %). Very few respondents reported using the piped water (0.3 %). In relation to distance from a water source, the majority (43.1 %) of potentially affected people reported living within 100 m-500 m of the nearest water source and 42.3 % living within 100 m distance from water sources in the study area [valid respondents: 390].

(14)Energy Sources

In the project affected areas of Bulambuli, and Kween primary data reveals that there is limited access to grid electricity hence the prevalence of biofuels as the main energy sources. In the study area, firewood was the main source of cooking energy (95.4 %) which is from three sources, eucalyptus, reeds and sticks from scrub and charcoal (33.3 %). On sources of energy for lighting, kerosene (89.8 %) was the main source of energy in the surveyed households followed by use of firewood in form of reeds (16.6 %). However, some households were connected to grid electricity in the trading centres (6.9 %); there were also biogas (0.3 %) and LPG gas lanterns (0.3 %) and charcoal (0.3 %) used by the affected households. Further inquiries in the study area also revealed that the responsibility of collecting and processing fuel wood lies with the women and children.

(15)Access to Credit

Most respondents acknowledged not being able to access credit services (72.5 %). Only 27.9 %are able to access credit [valid respondents: 358]. Those who access to credit have a various source of credit as shown in the table below. There are some challenges observed during field investigation carried out by the Study Team that small-scale farmers cultivating in lower-belt of Kween District have disadvantages in terms of the agro-climatic condition of the zone to make their crop produce unstable prone to climate disaster. This would be true if we compare the area with upper-belt horticultural farmers around Kween/Kapchorwa where the favoured rain fed condition exists. Inconsistent and unstable production mode may discourage commercial bank or microfinance institutions for the provision of credit opportunity to the farmers; while physical distance to those financial entities require additional cost for potential applicants to credit services. Overall it implies that enhancement of crop production may improve the eligible condition for loan application thus one's debt repayment ability tolerable to critical assessment by the finance institute or bank, in future.

Table 1.2.4 Sources of Credit

Source of Credit	Percentage	Number
Commercial banks	25.7	35
Microfinance institutions	2.2	3
Moneylenders	12.5	17
Input supply	8.8	12
Self-help group*	18.4	25
Internal (family and friends)	11.	15
Government	5.9	8
SACCO**	9.6	13
Other (specify)	4.4	6
Not available	1.5	2

Source: Primary data,
*similar to Village Saving and Loan Association, **SACCO: Savings and Credit Cooperative Societies.

(16)Vulnerable Groups

PISD project implementation will interrupt the normal ways of life of the people in the study area and there might be a loss of livelihood, social network, accessible education, and transport and health services. Particular emphasis should be made on the vulnerable groups who include the elderly, women, child headed household, sick and disabled. It is important that vulnerable people are identified and profiled for each project. This will help to have solutions to be formulated and mitigation measures put in place to ensure that they are able to live a good life even after the project disruption. According to the socio-economic survey, among 399 respondents, there are 109 vulnerable people out of estimated 3,216 people.

1.2.3 Condition of Land Tenure System and Problems

Figure 1.2.2 shows the result of landowner boundary survey which was conducted in Phase 2. There are 479 land owners and 688 plots within the project area. Mean acreage per landowner is around 1.4ha.

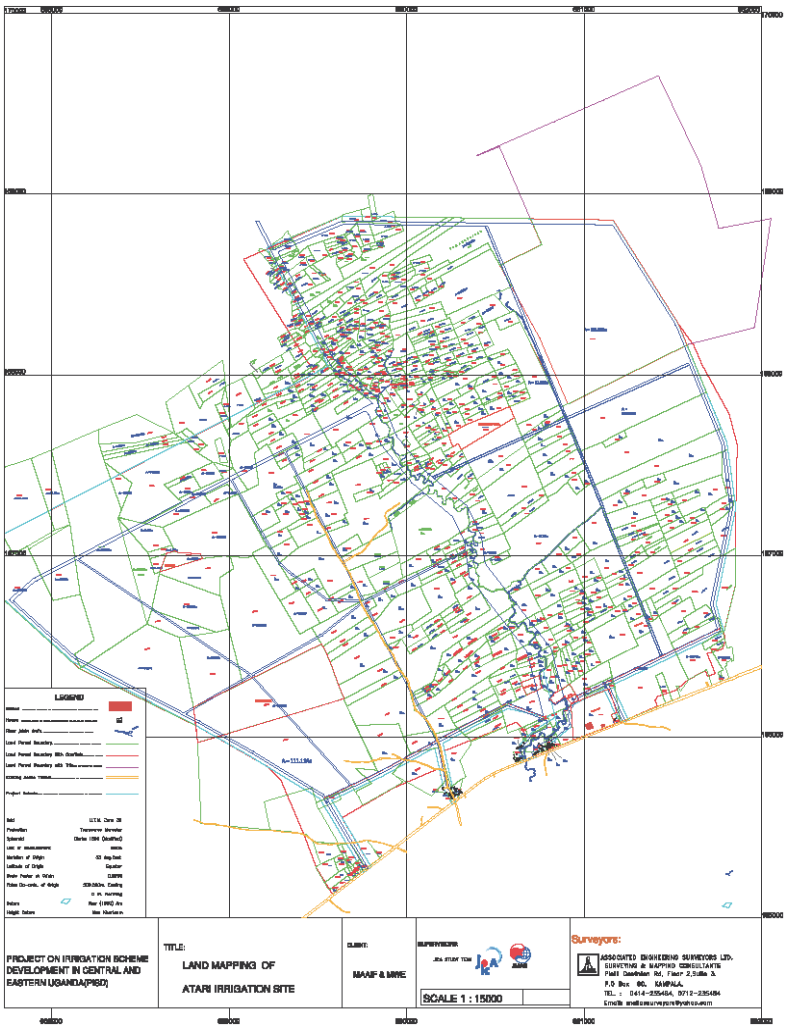


Figure 1.2.2 Land Boundary Map in Atari Site

Approval signatures from landowners were collected 99 % and 9 people didn't sign because of the land issue. Left side which is Buwebere Parish has plots, which are quite big plots and boundaries are very clear. Right side which is Sikwa Parish has many landowners and small plots, and the land issues are mainly in Sikwa Parish.

Factor of land issues are below

1. Part of the family land was sold by a relative without the family's permission.
2. One land was sold to couple of people without certification
3. A landowner sold a land, which was bigger than real size.
4. Problem of land ownership within a family
5. Problem of land ownership within a person who has land title and local community

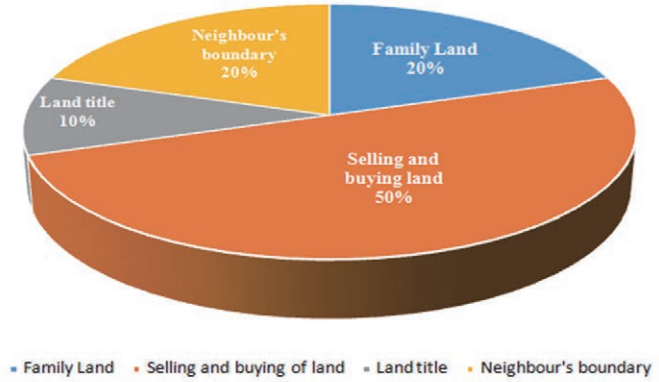


Figure 1.2.3 Type of Land Issues

The biggest reason of land issue was "Selling and buying land". There are much selling and buying land in Sikwa Parish, but there is no certificate, and someone sold one land to a couple of people. The wrong process of selling and buying made these problems. One member of the family claimed to the community related to the land title in Sikwa in 2007, and the case is in the process of getting the land title.

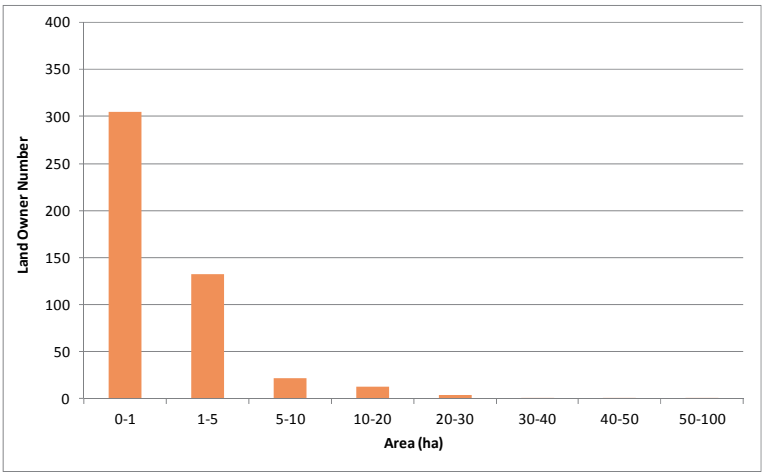


Figure 1.2.4 Distribution of Landowner by Land Holding Size

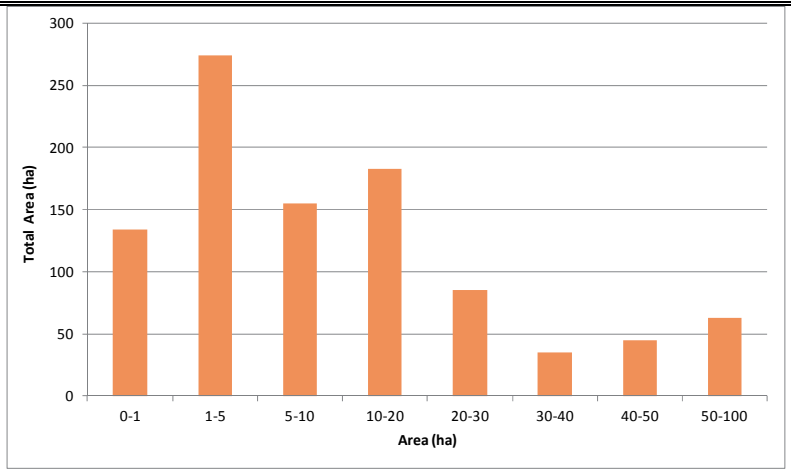


Figure 1.2.5 Distribution of Accumulated Area by Land Holding Size

Uganda census of Agriculture 2008 shows that national average of the area of farmer's land is 1.1 ha, and also an average area of a farmer's land in eastern Uganda is 1.1 ha, thus if someone has a land which is less than 1 ha, it means less than the average. Figure 1.2.5 shows the histogram of the area of a landowner. The overall trend of the result is that people who have land of less than 1 ha are the biggest number, and total 68 % is the landowners in Atari site. However, Figure 1.2.4 shows that threshold of 1 ha doesn't own large area, threshold of 1 - 20 ha is bigger than threshold of 1 ha, thus the trend of Atari site is that landowners of less than national average area are numerous, but area of Atari site is occupied by the landowners who have middle scale land.

1.3 Physical Condition of the Study Area

1.3.1 Topography and Geology

The topography of the study area, generally, is characterized as flat plain relief dissected by rivers emerging from the mountainous area and flowing toward the low-lying area of Awoja Wetland system. The area has mainly two types of soils, i.e., loam and sandy loam soils that are mainly accumulated around seasonal swamps where major agricultural activities are practised. These soils greatly favour the growth of pastures for livestock and growth of agricultural products.

1.3.2 Vegetation Cover

The vegetation cover of the area is characterized by scattered trees, grass and shrubs. In several areas, the vegetation has degenerated into secondary vegetation. The major contributing factor is human deliberate activities like animal grazing, construction, cutting of grass and trees for firewood and bush burning.

1.3.3 River and Water Body

There is a single river system in the study area. The Atari River Basin which lays its stream channel straight from the mountainous area of Mt. Elgon National Park (around Piswa area near the peak Muzoa; 3,338 m) and forwards to confluence point with the Kelim River which flows into the Lake

Opeta (Awoja Wetland System). A tributary of the Atari River, the Tabuk River which emerges from the same Mt. Elgon National Park and passes through the Ngenge River Basin (Kween District) and joins in the Atari River approximately 1.5 km downstream from the lower end of the planned scheme of the Atari River Basin.

1.3.4 Wetland and Land Resource

(1)Atari Wetland Area

The Atari wetland area is a sub-catchment of the Awoja Catchment which is one of the eleven (11) catchments of the Lake Kyoga Water Management Zone; other sub-catchments in this catchment are: Ukutat, Muchilmakat, Kelim, Taboki, Sipi, Muyembe, Simu-Sisi, the Lake Okolitorom, Opeta-Bisina, the Lake Kochobo, Apeduru-Apapi and Mt. Napak. The total area of the Atari River Basin covers 9.24 km^2 in the districts of Kween (Ngenge S/C) and Bulambuli (Bunambutye S/C) as shown in Table 1.3.1.

Table 1.3.1 Administrative Location of Atari Wetland Area

Name of Site	District	Sub-County	Parish
Atari Wetland Area	Bulambuli	Bunambutye	Buwebere
	Kween	Ngenge	Sikwa

Source: JICA Study Team

The location of Atari wetland area is shown in Figure 1.3.1.

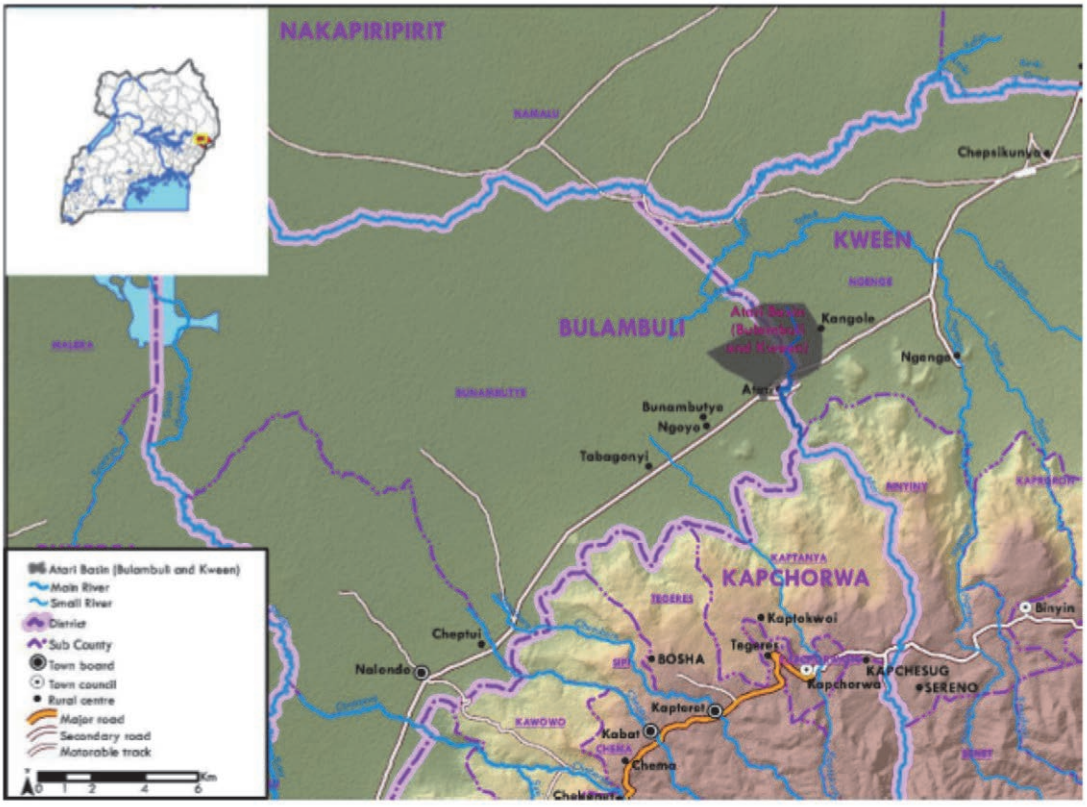


Figure 1.3.1 Overview Map of Atari Wetland Area

According to the National Wetlands Policy (1995), the term wetland refers to an area where plants and animals have become adapted to temporary or permanent flooding by saline, brackish or fresh water. They include areas of seasonally flooded grasslands, swamp forest, permanently flooded papyrus, grass swamp and upland bogs inhabited by animals that adapted to the water-logged conditions as well as fish, frogs and reptiles. Globally, wetlands constitute one of the most sensitive, biologically productive and vital ecosystems in the world. It covers 5 % of the earth's ice-free land surface.

In East Africa, Uganda has the largest percentage of wetland coverage, for example, Kenya has 4 % of the total land cover, Tanzania has 7 %, and Uganda currently has about 10.9 % as revealed by wetland mapping carried out in 2008. This is however much lower than the 13 % revealed from the data set of 1994.

(2) Land Resource

Given the various functions of the wetland components (open river water, permanent and seasonal in the area), the immediate and far communities get access to the following services as shown in Table 1.3.2.

Table 1.3.2 Services/Functions/Benefits from the Wetland

Provisioning Services	Regulating Services	Cultural Services	Life supporting Ecological Processes / Services.
➢ Water for humans and livestock; irrigation agriculture and industrial production; ➢ Food for humans and fodder for livestock; ➢ Wildlife habitat; ➢ Building materials (wood, reed, fibre, sand and clay); ➢ Herbal medicinal products; etc.	• Groundwater replenishment; • Water purification/ waste treatment and or dilution; • Biological control of pests/diseases; • Flood/storm control, flood storage; • Soil, sediment and nutrient retention; • Shoreline and riverbank stabilization; • Local climate regulation/ buffering of change; • Carbon storage/ sequestration	• Spiritual and religious values; • Recreational sports (swimming, hunting, fishing, tourism, etc.); • Cultural heritage; • Contemporary cultural significance including fine arts and creative inspiration; • Nature studies/ research pursuits/ educational use values; • Existence values; • Aesthetic and 'sense of place' values.	• Soil formation. • Primary production (photosynthesis, nutrient and carbon recycling); • Animal reproductivity; • Flora productivity, pollination, regeneration processes; • Species interactions, including grazing, predation, competition, dis- eases and pathogens; • Flora and fauna species dispersal and migration.

Source: JICA Study Team

The land use of Atari wetland area is shown in Table 1.3.3.

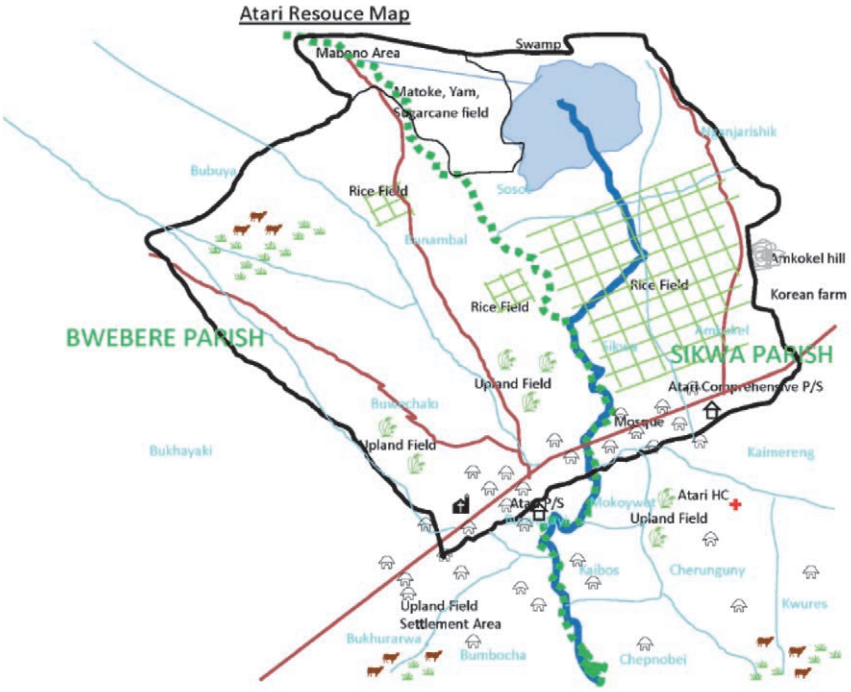
Table 1.3.3 Land use of Atari Wetland Area

Type of Use	Description
Cultivation	Crop production is the basis of community economy with over 80 % of the population deriving their livelihood from subsistence mixed farming (using hand-hoe and oxen plough). This approach to production has often resulted in annual food shortages and limited cash inflows in many households.

Type of Use	Description
	Community meetings brought out food crops (maize, beans, vegetables/tomatoes/cabbages, bananas, potatoes, sugarcane and rice), traditional cash crop (cotton and sunflower) and tree planting (agroforestry/fruit trees, tree plantations/eucalyptus, and boundary marking) as the most common undertakings.
Livestock grazing	Open grasslands in the study area are an important source of fodder for both domestic livestock (cattle, goats and sheep) and wildlife.
Hunting	Communal hunting for sitatungas, edible rats and some ducks is common as a source of game/wild meat. This dry season activity is undertaken by the youths/young men and is characterized by bush burning which results in the destruction of the ecosystem as well as the neighbouring crop fields and tree plantations.
Vegetation use	There are large tracts/patches of bush composed of flora and fauna as indicated above; these are very important sources of firewood, roofing grass and poles, medicinal herbs, raw materials for crafts-making and food/fodder for people and livestock. These are also areas for sitting apiculture bee-hives.
Housing and public infrastructure	The majority of homesteads and public infrastructure (such as primary schools, health centre, church, mosques) are constructed in the study area along the main roads. There are also narrow access roads and footpaths constructed by the community within the resource area.

Source: JICA Study Team

The resources in Atari wetland area provide a wide range of goods and services to the communities in and outside it. A participatory process by the stakeholders was adopted to evaluate the land resources and provided a basis for wise-use (resource use, zoning, restoration, etc.) and investments in the resource area. As a result of the process, a resource map was prepared by the communities and indicated in Figure 1.3.2.



Source: JICA Study Team

Figure 1.3.2 Resource Map of Atari Wetland Area

The Atari River had some diversion between 1964 and 1965 by the Nandis in neighbouring Kenya to water their herds of cattle. In the 1980s, some immigrants from Butaleja (Doho Irrigation Scheme) created a local water channel, upstream the Nandi diversion, for paddy rice growing and in 2004,

Action Aid constructed an irrigation canal upstream the earlier canals. Those diversions impacted negatively on the hydrological setting and the 2006/7 heavy rains led to soil erosion from the watershed, and deposition of soils along the Atari River course; progressively, erosion of the watershed has forced the river to change its course. This has created a permanent swamp downstream on the side of Sikwa Parish.

The historical Atari wetland use analysis was done and summarized in Table 1.3.4.

Table 1.3.4 Summary of Resource Use Trends in Atari Wetland Area

Land/Water Resource	Remarks on Causes of Change (legislations/policy, droughts, floods, civil strife, rustling, disease, etc.)		
	1940/1960	1961/1980	1981/2015
Fodder/Grass	No cattle rustling	Cattle rustling and diseases	Involvement in other agricultural activities e.g. cultivation, river course diversion.
Maize growing	Soil fertility, Good climate, Limited pests	Long drought, Insecurity	Less drought, Security, Improved technology
Rice	No knowledge of growing it	No knowledge of growing it	Knowledgeable farmers, Ready market
Bananas (now an indicator of the prevailing ecology)	No knowledge	Knowledgeable farmers	Improved technology, Climate change, Ready market
Building materials (grass, poles, sand, clay)	Low population, Less charcoal production, Nomadic living	Population growth, Charcoal burning, Settled life	Poor environment management, Area and need for structures, High demand for charcoal and firewood
Yams/ Cassava/ Potatoes	No seedlings, No idea, No swamps	Acquired seedlings, Increasing demand for food, Good weather	Increasing demand, Climate change
Vegetables (cabbage, onions, tomatoes)	Fewer seeds, Low market	Use of vegetables, Drought	Good climate, Improved technology, Ready market
Firewood /Charcoal	Low demand, No charcoal burning	Insecurity, Less cutting of trees	Population increase, Deforestation
Sugar cane	Low market, Less interest	Wild animals, Damage sugar cane, Drought	Poor transportation, Low skills, Limited land
Cotton	Ready market, Local Cooperatives, Local use	Insecurity, Pests/diseases, Poor markets & transportation	Poor market, No cooperatives, Limited land, Lack of skills to control pests
Sunflower	Limited idea, No seeds	Limited idea, No seeds	Availability of seeds, Ready market, Improved transportation
Coffee	No idea	No idea	Availability of seeds, Coffee Development Authority (C.D.A), Ready market
Millet	Main food crop, Good climate	Insecurity, Climate change, Limited farming equipment	Introduction of new varieties, Subsistence farming
Fruits	Climate, Pests/diseases	Climate, Pests/diseases	Climate, Pests/diseases
Crafts materials (fibres, round sticks, palm leaves, etc.)	Drought	Good climate	Good climate, Market
Fish	Fluctuating quantities of water in the river	High demand	High demand for fish given reduction in animal populations
Herbs	High medicinal knowledge amongst community men and women	High demand	Declining demand due to reduced livestock and more clinics
Water	With always the alternative source of water	Frequent droughts and hence only source of water	Frequent droughts and hence only source of water

Source: JICA Study Team

A simple economic valuation was introduced and discussed with individual resource users groups in

accordance with the manners below:

- ✓ Generate a list of some key wetland resources (produced or used);
- ✓ Establish the amount or quantity of resources produced or used and its value (price) for each resource;
- ✓ Attain an agreement on the amounts harvested or produced per day, week, month and year; and
- ✓ Multiply the amounts or quantities established with the price (unit price).

A list of products from Atari wetland with the tagged prices is shown in Table 1.3.5. The estimated values based on the local resources ran up to some USh 8 billion (equivalent to US$ 2.4 million)[2] per year.

Table 1.3.5 Economic Values Generated for Each Product from Atari Wetland Area

(a) Product	(b) Unit	Amount produced & sold per season		Selling price /unit per season (USh)		(g) No. of users	Total price per season (USh)		(j) Total estimate per year (USh)
		(c) High	(d) Low	(e) High	(f) Low		(h) High	(i) Low	
Banana	Bunch (20kg)	3	2	15,000	12,000	137	36,000	30,000	9,042,000
Maize	Kg	3,000	2,000	1,000	800	137	2,400,000	2,000,000	602,800,000
Beans	kg	500	400	2,000	1,800	137	900,000	800,000	232,900,000
Yams	Katalas	60	50	30,000	25,000	137	1,500,000	1,500,000	411,000,000
Cassava	Bag (300kg)	65	55	40,000	35,000	137	2,275,000	2,200,000	613,075,000
Rice	kg	15,100	12,100	2,200	2,000	107	30,200,000	26,220,000	6,079,740,000
Vegeta-bles	Bundle (3kg)	50	19	500	200	137	10,000	9,500	2,671,500
Building poles	pole	50	45	2,000	1,500	137	90,000	75,000	22,605,000
Roofing poles	pole	50	45	1,000	800	137	45,000	40,000	11,645,000
Reeds	Bundle	10	8	5,000	4,000	137	40,000	40,000	10,960,000
Grass (thatch)	Bundle	50	25	2,000	1,500	137	75,000	50,000	17,125,000
Grass (livestock fodder)	Bag (50kg)	4	2	10,000	8,000	79	32,000	20,000	4,108,000
Fibres/ ropes	Bundle	10	8	3,000	2,500	16	25,000	24,000	784,000
Water (domestic)	Jerry can	4	2	500	300	137	1,200	1,000	301,400
Water (livestock)	Jerry can	15	10	500	300	137	5,000	4,500	1,301,500
Herbs	Handful (1kg)	2	1	5,000	3,000	33	6,000	5,000	363,000
Fish	Piece	3	1	10,000	8,000	28	24,000	10,000	952,000
Firewood	Headload	7	5	3,000	2,500	137	17,500	15,000	4,452,500
								Total	**8,025,825,900**

Source: JICA Study Team
Note: (h) = (c) x (f), (i) = (d) x (e), (j) = [(h) + (i)] x (g)

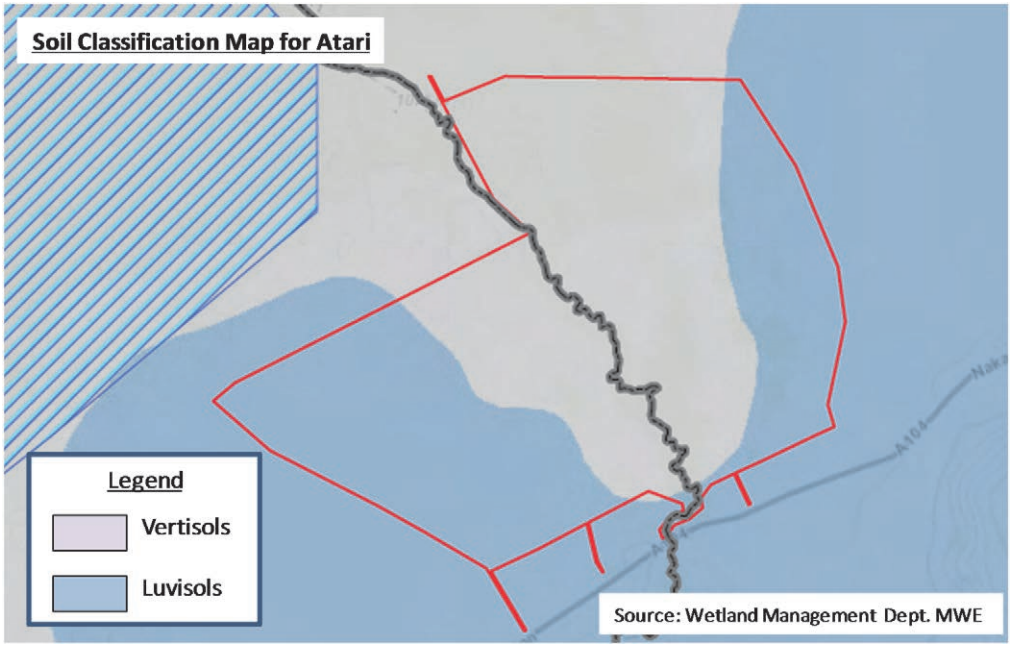
1.3.5 Soil

The area lies on an alluvial plain with sediment from rivers. According to the soil maps prepared by National Agricultural Research Organaiasion (NARO) of Uganda, Vertisols are dominant in the area,

[2]US$ 1.00 = USh 3,300

followed by Luvisols. Vertisols are heavy clay soils with a high proportion of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. These soils have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains where reclamation and mechanical cultivation can be envisaged are assets of Vertisols. Their physical soil characteristics, and notably their difficult water relations, cause management problems. The agricultural uses of Vertisols range from very extensive through smallholder post-rainy season crop production to small-scale and large-scale irrigated agriculture. Management practices for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility.

Luvisols have a higher clay content in the subsoil than in the topsoil, as a result of pedogenetic processes (especially clay migration) leading to an argic subsoil horizon. Luvisols have high-activity clays throughout the argic horizon and a high base saturation in the 50–100 cm depth. Most Luvisols are fertile soils and suitable for a wide range of agricultural uses. Luvisols with a high silt content are susceptible to structure deterioration where tilled when wet or with heavy machinery. In places, the dense subsoil causes temporarily reducing conditions with stagnic properties.



Source: Based on MWE

Figure 1.3.3 Soil Classification Map of the Study Area

In soil profile observation at the several points of right and left banks, the topsoil of the area is characterised by heavy clay to sandy clay, very sticky and black to brownish black colour. The boundary of the subsoil is usually not clear. The texture of subsoil is generally clay.

As a part of the Environmental Impact Assessment (EIA), soil survey was carried out. The soil sampling was done at 2 sites of paddy field and 1 site of the upland field and laboratory analysis was carried out for their top soils. The major chemical characteristics are; pH of the soils is neutral to slightly acidic; total nitrogen, organic matter and available phosphorus are at a moderate level; and

exchangeable potassium, calcium and magnesium are sufficient. The PISD-EIA concluded as the soils have moderate to high productivity in terms of agricultural production.

According to the PISD-SES, 25 respondents out of total 28 answered: "very good" or "good" in soil fertility or their farmland. Therefore, most farmers in the area satisfy soil fertility in crop production. To maintain or improve soil fertility, most of the farmers use some kinds of organic fertilizers, such as backyard manure, compost and green manure. Crop rotation is partly practised in the area. Only 4 % of the farmers use chemical fertilizers, by possible reasons of their high price, poor access to suppliers and suspicion about their efficiency.

1.4 Water Resource and Hydro-meteorology

1.4.1 Climate and Rainfall

The climatic classification of Uganda is the tropical climate with rainy and dry seasons. Directorate of Water Resource Management (DWRM) classified the 16 climate zones based on the analysis of monthly rainfall records at 102 rain gauges for the period 1940-75 in "Hydro-Climatic Study Report on the Water Resources of Uganda (2010)". The study area is located in zone F. It is assumed that there is virtually one rainy season from March to October, with the main peak in April and a secondary peak in August and one dry season December to about mid-March.

Since there is no weather station in the area or watershed, data for the nearest meteorological station in Soroti was adopted. Summary of Soroti monthly meteorological data is shown in Table 1.4.1.

Table 1.4.1 Summary of Monthly Meteorological Data at Soroti

Month / Item	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total or Average
Temp (°C)	25.3	26.1	26.0	24.8	24.2	23.8	23.4	23.5	24.1	24.2	24.2	24.9	24.5
Relative Humidity (%)	50.0	47.5	56.6	64.0	67.3	68.2	69.2	69.9	66.4	64.8	62.7	53.8	61.7
Rainfall (mm)	37.2	27.5	94.7	165.9	160.0	113.3	130.8	167.0	138.9	146.1	111.0	47.4	1,339.9
Sunshine hours (hr)	8.3	8.4	7.9	7.6	7.8	7.6	6.3	6.9	7.9	8.5	8.6	8.7	7.9
Evaporation (mm)	5.9	6.1	6.1	5.3	4.4	4.5	3.8	4.2	5.0	5.0	5.2	5.6	5.1

Source: Uganda National Meteorological Authority
Arranged by JICA Study Team from the Development Study on Water Resources Development and Management for Lake Kyoga Basin, JICA, 2011

Monthly mean maximum temperature is 33.0 °C in February, while the monthly mean minimum temperature is 18.1 °C in August. Annual rainfall ranges from 1,055 mm to 1,788 mm and the average is about 1,340 mm. The annual mean pan evaporation is 1,853 mm. Since evaporation data was not observed in Soroti meteorological station, the data in Tororo was shown below. Although the meteorological data in Tororo has been utilized for water balance analysis for Atari irrigation scheme in Phase 1, the meteorological data in Soroti was utilized for water balance analysis in Phase 2 based on the result of observation of meteorological data in Atari irrigation scheme.

1.4.2 Installed Meteorological and Hydrological Stations

(1)Sitting of the Meteorology and Rain Gauge Stations

In order to collect accurate meteorological data for the study area, weather station, rain gauge and automatic water level gauge had been installed within or nearby the study areas and within or nearby the corresponding watersheds and at the Atari River respectively. For the selection of the appropriate space for the installation of the equipment, site visits were conducted together with the DAO of each target site to ascertain space and considering the security situation and easy accessibility, the sites for the installation of the equipment were decided upon as shown in Figure 1.4.1.

(2)Location of the Installation Sites

Selected sites for the installation of the meteorological station, rain gauge and water level gauging station are listed below.

Table 1.4.2 Location of the Meteorological Station, Rain Gauge and Water Level Station

Installed equipment	Name of Place	District of Location	Coordinates	Elevation
Meteorological Station	Atari Health Centre II	Bulambuli	N 1°29'53.18" E 34°26'36.65"	1,088m
Rain gauge station	Kapchorwa District LGO	Kapchorwa	N 1°23'36.97" E 34°27'02.82"	1,961m
Water Level Gauge	The Atari River water level monitoring station	Kween	N 1°30'05.21" E 34°26'44.04"	1,086m

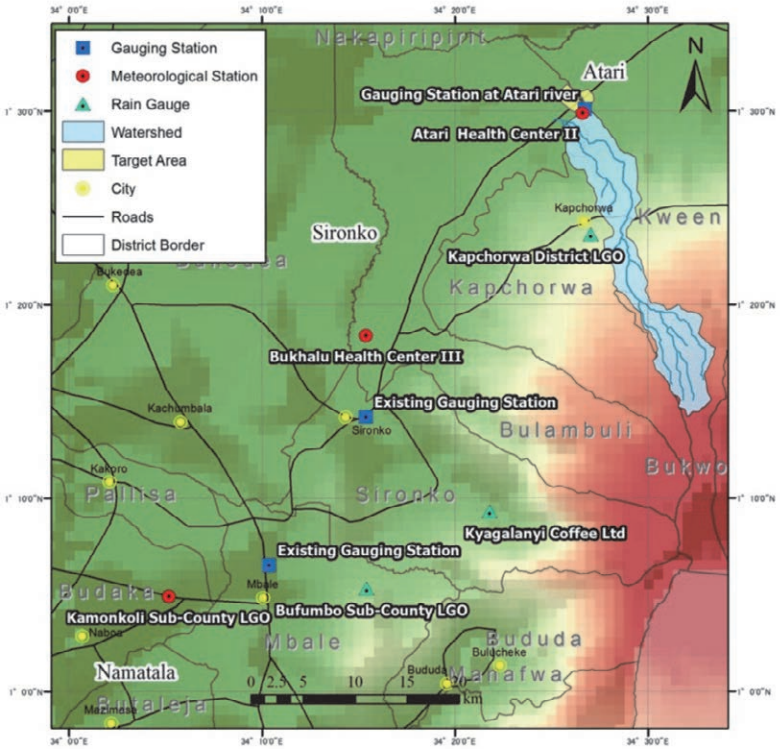


Figure 1.4.1 Installed Station in the Study Area

1.4.3 Collection of Meteorological Data

(1) Item of Meteorological Data

A collection of Meteorological data as shown below in the table started from March 2015. These observed items are mainly used for selection of applicable rainfall data and calculation of the evapotranspiration by using Penman-Monteith equation for the water balance analysis.

Table 1.4.3 Item of Meteorological Data

Item	Unit	Interval	Remark
Temperature	°C	10 min.	
Relative humidity	%	10 min.	
Solar radiation	W/m²	10 min.	Hours of sunlight and Solar irradiance are calculated from observed data
Wind speed and Gust speed	m/sec	10 min.	
Rainfall	mm	10 min.	

(2)Observed Data

The observation started from the end of February 2015 at Atari Health Centre II and Busulani S/C. The figures below show the results of observation after installation of the meteorological station near to the study area and rain gauge station of the watershed. Figure 1.4.2 shows observed temperature data. It's showing that average temperature is almost constant through a year and maximum temperature in the site is almost reach to 40°C in site. The temperature in the watershed is cooler than that in the site because of the high altitude of the station.

Figure 1.4.3 showing that monthly rainfall in the watershed is higher than that in site. The first peak of rainfall is in April to June and the second one appears in October to November. There is almost no rainfall in the site in February.

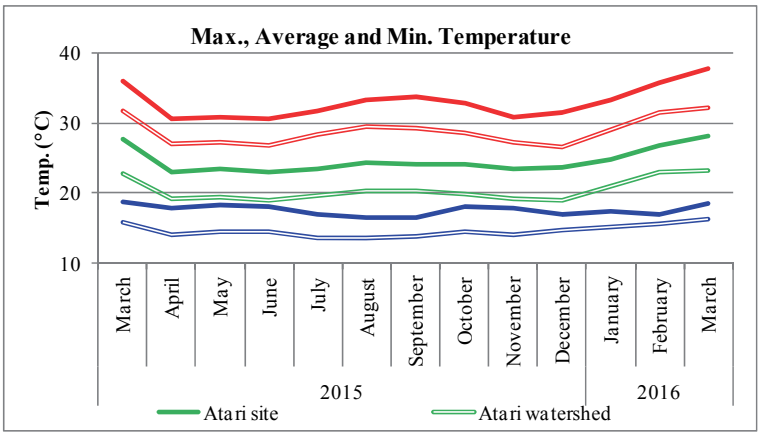


Figure 1.4.2 Observed Temperature at Site and Watershed

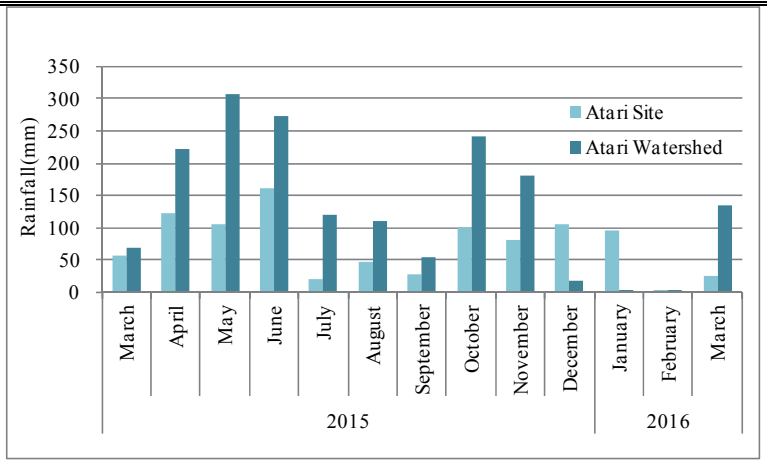


Figure 1.4.3 Observed Rainfall at Site and Watershed

1.4.4 Observed Hydrological Data

Since there had been no facility for recording water level in the Atari River, JST installed automatic water level gauge at the intersection of the Atari River and national road. Observed water level data was converted to discharge by H-Q curve which is newly developed by JST.

Figure 1.4.4 below shows the observed discharge data at the Atari River gauging station and daily rainfall data at the site and watershed. It show's seasonal change of the discharge. After increment of rainfall from April to June, river discharge is gradually increased a little later. From May to August, the river has plenty of water. When the second rainy season come, the river discharge increase again from the end of October to December. After that amount of river discharge is gradually decrease until next rainy season come.

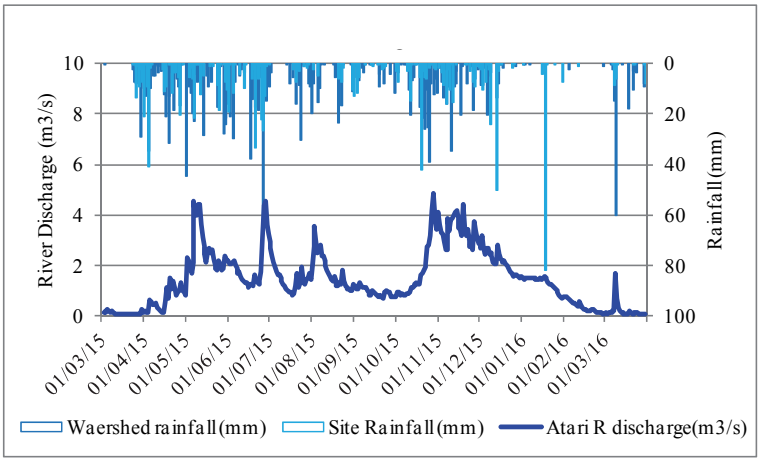


Figure 1.4.4 Observed Discharge Data at the Atari River Gauging Station and Daily Rainfall Data at the Site and Watershed

1.4.5 River Discharge

Water resource for this area is the Atari River with a catchment area of 103 km^2. Within a part of the area, 450 ha of paddy planting are practised so far, but acreage is rather small and restricted compared with its potential. As for the existing intake facilities at the Atari River, irrigation water is drawn

from the river through weir made of reinforcing concrete installed by NGO. However, lower parts of gates are corroded and hoisting devices are out of function. The Atari River flows in the direction from south to north from halfway up the Mt. Elgon region as the origin then the flow enters into the study area. The Atari River flows into the Kelim River and finally drains into the Lake Opeta.

Since there was no gauging station along this river, the specific discharge data of the Sipi River, which is the closest station to the Atari River and has a correlation with it, was used to estimate the Atari River discharge. The record is collected manually two times a day at 9:00 AM and 3:00 PM. The catchment area of the water level gauging station is measured by MWE. The total catchment is 92 km^2 and this figure is used to calculate specific discharge of the Sipi River. The location map of Discharge station is shown in Figure 1.4.5.

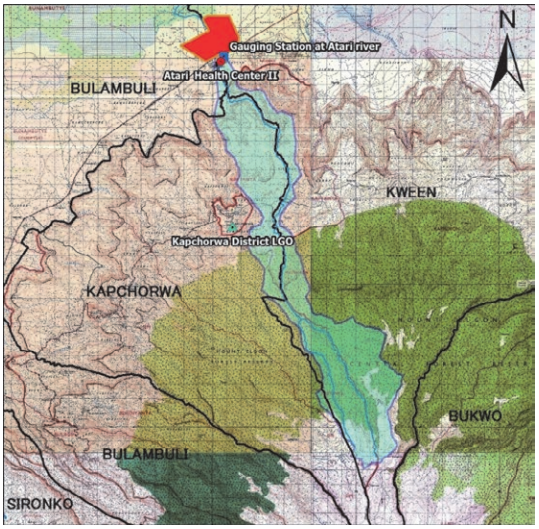


Figure 1.4.5 Location of Gauging Station in the Atari River

Monthly river discharge and annual total discharge are shown in Table 1.4.4 and Table 1.4.5 respectively. The figure shows seasonal discharge pattern, which is obtained from the monthly averages for the period from 2000 to 2012. Discharge increases from April to November and then decreases in December. Maximum monthly discharge is observed in August to December.

Table 1.4.4 Monthly Average, Maximum and Minimum River Discharge (2000-2012)

Unit: m^3/sec

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Monthly Average	0.88	0.64	0.82	1.30	2.34	1.88	2.70	5.14	4.67	3.69	3.33	1.83	2.43
Max	1.88	1.51	4.36	6.42	8.58	6.45	6.73	8.49	8.55	8.80	7.06	4.58	6.12
Min	0.26	0.18	0.16	0.21	0.59	0.24	0.20	1.67	1.24	1.26	0.72	0.57	0.61

Source: MWE

Table 1.4.5 Annual Total River Discharge (2000-2012)

Unit: Mm^3/year

Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Average
Total Discharge	46	57	23	58	49	61	86	108	80	52	170	108	105	77.2

Source: MWE

1.5 Irrigation and Drainage

1.5.1 Irrigation Condition

Cultivation of paddy rice was introduced to the area in the 60's by a soldier who first moved to the area from Doho Irrigation Scheme. Since then, many farmers (especially on Sikwa side) have engaged in the production of rice by diverting the river to their land. Around 2004, Action Aid installed permanent intake structure to divert water to their field. After the introduction of this modern irrigation, the communities on both sides of the river have diverted the water to their fields at about three points upstream of the intake structure. These (modern and traditional) intake structures are diverting the uncontrolled amount of water to their respective irrigation area, resulting in over flooding of the field, poor drainage system and conflict over the water resource.

Presently, around 226 ha of land in Atari area is developed by both Sikwa and Buwebere sides using the existing diversions. The area covered by irrigated paddy land is increasing annually, mainly toward Buwebere side along the river. However, the change in the course of the river hindered the expansion at the pace the community of Buwebere side wishes because the water in the old river course vanishes at the middle of the land and all the water in the river flows towards Sikwa side.

1.5.2 Drainage Condition

Presently the Atari River is diverted at about 3 points upstream of the Action Aid Intake Structure. Most of the water diverted from these points is conveyed in hand-dug canals of unsuitable sizes. It is very common to see water flowing out of the canal into the field. No properly designed drainage canals are available in the existing irrigation system. In addition, the river course has been changed toward Kween District (Sikwa Parish) creating semi-permanent flood plain on the cultivated area around the downstream portion of the study area where the main drainage canal dug by Action Aid is located. This drainage canal is totally failed to provide its intended purpose and is totally flooded in the semi-permanent flood plain created due to the change in the river course.

1.5.3 Flood Affection

During the rainy season, a huge amount of water flows from the hilly catchment of the river resulting in overtopping of the water from the river bank along the river course. This water floods not only the residential area and the main road but also the farmland within the study area. The provision of a flood protection dyke along the river is an important intervention that should be taken into account during the planning stage of irrigation development of the area.

1.6 Other Infrastructures

1.6.1 Roads and Transport System

The study area can be accessed through Mbale-Moroto national Road which is about 77km away from Mbale. The condition of the road is relatively good but during the rainy season, there are many

points where the road is impassable due to muddy soil. Presently the Ugandan Government is upgrading the road all the way to Moroto which is planned to be completed around 2020.

As the study area is located along Mbale-Moroto national road, there are different public transportation systems in the study area such as mini-bus and motorcycle (locally called boda-boda).

1.6.2 Potable Water

Within the study area, there are about 2 boreholes serving as water supply points to the community within the study area. The Atari River is also the source of water for household consumption.

1.6.3 Communication

The only communication system in the study area is the use of the mobile telephone. The major telephone service providers are MTN and Airtel that covers most of the rural area of the country.

1.6.4 Power Supply Line

The main electric line passes through the study area along the main road. Presently, some of the community get electricity from the facility/national grid.

1.6.5 Public Facilities

(1)School Facility

There is one government-aided primary school within and around the study area and one private primary school which is a boarding school aided by the government. The list and location of these schools are summarized in Table 1.6.1 below

Table 1.6.1 School Facility in the Study Area

Name of School	Location		Comment and status
	Sub-county	Parish	
Atari PS	Bunambutye	Buwebere	Located at Atari centre It is in good condition
Atari Comprehensive PS	Ngenge	Sikwa	Located in Sikwa side Private school and in good condition

(2)Health Facility

The majority of the community in the study area uses Ngenge HC III which is about 6km far from Atari centre. The closest available health centre to the community is Atari HC II.

Table 1.6.2 Health Facility in the Study Area

Name of Health Centre	Location		Remarks
	Sub-county	Parish	
Ngenge HC III	Ngenge	Sikwa	It is in a very poor condition
Atari HC II	Bunambutye	Buwebere	

1.7 Agriculture

1.7.1 Land Use

The land use classification was initially carried out by using satellite images and GIS software, and then site investigation was made for confirmation and revision of the results. The target area of the Atari irrigation scheme is 680 ha. The area of lowland paddy field is 211 ha, which is 31 % in the target area. Lowland paddy field extends mainly in upper right bank area and a small portion of the left bank area near the river course. The area of upland field and grassland is 219 ha and 196 ha, respectively. The present land use is shown in the following table.

Table 1.7.1 Present Land Use in the Study Area

(Unit: ha)

Name of Site	Total Area	Lowland Paddy Field	Upland Field	Grassland	Trees	Bush	Others
Atari	680	211	219	196	2	28	24

Source: JICA Study Team

Source: JICA Study Team

Figure 1.7.1 Land Use Map of the Study Area

1.7.2 Land Tenure and Landholding

Average land holding size is about 2 acres (0.8 ha) in the left bank area in Bunambutye S/C and 20 acres (8 ha) in the right bank area in Ngenge S/C, according to the interview survey with the sub-counties. The mean holding area is smaller than that because there are large-scale landlords especially in Ngenge S/C.

According to the PISD Land Boundary Survey (PISD-LABOS), there are 479 landowners in the

surveyed area of 962 ha. It shows that the average land holding size is about 2.0 ha and the median is 0.7 ha. The middle part used for paddy field, upland field and settlement is divided into lots of small parcels, but eastern and western parts are extensively divided for rather large-scale owners.

The PISD-SES, n=28 in Phase 1 gave an average farmland holding size in the target area of about 4 acres (1.6 ha). Out of the area, about 3.3 acres (1.3 ha) is used for crop production. While, the PISD-FHS, n=63 in Phase 2 gave an average farmland holding size of about 5 acres (2.0 ha). Out of the area, about 4 acres (1.6 ha) is used for crop production.

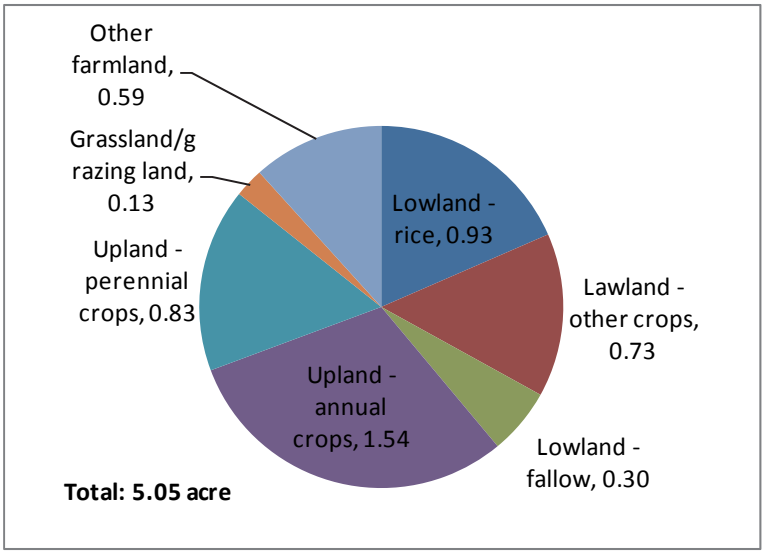


Figure 1.7.2 Land Holding Size by Usage

Source: PISD Farm Household Survey

There are some types of land tenure system, namely 1) Customary tenure, 2) Freehold tenure, 3) Leasehold tenure, and 4) Mailo land tenure. The customary land tenure system is dominant in Ngenge S/C sharing 85 %, while Freehold land tenure system is dominant in Bunambutye S/C sharing 70 %. There is neither land registration book nor cadastral map, especially in Ngenge S/C. Land can be easily sold under negotiation between a landowner and a buyer with the witness of local authorities.

According to the PISD-SES, about 75 % of the farmers in the target area are landowner farmers. The share of fully or partly rented farmers is about 36 %. According to the PISD-FHS, 75 % of the land is under customary tenure, and 17 % is under leasehold tenure, as shown in the following chart.

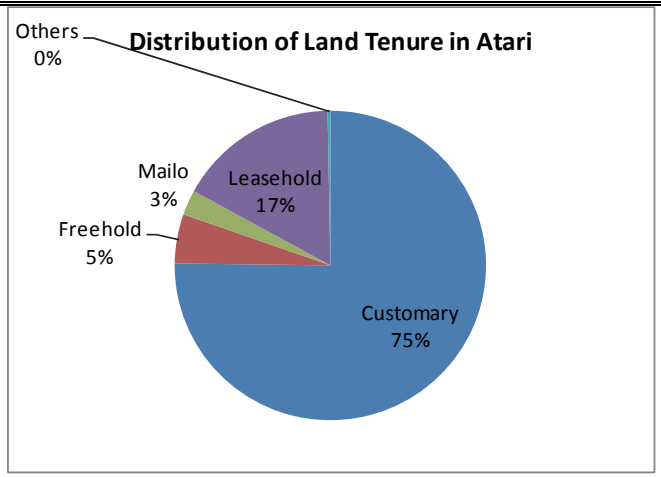


Figure 1.7.3 Distribution of Land Tenure

Source: PISD Farm Household Survey

1.7.3 Cropping System

(1)Cropping System

In general, there are 2 cropping seasons in a year, depending on bimodal rainfall pattern. The first cropping season is March - July, and the second season is August - December in this area. Main crops in the area are rice, maize, plantain (banana), cassava, cotton, sesame and sunflower.

According to the PISD-SES, the ratio of producers of rice, maize and plantain are 93 %, 89 % and 39 %, respectively. Average cropped areas of all respondent farmers for the above crops are 1.4 acres, 1.6 acres and 0.4 acres, respectively. Cassava, cotton, sesame and tomato are also cultivated in the small area.

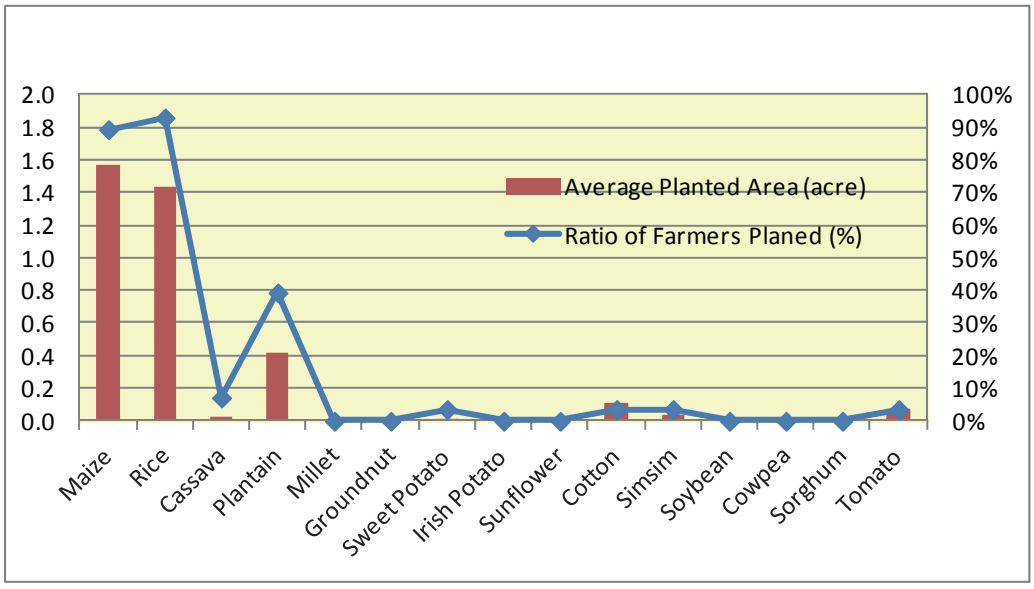


Figure 1.7.4 Average Planted Area and Ratio of Farmers Planted by Crop

Source: PISD Socio-economic Survey

The present cropping pattern in the target irrigation area was estimated by the interview surveys and satellite images, as tabulated in the following table. The lowland paddy is cultivated on 63 ha and 190 ha during the first and second season, respectively. Upland crops, such as maize and cassava are cultivated on 219 ha and 131 ha in the first and second season, respectively.

Table 1.7.2 Present Cropping Pattern in the Study Area

(Unit: ha)

Name of Site	Total Area	Lowland Paddy-1	Lowland Paddy-2	Upland Crop-1	Upland Crop-2	Perennial Crops
Atari	680	63	190	219	131	Nil

Source: JICA Study Team

The cost-benefit analysis made by Mbale District in 2012 shows rice is more profitable than other food crops. The net return of rice with a productivity of 3 ton/ha was estimated at about USh 2,200,000 per ha, while those of maize with 5 ton/ha and beans with 2.5 ton/ha were USh 1,100,000 and USh 1,500,000 per ha, respectively. In the case of plantain, the net return from 1 ha was about USh 320,000 only. Judging from this sample analysis and other information of District officials concerned, rice is recognized very profitable crops compared with other upland crops in Uganda.

(2)Farming Practice of Rice

The common farming method of lowland rice in this area is as follows, referring to the results of the PISD SES, the PISD-FHS, field inspection and interviews with relevant officers.

Rice cropping season (PISD-FHS):
Rice cropping season varies from farmer to farmer depending on field condition, rice variety, the combination with other crops, etc. Double cropping rice is implemented by 16 % of rice growers.

Rice variety and seeds (PISD-SES):
The dominant variety of rice is Super (TDX305), whose share is about 68 %. It can be sold at a higher price because of highly preferable quality, but the growth period is long (about 6 months). The second major variety is Kaiso (K85) with a share of 32 %. It is suitable for the site condition and it can be planted twice a year because of short growth period (about 4 months). New Rice for Africa (NERICA) series is not introduced to the area, even though National Crops Resources Research Institute (NaCRRI) promotes NERICA-6 and WITA-9 because of high-yielding and tolerance to yellow mottle virus.
About 38 % of farmers keep their previous products as seeds for next season, and most of the remaining farmers buy rice seeds from shops and fellow farmers of the local market. The certificated rice seeds are not circulated to farmers at present. Therefore, a mixture of varieties is commonly found.

Land preparation (PISD-SES):
The common method of bush clearing is slash-decompose with a share of 51 %. The shares of slash-burn and slash removal from the farm are 29 % and 17 %, respectively. Only 2 % of farmers

use herbicide.

Three-quarters of farmers use only hand hoes for land preparation. The tractor was used in lowland rice cultivation by 18 % of farmers. The remaining use is ox-plough.

Nursery preparation and transplanting:

Wet nursery is commonly established in a part of the main field to prepare seedlings in these years. Nursery period is estimated at 3 to 5 weeks in this area. Random planting method is dominated, although some trained farmers employ line planting method.

Fertilizer application (PISD-SES):

Very few farmers use chemical fertilizer to wetland rice, although most of the farmers use chemical fertilizer to upland crops and horticultural crops. The effect of fertilizer on rice yield is not always promised in the local condition.

Pest and disease control (PISD-SES):

The most serious diseases in rice are rice blast and yellow mottle virus. About 42 % of rice growers use agrochemicals to control those diseases. More than a half of farmers do not care about pest and disease control so much. Bird scaring is commonly done by young boys during the ripening period.

Weed control:

Weeding is done once or twice by hand. No rotary weeder is found in the area, even though some farmers transplanted in line.

Harvesting:

Rice is harvested manually by using the sickle. Harvested rice is sometimes heaped in a field for a short period. The common threshing method is hitting rice panicles to the ground. After threshing, rice grains are exposed to the sun on drying floor or tarpaulin until dry enough.

Postharvest (PISD-FHS):

More than 90 % of rice growers use private rice mills. Most rice growers bring rice to middlemen in the local market (46 %) or in city market (29 %). Less than 20 % sell rice to middlemen coming to their house or field. About 87 % of rice growers store rice in the house and 13 % in the granary.

Constraints in farming (PISD-FHS):

Major constraints in rice farming are; Unstable irrigation water supply (21 %), Low productivity (15 %), Lack of farm labour (14 %), Pest & disease damage (14 %), Size limitation of field (8 %), High cost of farm input (8 %), Low price of rice in market (8 %) and so on.

Constraints in marketing (PISD-FHS):

Major constraints in rice marketing are; Low bargaining power against traders (32 %), Long distance to rice mill/wholesaler (21 %), Poor quality of rice mills (19 %), Low availability of traders at site (13 %), and Low capacity of trading place at site (9 %) and so on.

(3)Farming Practice of Upland Crop (Maize)

Several upland crops, such as maize, cassava, millet and sweet potato, are cultivated in both lowland and upland fields. Maize is selected as a representative upland crop in the area, as it is the most popular food crop among them. Maize is sometimes cultivated under an intercropping system with legume crops. The farming practice of maize is surveyed in the PISD-FHS and summarized below.

Average cropped area among 58 maize growers is 2.6 acres in the main season. Double cropping of maize is practised by 29 % among rice growers (17 in 58).

Varieties of Longer series are dominant. The main source of maize seeds is a local market (38 %), followed by home saved (29 %), and input shops (19 %).

Bush is cleared by slashing without any herbicide. Land preparation is made by hand tools (47 %), by ox plough (29 %), and by power tiller or tractor (24 %).

About 95 % of maize growers do not manage soil fertility. About 84 % of maize growers do not control pest and diseases.

More than half (55 %) maize growers sell maize to middlemen coming to their house or field, and others bring maize to middlemen in the local market (10 %) or in city market (14 %). About 73 % of maize growers store maize in the house and 24 % in the granary.

(4)Farming Practice of Perennial Crop (Plantain)

Plantain is selected as a representative perennial crop in the area, as it is the most popular food crop among them. The farming practice of plantain was surveyed in the PISD-FHS and summarized below.

Average cropped area among 18 plantain growers is 1.3 acres.

The main source of seedlings is fellow farmers (67 %), followed by local market (20 %).

Bush is cleared by slashing without any herbicide. Land preparation is made by hand tools (76 %), and by ox plough (24 %).

About 94 % of plantain growers do not manage soil fertility. About 88 % of plantain growers do not control pest and diseases.

Nearly half (46 %) plantain growers sell plantain to middlemen coming to their house or field and bring plantain to middlemen in the local market (38 %). About 57 % of plantain growers store plantain in house and 14 % under shed

(5)Farming Practice of Industrial Crop (Sunflower)

Several industrial crops, such as soybean, sunflower, sesame and cotton, are cultivated mainly in upland fields. Sunflower is selected as a representative industrial crop in the area, as it is the most

popular industrial crop among them. The farming practice of sunflower is surveyed in the PISD-FHS and summarized below.

Average cropped area among 7 sunflower growers is 1.3 acres.

The main source of seeds is home saved (57 %) and fellow farmers (29 %).

Bush is cleared by slashing without any herbicide. Land preparation is made by hand tools (57 %), and by ox plough (29 %).

All (100 %) of sunflower growers do not manage soil fertility. All (100 %) of sunflower growers do not control pest and diseases.

About 86 % of sunflower growers sell sunflower seeds to middlemen coming to their house or field. About 80 % of sunflower growers store sunflower seeds in the house.

(6)Farming Practice of Vegetable (Tomato)

Some vegetables are cultivated in both lowland and upland fields. Tomato is selected as a representative vegetable in the area, as it is the most popular vegetable among them. The farming practice of tomato is surveyed in the PISD-FHS and summarized below.

Average cropped area among 5 tomato growers is 1.4 acres.

The main source of seeds is input shop (50 %), home saved (25 %) and local market (25 %).

Bush is cleared by slashing without any herbicide. Land preparation is made by hand tools (80 %), and by power tiller/tractor (20 %).

Some 40 % of tomato growers do not manage soil fertility, but 40 % use chemical fertilizer. About 60 % of tomato growers use agrochemical and 40 % do not control pest and diseases.

All (100 %) of tomato growers sell tomato to middlemen coming to their house or field.

(7)Animal Husbandry and Fishery

The major livestock in the area are cow, goat and poultry. Milk production from cows is rather an important source of income to farmers. The maximum number of cattle kept is about 20 heads. There is no large cattle keeper to avoid conflicts with Karamojong people. Recently, the local government has supported the farmers' group of the area to keep goats.

The following table shows the results of PISD-SES. The ratio of farmers who keep cattle, goat and poultry are 54 %, 54 % and 86 %, respectively. The number of cattle per household is 3.7 and 73 % of cattle keepers use it for milk production.

Table 1.7.3 Status of Animal Husbandry in the Study Area

Livestock	% of Breeders	Average breeding number (head/HH)	Remarks
Cattle	54	3.7	73 % for milking purpose
Goat	54	3.0	
Sheep	7	1.5	
Pig	4	3.0	
Poultry	86	5.8	
Others	-	-	

Source: PISD Socio-economic Survey (Farm Household Survey)

Inland fish culture with fishpond is not very active in the area. Fish catching activity using local-made nets or traps is sometimes practised for the local consumption.

1.7.4 Crop Production

The present yield of rice was initially estimated by statistic data, relevant information and the results of the PISD-SES and the PISD-FHS, but the data is not always accurate. Therefore, a simple fertilizer application trial and some yield surveys were conducted in the target area in the second season of 2015.

In the trial site, the rice (Super) yield was 2.8 ton/ha without fertilizer and 3.8 ton/ha with fertilizer (basal application of Urea 50 kg/acre and DAP 25 kg/acre at transplanting time). The simple fertilizer application trial shows the yield of rice can be increased by 1 ton/ha or more.

The yield of rice (Kaiso) in the existing irrigated area on the right bank area was 4.5 ton/ha without fertilizer. The yield of rice (Super) broadcasted in unstable water condition was only 1.2 ton/ha. Considering the sample fields were better than average, the average yield of rice is comprehensively estimated at 3.0 ton/ha at present. Also, it was confirmed that the rice (Kaiso) has a potential yield of more than 4 ton/ha without fertilizer application in the area.

Table 1.7.4 Result of Rice Yield Survey

Location	Harvesting Date	Variety	Area (m^2)	Yield (ton/ha)	Remarks
Atari-Right	Dec. 04	Super	770	3.8	Sown on July 11, Transplanted on Aug. 11, Fertilizer Trial site: With Fertilizer
Atari-Right	Dec. 05	Super	1,010	2.8	Sown on July 11, Transplanted on Aug. 11, Fertilizer Trial site: Without Fertilizer
Atari-Right	Dec. 02	Kaiso	1,254	4.5	High yield, confirmed by additional unit area survey method
Atari-Left	Dec. 06	Super	1,020	1.2	Broadcasted on May 15, Affected by water shortage

Source: JICA Study Team

The annual rice production is estimated at 837 ton at present, based on annual rice cropped area of 279 ha and yields of 3.0 ton/ha.

The yield of maize is also estimated at 3.5 ton/ha, based on statistic data, relevant information and the results of the PISD-SES and the PISD-FHS. Therefore, the annual production of maize is calculated

at 1,225 ton, based on the annual maize cropped area of 350 ha.

1.7.5 Post harvesting and Marketing System

(1)Situation and Capacity of Rice Millers in the Area

Rice millers in Atari show the following milling condition and relevant challenges. The information was collected during the milling survey conducted in November 2015 scoping for rice distribution within the far eastern region along Kween, Bulambuli and up to Mbale as a channel of rice/paddy produced in the area of Atari.

Table 1.7.5 Current Capacity and Challenges in Rice Milling in Atari Area

Item	Kween/Bulambuli (Ngenge near)	Bulambuli	Mbale (Industrial area*)
Year of establishment	2010	2007	2001-2006
Capacity and power source	< 10 m^2, fuel	> 20 m^2, fuel	> 100 m^2, storage adjoining, fuel/electricity
Range of milling capacity	0.8 ton/day (at the peak) to 0.3 ton/day	3.5 ton/day (at the peak) to 1.5 ton/day	8 ton/day (at the peak) to 2 ton/day
Peak months of operation	Oct. to Nov.	Sep. to Dec.	Aug. to Dec.
Milling rate (ratio)	50 %	50 %	65 %
Annual volume of milling (rice paddy, maximum level)	110 tons approx.	880 tons approx.	1,200 tons approx.
Milling fee	USh 200 /kg	USh 120 /kg	USh 100 /kg
Distribution of paddy milled by source (from)	Farmer: 70 % Middleman: 30 %	Farmer: 65 % Middleman: 35 %	Farmer: 60 % Middleman: 25 % Buying on-site (direct): 15 %
Distribution of paddy milled by variety	Kaiso: 70 % Supa: 30 %	Kaiso: 85 % Supa: 15 %	Kaiso: 50 % Supa: 40 % Upland: 10 %
Major production site based on the share (%)	Kaiso: Ngenge Supa: Ngenge	Kaiso: Bunambutye Supa: Bunambutye	Kaiso: Ngenge, Bulambuli (each at 20 % share including other areas) Supa: Budaka, Bukedea (ditto)
Major challenges	- Milling quality - Milling capacity (competition with Maize processing)	- Unstable power supply - Maximization of milling capacity to meet demands	- Power supply and thigh tariff - Road network and condition with associated transportation costs
Estimated no of millers within the vicinities of trading centre	3	7	6 (out of 14 in total)

Note: *the values presented were an average of three (3) millers located in the industrial area of Mbale.

(2)Current Status of the Facilities under CAIIP Programme

1)Challenges in Operation and Management

There are three sub-counties; Ngenge (lower-belt), Benet and Kitawoi (upper-belt), where post-harvesting and marketing facilities were newly constructed and installed under the Ministry of Local Government with supports of African Development Bank (AfDB) for the CAIIP (Community Agricultural Infrastructure Improvement Programme). Each sub-county received packaged components of rice/maize milling, coffee processing, market and milk cooler (storage) according to

area specific needs of agro-industry. Main objectives of the programme are to enhance competitiveness and to increase crop productivity by constructing agro-processing facilities and rural market structure.

In Chepsukunya Parish of Ngenge S/C, the nearest CAIIP site to Atari, installation of milling facility has not been completed yet due to delay of implementation and related planning for Operation and Maintenance (O&M) after construction work for building and procurement of the machine in 2013. There has been therefore no operation in the past 3 years and no entity for operation and management. The general structure for operation and management of the processing facilities is shown below as an example in Benet (maize processing).

Rice/maize milling facilities left uncompleted for installation (left). Market structure and milk cooling facilities (right) in Ngenge S/C.

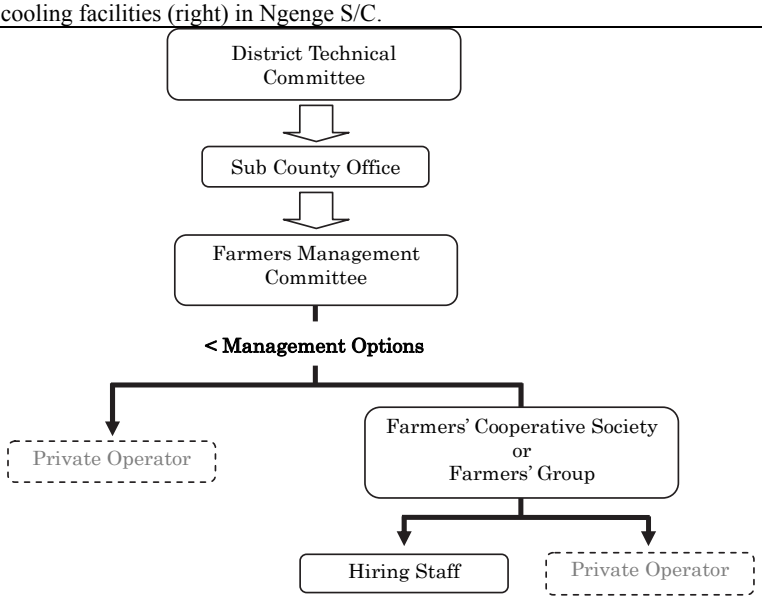


Figure 1.7.5 Operation and Management Structure for Agro-processing Facilities

Source: after "Illustration of processes for selection, installation and management of agro-processing facilities under community agricultural infrastructure improvement programme (CAIIP)" developed by Ministry of Local Government, Government of Uganda/ African Development Bank.

Table 1.7.6 Major Roles and Key Area for Operation and Management for Agro-processing Facilities

Stakeholder	Major roles and Key area for operation and management
District Technical Committee	To interact with MoLG, interact with suppliers, supervise sub-county and procure private operator. The committee comprises of 5 members.
Sub-county Office	To mobilize farmers, open Capital Fund Account, collect revenue from agro-processing facilities and oversee operations
Farmers Management Committee	To mobilize farmers, develop a business plan, ensure record keeping, signature to Capital Fund Account and supervise private operator or farmers group/ society. The committee comprises of 9 members.

(3)Situation of Market Access

In the area, the farmers sell both paddy rice and milled rice. In the case of paddy rice, the dealers go straight to farmers to buy paddy and bring it to rice millers. Whereas the case of white rice, farmers directly bring their product to rice millers where they also find middlemen. Rice millers function as an exchange point though they merely provide milling service. The market for the purchase of rice inputs and sale for rice products is in Mbale. Likewise, most of other crops are handled by middlemen, for example, maize is threshed by farmers and sold to middlemen at the stores who in turn sell the maize to big towns like Soroti and Mbale (some products are carried by the buyers from Kenya).

There exist local markets that keep rotating on different days throughout the week in different areas. In Kween the main market day is Monday and animals are the main item in the market although other items like food crops are sold in small quantities in the market. In spite of long distance to market, the majority of farmers in the area try to bring their product to the main market (more than 50 %); while some others carry their produce to the big cities; Mbale, Jinja and Kampala etc.

For determination factor of rice, the most important factor is cleanness (nearly 60 %). Cleanness is the first importance commonly in another area of the country. The purity of variety is the second importance. The market price of paddy/milled is almost fixed indicating that price is not negotiable for some farmers also implying importance in need of differentiation for quality control during post-harvesting.

Table 1.7.7 Price Formation of Rice around Eastern Region

Variety	Farm gate		Milled		Wholesale (Mbale)	Retail (Mbale)
	Atari (Kween)	Sironko TC	Atari (Kween)	Sironko (Bulambuli)		
Kaiso	1,600	1,300	2,200	2,300	2,500 (Grade1:3,000*)	2,600
Supa	2,000	1,900	2,500	2,700	3,100 (Grade1:3,800*)	3,500
margins added (%) by stage	PISD-2 (Nov-Dec, 2015)	Kaiso ⇒ Supa ⇒	+38 - 77 % (+57 %) ⇒ +42 - 77 % (+59 %) ⇒		+ 9 - 14 % ⇒ +15 - 24 % ⇒	+ 4 +13 %
	PRiDe ** (Mar-Apr, 2013)	Kaiso ⇒ Supa ⇒	+54 % ⇒ +54 % ⇒		+23 % ⇒ +18 % ⇒	+10 % +13 %

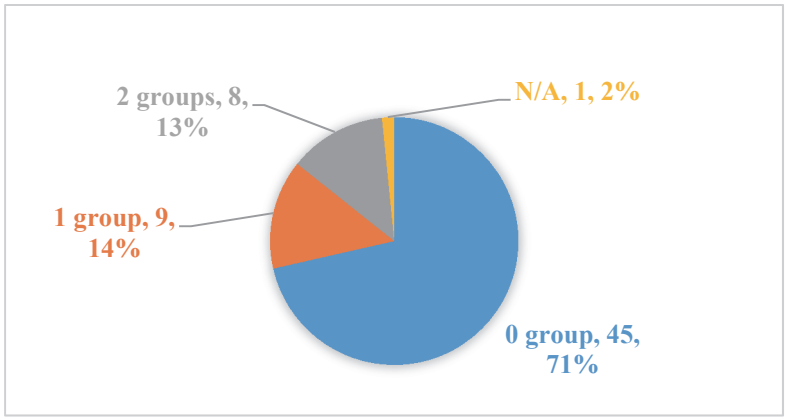
* Mbale Central Market (case of the highest quality), ** Across all the regions out of Kampala (average), after PRiDe (2013) Rice in Uganda: Viewed from Various Market Channels A Survey Report. Promotion of Rice Development Project (PRiDe), Japan International Cooperation Agency (JICA).
Note: Pakistan rice at supermarket priced as USh 5,000 /kg (produce in Uganda), others ranging from USh 8,500-13,000 /kg for Grade 1, imported from Pakistan; while, USh 8,000 /kg for imported Kenyan rice (Mwea).

1.7.6 Farmers Organization

In Atari area, the survey on farmers' organization was conducted in two ways. The first was the PISD-SES outsourced to the consultant. This survey took an interview-style to individuals. A total number of respondents in Atari area is 63. The second was inventory survey on group activity in form of interview with group leaders. PISD team directly conducted the questionnaire in this survey. The number of respondent groups was 16. PISD-SES shows how individuals engage in group activities, and inventory survey shows outline and detail of activities.

(1)Situation of Participation in Group Activities

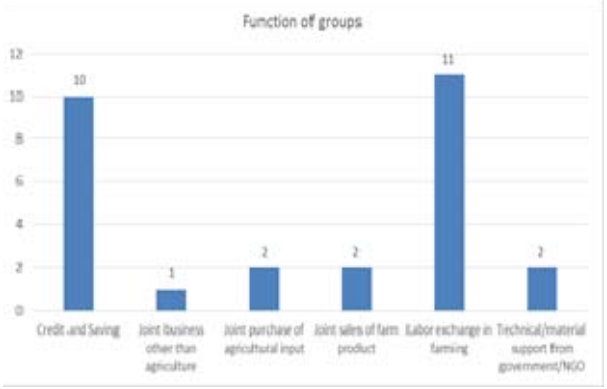
In the area, 27 % (17 persons) participate in groups. Of them, 13 % (8 persons) belong to two groups and 14 % (9 persons) belongs to one group. 71 % (45 persons) do not belong to any group. Participating in a group activity is not so common but the participation ratio is higher than Sironko area.



Source: PISD SOCIO-ECONOMIC SURVEY2015

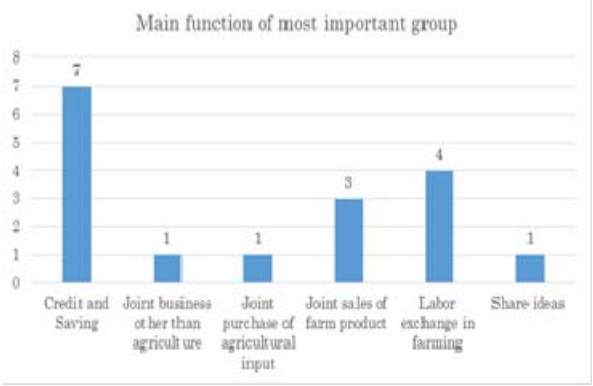
Figure 1.7.6 Number of Groups People Belong to

The most popular function of farmers group is labour exchange (11 persons) and credit and saving (10 persons). These functions are very popular in other areas. Securing fund and labour would be an important motivation for people to join groups. For people who belong to several groups, a group of credit and saving is more important than another group.



Source: PISD Socio-Economic Survey 2015

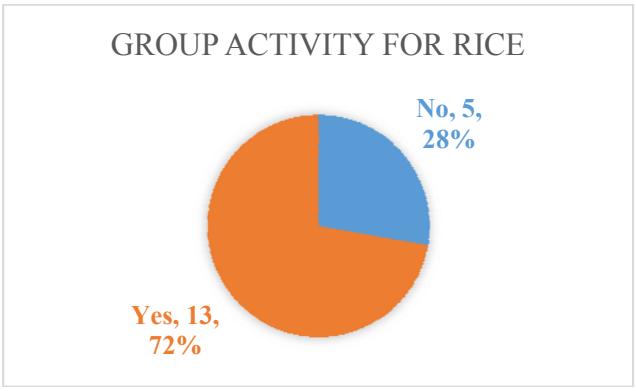
Figure 1.7.7 Function of Group



Source: PISD Socio-Economic Survey 2015

Figure 1.7.8 Main Function of most Important Group

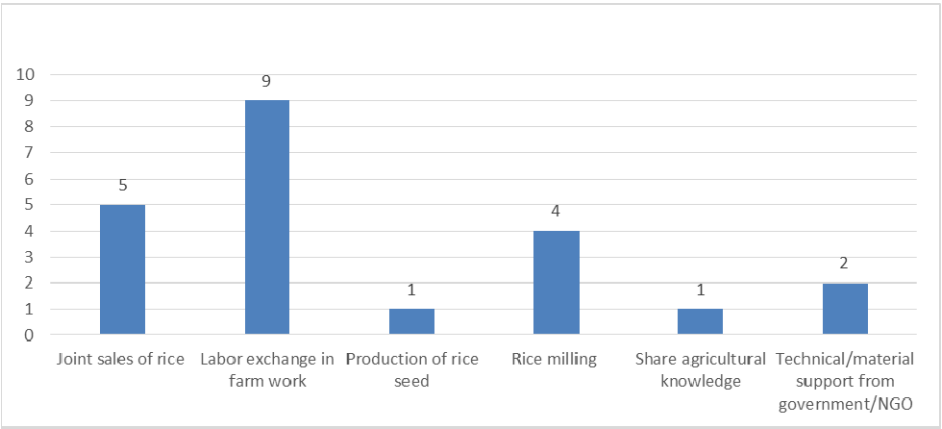
Of people who belong to groups, 72 % (13 persons) are involved in rice cultivation through groups. Rice cultivation by farmers group seems to be very popular in Atari area.



Source: PISD Socio-Economic Survey 2015

Figure 1.7.9 Group Activity for Rice

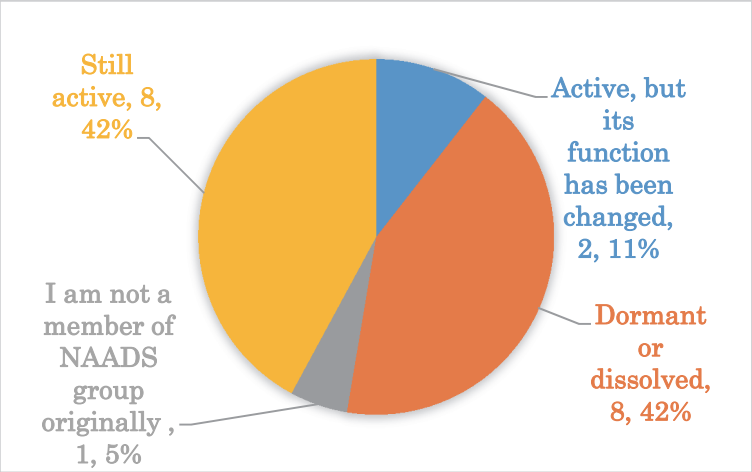
Breakdown of group activity related to rice is labour exchange (9 persons), joint sales of rice (5 persons) and joint rice milling (4 persons). For rice cultivation, most important aspect is to secure labour but marketing functions are also emphasized. This result might be affected by the characteristic of rice as a commercial product.



Source: PISD Socio-Economic Survey 2015

Figure 1.7.10 Breakdown of Type of Activity by Groups Doing Rice Cultivation

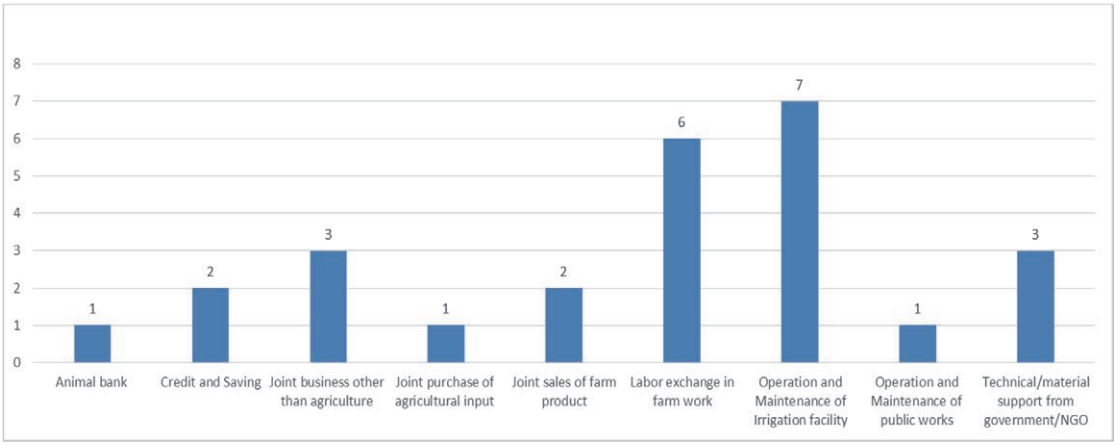
As to National Agriculture Advisory Service (NAADS) groups which deeply affected the formation of farmers group in the area, about 40 % answered that their NAADS group is dormant or dissolved. About 50 % replied that the group is still active but some group has changed its original functions.



Source: PISD Socio-Economic Survey 2015

Figure 1.7.11 Situation of NAADS Group

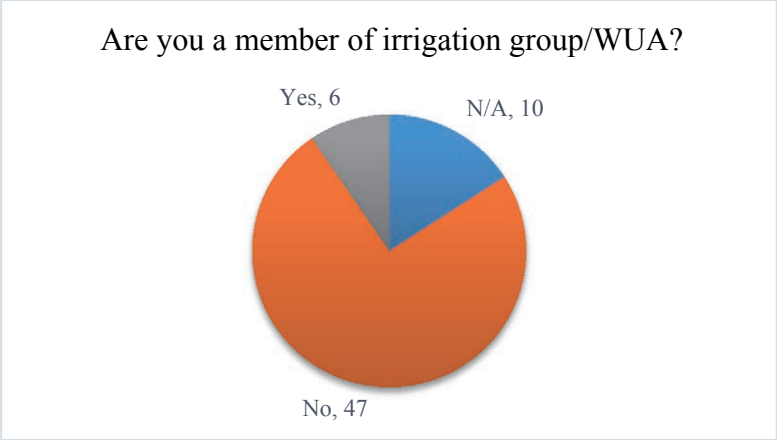
The most popular function of a group that people want to newly participate in is irrigation O&M (7 persons) and labour exchange (6 persons). Regarding high demand of irrigation O&M, the respondents could be affected by the project consultation meeting which was held just before PISD-SES.



Source: PISD SOCIO-ECONOMIC SURVEY2015

Figure 1.7.12 Type of Group which People are Willing to Participate in

In the area, 6 persons are confirmed as a member of Water Users' Association（WUA）. For these WUAs, more information is collected through the inventory Survey.



Source: PISD Socio-Economic Survey 2015

Figure 1.7.13 Participation in WUA

In summary, in Atari area, participation ratio in a group activity is not so high but some people join several groups. Several groups doing rice cultivation are confirmed. The popular functions of existing groups are credit and saving and labour exchange, which infers that people expect access to fund and labour through the group. Rice is an important to crop in the area and expectation to irrigation project is naturally high.

(2)Situation of Farmers Group in Atari Area

In September 2015, JST made the list of active farmers' organization in cooperation with Bulambuli District, Bunambutye S/C and Ngenge S/C. JST conducted an interview with 16 of 18 groups whose active status is recognized.

Table 1.7.8 Existing Farmers Group

Number	District	S/c	Parish	Village	Name of Farmers Group	Leader		History of group	Number of member	Main Function of group												Main crops produced by members						
						name	phone	year	person	Credit /saving	farm/material support	Labor Exchange	O&M irrigation	Rice mill	Rice seed production	public work	Joint sale	Joint purchase	animal rearing	fishing	other joint business	other	rice	maize	planten	beans	vegetable	fruits	other
1	Kween	Ngenge	Sikwo	Amukokel	Amukokel United Group	Cherotwo Stephen		3	12		x								x				x	x		x			simsim sunflower
2	Kween	Ngenge	Sikwo	Kaibos	Rice Development Group	Cherotwo Micheal		8	12		x	x	x				x	x					x	x					vegetable
3	Kween	Ngenge	Sikwo	Kaibos	Sosei United Group	Janet Yamongusho		3	25	x		x											x	x		x			Soy bean, sunflower
4	Kween	Ngenge	Sikwo	Sikwo	Atari Umoja Women's Group	Mary Matei		1	26	x		x	x									social help	x	x					cocoyams
5	Kween	Ngenge	Sikwo	Sikwo	Sikwo Youth United	Solimo Simon		1	23	x									x				x	x					cocoyams
6	Kween	Ngenge	Sikwo	Sikwo	Lower Atari Rice Growers Association	Chemayeki Christopher Bwire		11	20				x									sensitization-gender reproductive health, AIDS, and advocacy	x	x					
7	Kween	Ngenge	Sikwo	Sikwo	Yetana Group	Mutanji James		1	24	x		x	x				x	x					x	x		x			soybean, grud, simsim matoke
8	Kween	Ngenge	Sikwo	Sikwo	Muwungano Group	Kosei Rogers		3	10	x		x					x	x	x				x	x		x			soybean, cocoyam
9	Kween	Ngenge	Sikwo	Sikwo	Kaimareng United Farmers Group	Mutai Asadi		4	10			x	x	x			x	x				public work, animal rearing (cow from Kaabi), social financial help	x	x		x			cocoyams, cassava, matoke
10	Bulambuli	Bunambutye	Buwebere	Bumbocha	Bumbocha Elderly Farmer's Association	Makona David		5	15	x	x	x												x		x			Cassava
11	Bulambuli	Bunambutye	Buwebere	Bunambale	Sahamubo farmer's group	Namwaki Esther		3	42	x	x	x	x										x	x		x			
12	Bulambuli	Bunambutye	Buwebere	Bubuya A	Buwebere Youth farmer group	Chakali Juma		3	15	x	x		x				x	x					x	x		x			Sunflower
13	Bulambuli	Bunambutye	Buwebere	Busangayi	Buwebere United Farmer's Association	Masaba Davis		3	27	x	x	x	x	x			x	x	x			Purchase yams	x						Sunflower
14	Bulambuli	Bunambutye	Buwebere	Bukhayaki	Bukhayaki farmer's Development Association	Makoha John		3	15	x		x	x										x	x		x			Sunflower, Simsim
15	Bulambuli	Bunambutye	Buwebere	Busangayi	Atari red cross women group	Kakai Sabina		11	25	x	x	x	x			x	x	x	x					x		x			Soya
16	Bulambuli	Bunambutye	Buwebere	Bunambale	Bunandutu Woman farmer's Association	Namaemba Hadijah		3	20	x	x	x	x	x		x	x	x	x				x	x		x			
uninvestigated	Bulumbli	Bunambutye	Buwebere		Buwebere Women's group	Salimat Namutosi																							
uninvestigated	Bulumbli	Bunambutye	Buwebere		Bukhayaki Sunflower project	Mongesa Vicent																							

Source: Bulumbli District & Ngenge S/C, modified by PISD Study team (as of November 2015)

Most of the groups were formed when NAADS worked actively, 3 to 5 years ago. Most groups are registered at sub-county level. Of 16 groups, there are 10 registered at sub-county level, 1 registered

at the district level, 2 registered at sub-county and district level, and 3 non-registered. Possibly because of NAADS program, groups are appropriately managed in terms of group structure (e.g. selection of board member, the frequency of meeting) and recording of activities. An average number of member is 20.1 persons and percentage of women is high (56 %) because there are several women's groups. Apart from 2 groups of Red Cross and national project, all groups work individually and even groups formulated under NAADS program do not cooperate. Most of them are relatively small-scale.

Table 1.7.9 Outline of Group (n=16)

History of group (years, average)	Number of members (persons, average)	% of female (%, average)
4.1	20.1	56.4

Source: Inventory survey on farmers group 2015

Main crops produced by members are rice and maize followed by beans. As other crops, cocoyam, sesame, and sunflower are seen. In Atari, rice is considered as important crop than in another area. Cocoyam is also popular because it can be cultivated in law land like rice, needs less labour input and can be sold at high price.

Table 1.7.10 Main Crops Produced by the Members (Multiple Answer)

Rice	Maize	Plantain	Beans	Vegetable	Fruits
14	15	0	11	0	0

Source: Inventory survey on farmers group 2015

Most groups charge a membership fee but it is the very small amount (on average, USh 5,100 for entry fee and USh 3,700 for an annual membership fee). Farmers pay only US$ 2 annually for group activity. Apart from these charges, groups with credit and saving function collect USh 1,000-5,000 weekly. On the other hand, the rate of members who pay membership fee is almost 100 % because the popular penalty for unpaid is withdrawal from the group. The collected money is mainly used for labour for agriculture. Even groups doing labour exchange suffer from a labour shortage in the peak season and they sometimes have to hire outsiders. Five groups have social help functions such as financial support in case of emergency of members (e.g. failure of harvest, illness or school fee). The situation of revenue and expenditure in Atari area is quite similar to Sironko area.

Table 1.7.11 Expenditure Items (Multiple answers)

Labour	Maintenance Tool	Maintenance Material	Salary For Board Members	Credit Seed Money	Common Property	Social Help
8	3	1	1	3	0	5

Source: Inventory survey on farmers group 2015

The frequency of group regular meeting is 2.3 times/month. Groups with credit and saving function tend to gather more often to collect saving money. Labour exchange groups plan their activity in accordance with cultivation calendar. The average frequency of activity in the field is 2 times for ploughing, 1 time for planting of rice, 2-3 times for weeding and 1 time for harvesting per season.

The most popular functions of the group are credit and saving, Labour exchange and irrigation O&M. It is characteristic in Atari that Irrigation O&M is considered important. People are aware of the advantage of grouping to gain technical or material support but also understand that grouping does not always secure these supports. Then, the function of technical and material support is not recognized as much as functions of credit and saving and labour exchange. People also relatively understand the economic advantage brought by joint sales and joint purchase.

Table 1.7.12 Main Function of Groups (multiple answers)

Credit & saving	Tech. & Material. support	Labour Exchange	O&M irrigation	Rice mill	Rice seed Production	public work	Joint sale	Joint purchase	animal rearing	fishing	Other joint business
12	8	12	11	3	0	2	8	8	6	0	0

Source: Inventory survey on farmers group 2015

The average of total farm area irrigated by members is 15.8 acre (6.3ha) (including individual land and group land). The calculated irrigated area per member is 0.8 acre (0.3ha).

Regarding the type of land ownership, owned and rented has same proportion.

Table 1.7.13 Type of Land Ownership (n=16)

Owned	6
Rented	6
Owned & Rented	3
N/A	1

Source: Inventory survey on farmers group 2015

Maybe because of the importance of rice in the area, groups that manage jointly irrigation facilities are often seen. The facilities managed by groups are intakes and water gate created by themselves with local technologies. Main O&M activities are slashing of banks and de-silting. No group arranges water distribution.

Table 1.7.14 Types of Irrigation Facilities Created by Groups (multiple answers)

Canal	Water Gate (Concrete/Block)	Water Gate (Soil Bag)	Intake (Stone/Branch)	Water Pump
6	0	4	8	0

Source: Inventory survey on farmers group 2015

Table 1.7.15 Type of O&M (multiple answers)

De-silting	Slashing	Repair Canal	Repair Gate	Water Control
7	9	4	0	0

Source: Inventory survey on farmers group 2015

People recognized that group members have more access to support from government and NGOs but

only 6 of 16 groups (38 %) have received support actually.

Table 1.7.16 Support from Government and NGOs (multiple answers)

No Support	Technical Support	Material Support	Maintenance Tools	Financial Support	Other
10	2	3	1	2	7

Source: Inventory survey on farmers group 2015

In summary, in Atari area, existing groups are small-scale and not collaborated with other groups but no serious problem is seen in group management. The importance of rice is high and some groups work on rice cultivation. The cost for group activity is very little, US$ 2 per year. In terms of group's function, labour exchange, credit and saving and irrigation O&M are popular. Compared to Sironko area, more groups are engaged in rice cultivation and rice is more popular as a group activity.

1.7.7 Farm Household's Economy and Farmer's Intension for Development

(1)Characteristics of the Farm Household

The following characteristics were drawn from the Farm Economic Survey (conducted in YR2015).

- ✓ 75 % of households (total 63 samples) subjected to PISD household survey for their first time.
- ✓ Age of farm household head is 45 in average and its majority age group of its members is 30-49.
- ✓ The education level of household head is either Primary (60 %) or Secondary (30 %) level.
- ✓ Average family labour in farming is 4 out of 7 total family members in average.
- ✓ Average years of experience for farming is 15 years for the current household head while 22 % of them have no rice-cultivation experience.

Table1.7.17 Characteristics of Farm Household in Atari

Item	Results
Age of household head	45.1
Age group of household member (youth/adult more than 20) :	
20-29	11 %
30-49	66 %
50-69	22 %
> 70	11 %
Sex of household head :	
Male	95 %
Female	5 %
Education level of household head :	
None	5 %
Primary	60 %
Secondary	30 %
Vocational institution etc.	2 %
College/ University	3 %

Unknown	-
Total number of household member	7.3
Family labour in agricultural activities	3.6
Experience of farming: current household head	14.6 years
Experience in rice cultivation	5.2 years
<Farm household head with no experience in rice cultivation>	22 %
Participation in the PISD-SES in YR2014:	
Yes	25 %
No	75 %

Source: PISD Farm household economic Survey (YR2015)

(2)Farmer's Economy

Economic status for the farm household in the study area is summarized in the table 1.7.18 below.

Table1.7.18 Financial Balance of Farm Household in the Study Area

Items	Amount (USh)	Remarks
1) Income		
- Average annual farm income	1,844,000	
- Average annual off-farm income	350,000	second income source
Rank 1:		n/a
Rank 2:		petty trade
Rank 3:		sell labour to other farmers
Total:	2,194,000	
2) Expenditure		
- Agricultural production*	1,648,000	at cropping intensity of 100 %
- Live expenses / food staff	760,000	
Total:	2,408,000	
3) Balance	(214,000)	*presenting year alone
4) Forms of household savings (the topmost)	1st option: keep with friend/relative or at home (22 %) 2nd option: n/a 3rd option: n/a	
5) Possession rate of house properties	Bicycle: 56 % Radio: 67 % Mobile phone: 67 %	Motorcycle: 0 % TV sets: 7 %

Source: PISD Socio-economic Survey (Farm Household Survey) and The Study Team based on hearing to the farmers in the project site.

Note: Sampled size of farm household was $n = 27$ (n/a denotes data not available). The agricultural production costs (*) were calculated at 100 % cropping intensity over lowland rice and upland (represented by maize) and were set at a reasonable range based on established unit production cost in acreage.

The following characteristics can be described from above.

- Costs of agricultural production make its weight approximately 75 % of the total income.

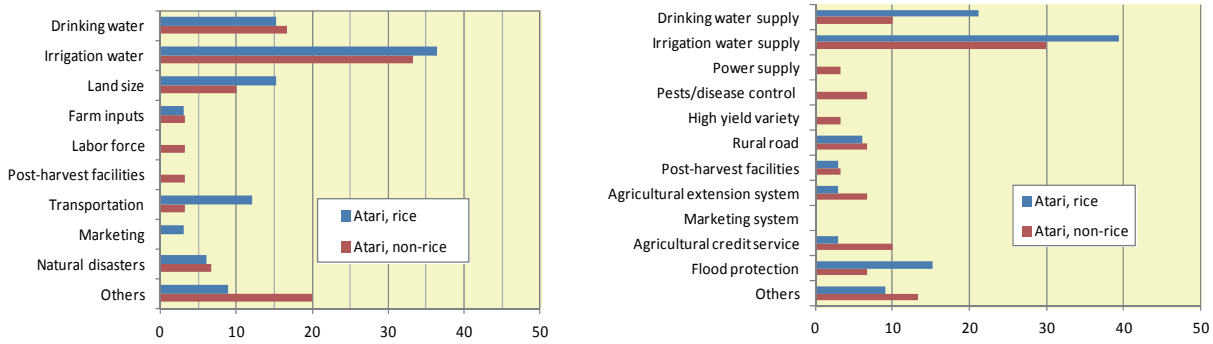
(3)Farmer's Intension for Development

In order to achieve effective development plan, the farmers' intentions were inquired through the Farm Economic Survey (conducted in 2015). The sampled farm households (N=63) of the target area of Atari were categorised into two group including; rice-growers and non-rice growers. The following key remarks were found and summarized in the table below.

Table1.7.19 Major Findings for Intension to Development by Farm Household

Rice-grower (N=33)	Non-Rice grower (N=30)
• Major constraints in present farming or living condition are; irrigation water (36 %), drinking water (15 %), land size (15 %) and transportation (12 %). • In contrast, intention to improve current constraints in agricultural or livelihood activities are put on irrigation water supply (39 %), drinking water supply (21 %) and flood protection (15 %); overall as water resource issues. • For crop preference or priority, Rice (79 %) and Tomatoes (12 %) are nominated as a 1st preference; while, Maize (42 %) and Tomatoes (9 %) are held as a 2nd preference. • The majority of the lowland-rice-growers (91 %) hold the intention to extending their lowland rice area in a wetland under enhanced irrigation system. However, nearly 9 % of rice-grower in Atari retained their opinions or had no idea over irrigation-development being planned.	• Major constraints in present farming or living condition are; irrigation water (33 %), drinking water (17 %), land size (10 %). • Intention to improve current constraints in agricultural or livelihood activities are put on irrigation water supply (30 %), drinking water supply (10 %) and agricultural credit service (10 %); overall as water resource issues. • For crop preference or priority, Rice (63 %) and Tomatoes (20 %) are nominated as a 1st preference; while, Tomatoes (33 %), Maize (13 %), subordinately Cabbage (10 %) or Yam (10 %) are held as a 2nd preference. • The majority of the non-rice-growers (94 %) hold the intention of extending their lowland rice area in a wetland under enhanced irrigation system. However, 20 % of non-rice-grower in retained their opinions or had no idea over irrigation-development being planned (this is the highest rate among all groups of Atari).

Note: The sampled farm households of Atari (N=63) were categorized arbitrarily into two groups of: "Rice-grower" for those who answered rice cultivation area (in lowland) greater than 0 acres; while another group as "Non-rice grower" with their answers in vice-versa. This arrangement was made as current cultivation practices and land location (ex. Lowland versus Upland etc) meant to influence their intentions against irrigation development planning of the PISD.



Source: PISD Farm household economic Survey 2015

Figure 1.7.14 Current Constraints and Intensions to Development Held by Household

CHAPTER 2

DEVELOPMENT PLAN FOR ATARI SITE

CHAPTER 2 DEVELOPMENT PLAN FOR ATARI SITE

2.1 Needs of Irrigation Development

The Community-based Wetland Management Plan prepared and approved by the community and local leaders in collaboration with WMD of MWE, stated that the major problems of the resource users in the area are drought and flood followed by the poor farming method, deforestation and soil erosion. In addition to the major problem mentioned, the main cause of conflict among the resource users in the area is caused by lack of fair distribution of the available resource, especially the water.

After the introduction of the modern irrigation system by Action Aid by the installation of intake structure across the Atari River (around 2004), the communities on both sides of the river have diverted the water to their fields at about three points upstream of the intake structure. These (modern and traditional) intake structures are diverting uncontrolled amounts of water to their respective irrigation areas resulting in over flooding of the field, poor drainage system and conflict over the water resource. This condition necessitates the introduction of properly designed and planned irrigation facilities that address the conflict arising from unfair water distribution and some of the other problems of the area such as flooding and drought.

On the other hand, the course of the Atari River has been changing since 1960's due to uncontrolled human interference. Originally, the Atari River flowed at the boundary between Bulambuli and Kween Districts before entering a Ramsar Protected Area. However, presently, the river is flowing in a totally different course, making a 90 degree turn away from the old river course toward Kween District (Sikwa Parish) creating semi-permanent flood plain on the cultivated area around the downstream portion of the study area. This situation, aside from creating a flood plain which is unsuitable for crop production to the community of Sikwa Parish, forces the people on Bulambuli side (Buwebere Parish) to go further downstream, encroaching on Ramsar Area in search of water for cultivation.

Therefore, in addition to improving the socio-economy of the area and livelihood of the community, the advantages of implementation of this project are many folds, among which:

- It eliminates the existing conflict among the resource users through fair distribution of the water;
- Reduces the problem of drought and flood;
- Readjusts the Atari River to its original river course;
- Reduces the extent of encroachments on Ramsar Area.

2.2 Basic Policy of Development Plan

2.2.1 Components of Development Plan

(1)Components of Development Plan

Irrigation development plan includes the following components: to harmonize the development of agricultural land and environmental and social circumstances in the swamp and wetland.

Many sensitization meetings in the community and stakeholder meetings through the several workshops with PACC, PISD District Coordination Committee (PDCC), and C/Ps were carried out during phase two study. An Irrigation development plan was developed by extracting many ideas, requests, complaints and needs from the community through the community meetings. Many issues were raised, and these (issues) are sorted on the basis of achieving synergy between agricultural development and the wetland environment through sustainable irrigation and drainage project, which improves community livelihood, while at the same time protecting the environment. Considering these issues, engineer's judgment and brief evaluation were carried out, an Irrigation Scheme Development was formulated with following components.

Table 2.2.1 Components of Development Plan

Water Resources Development Plan	Water Resources Plan Irrigation Water Plan (Including water plan for livestock and drinking water)
Flood Protection Plan with Buffer Zone Plan	Flood Protection Dyke Plan Buffer Zone Plan
Agricultural Development Plan	Land Use Plan Cropping Plan Farming Management Plan Crop Production Plan Farmers Organization Agricultural Extension Plan Wetland Management Committee
Irrigation and Drainage Plan	Irrigation Facility Plan (Intake, Canal and diversion) Drainage Plan On-farm Plan (Main farm ditch, supplemental farm ditch, farm ditch and farm drainage) Demonstration Farm Plan
Community Development Plan	Road Network Plan (Farm road and access road to connect national road to project site) Community Development Plan Postharvest Facilities Plan Marketing Plan

Source: JICA Study Team

(2)Adopted Basic Policy for Development Plan

Several alternative plans were examined and evaluated and finally, the following plan was proposed and selected as Atari irrigation development plan as a most available and feasible plan among them.

1)Alignment of Protection Dyke and Protection Area

ALT-3: Leaving 30 m wide area from hypothetical river centre

2)River Course

ALT-L1: Restoration of original waterway

3)Development Scale

CASE 3: Development Area with 680 ha

2.2.2 Components for Project Evaluation

Table 2.2.2 shows the components for project evaluation which is directly included in Atari irrigation development plan from the above-mentioned components.

Table 2.2.2 Components for Project Evaluation

No	Facility	Quantity	Description	Remark
1	Intake facility	1 Place	Reinforcement concrete Intake sluice gate	Including de-silting basin, spillway
2	Main canal	2.4km	Concrete block lining	
3	Secondary canal	15.1km	Concrete block lining	
4	Main farm ditch	10.0 km	Earth canal	
5	Drainage	22.1km	Earth canal	
6	Flood Protection Dyke	10.0 km	Both sides, 1.4 m height	
7	Farm Road	27.7km	4m width, laterite pavement with 100 mm thickness	
8	Appurtenant structures	Lump Sum		
	Diversion		Reinforcement concrete	
	Check gate		Sluice gate	
	Culvert		Pipe culvert	

Source: JICA Study Team

2.3 Alternative Plans for Development

The results of the study during Phase one showed that the large-scale irrigation plan is more economical and feasible than the small-scale irrigation plan. Accordingly, JST studied the maximum irrigable acreage which might be more feasible plan in the study area based on the meteorological, hydrological analysis and considering another water usage in the Atari River Basin which is described in Chapter 2.3. Accordingly, it was estimated that a total of 680 ha as a maximum command area when the target area is fully covered by paddy rice which consumes more water than upland crops. On the basis of the irrigable acreage, an alternative plan was considered for Atari irrigation development plan from three points of view as shown below that is a key factor to identify the study area and which has more impact on the environment and social condition such as flood control and function as a buffer zone in the riparian zone. In addition to this, the layout of the facility and type of canal is considered and compared under Chapter 3 “Facility plan”. The alternative plan is explained under the following three viewpoints which are;

- ✓ Alignment of Protection dyke and protection area
- ✓ Comparison of adjusting the river course
- ✓ Optimum development scale

2.3.1 Alignment of Protection Dyke and Protection Area

(1)Consideration Points for Determination of Alignment of Protection Dyke

Alignment of protection dyke must be taken into consideration from various points of view such as location and topographical condition, hydrological condition and function of flood control, the function of environmental aspects such as purification of water, sedimentation, and preserving the biodiversity, and social impacts like resettlement of existing households and sustainable resource supply for livelihood.

Consideration Points for determination of alignment of protection dyke are;

- ✓ Location, topographic and geological formation condition
- ✓ Allowable dimension against flood flow
- ✓ Necessary width for sedimentation against runoff from upstream
- ✓ Preservation of natural resources for biodiversity
- ✓ Preservation of sustainable resource for livelihood
- ✓ Regulation[3] which states that buffer zone shall be 30 m from highest water mark of the river.
- ✓ The approved Community-based Wetland Management Plan (CWMP) which was agreed by the community to set the buffer zone at 5 to 20 m width

(2)Necessary Width for Sedimentation against Runoff from Upstream

With regard to the required buffer width for sediment trapping, there are several preceding research papers and some empiric formulas have been proposed. Figure 2.3.1 shows the result of verification of precedence research and relationship between trapping rate of sediment and riparian buffer width in case of gentle slope which is expressed by equation (1)[4] below. In this research, the following two equations were proposed for the relationship between required minimum buffer width and riparian slope gradient by Trimble & Sartz (1957) and Takahashi & Suzuki (2004). After verifying these two equations by analyzing the data collected in their study, it is considered that the proposed relationships are recommendable[2].

[3] "The National Environment (Wetlands, River banks and lakeshore management) Regulations, 2000"
[4] Kazuya Takahashi & Yoichiro Suzuki (2004) : Consideration of riparian buffer width required for trapping sediment

Regression formula by Takahashi & Suzuki (2004)

$y = 100 - 100\ e\ ^{(-0.29x)}$ Equation (1)

Where;

y: trapping rate of sediment (%)
x: riparian forest buffer width (m)
Riparian slope gradient not more than 12 %

Trimble & Sartz (1957)

Equations for the relationship between required minimum buffer width and riparian slope gradient

$y = 0.6\ X + 8$ [for farmland] Equation (2)

$y = 1.2\ X + 16$ [for domestic consumption] Equation (3)

y: riparian buffer width (m)

x: riparian slope gradient (%)

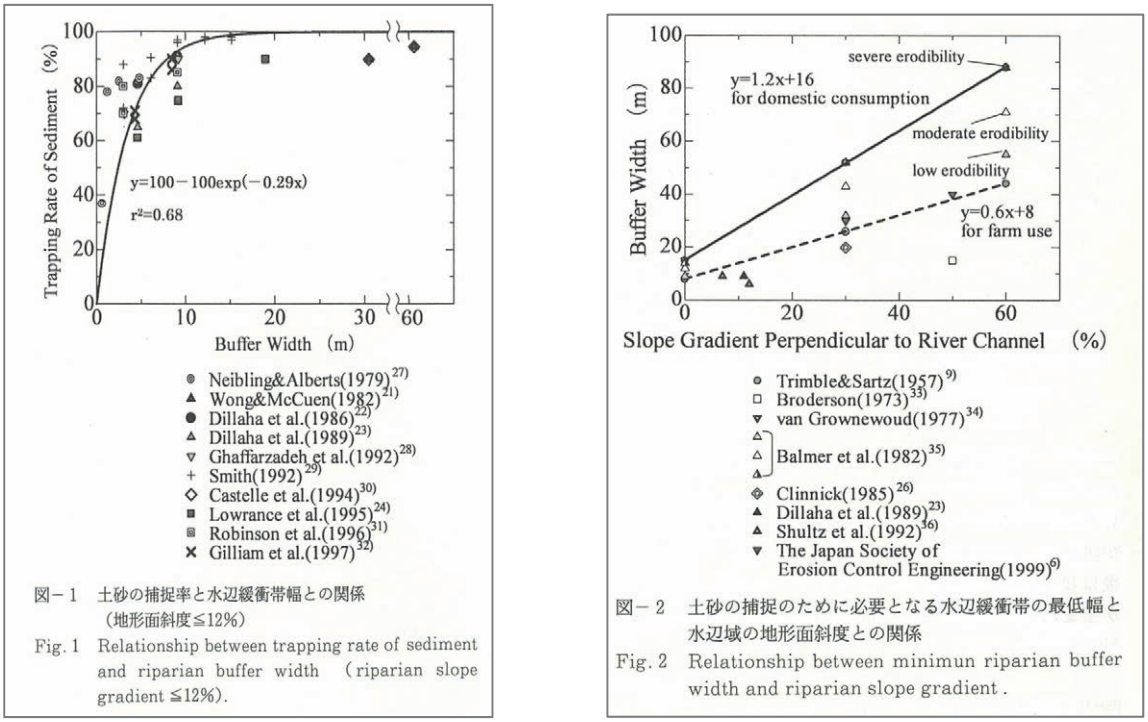


Figure 2.3.1 Riparian Buffer Width Required for Trapping Sediment

The target area of Atari site has a steep ground slope of 1/275 and river slope of 1/300. According to the Trimble & Sartz formula, the variable is identified only by ground slope and it is calculated as shown in table 2.3.1 below for the target are. Since the largest part of the study area is used for agricultural purpose, required minimum buffer width is about eight (8) metres. Accordingly, the nearest point between protection dyke and river curvature point is set as five (5) metres wide basically. Consequently, most part of the dyke has a distance of more than eight (8) metres that is fourteen (14) metres on average in case of ALT-L3.

Table 2.3.1 Minimum Buffer Width for Sedimentation Trap

Place	Ground Slope	Required minimum buffer width
Upstream Area	1/275	8.2 m

Source; JST calculated based on the equation (2)

According to equation (1), trapping rate of sediment can be estimated and presented in the table below. Even in the case of ALT-L3, average riparian forest buffer width with fifteen metres is sufficient for sediment trapping with ninety-nine percent (99 %) of trapping rate.

Table 2.3.2 Buffer Width and Trapping Rate

Riparian forest buffer width (m)	Trapping rate of sediment (%)
1	25
2	44
3	58
4	69
5	77
6	82
7	87
8	90
9	93
10	94
15	99
20	100

Source; JST calculated based on the equitation (1)

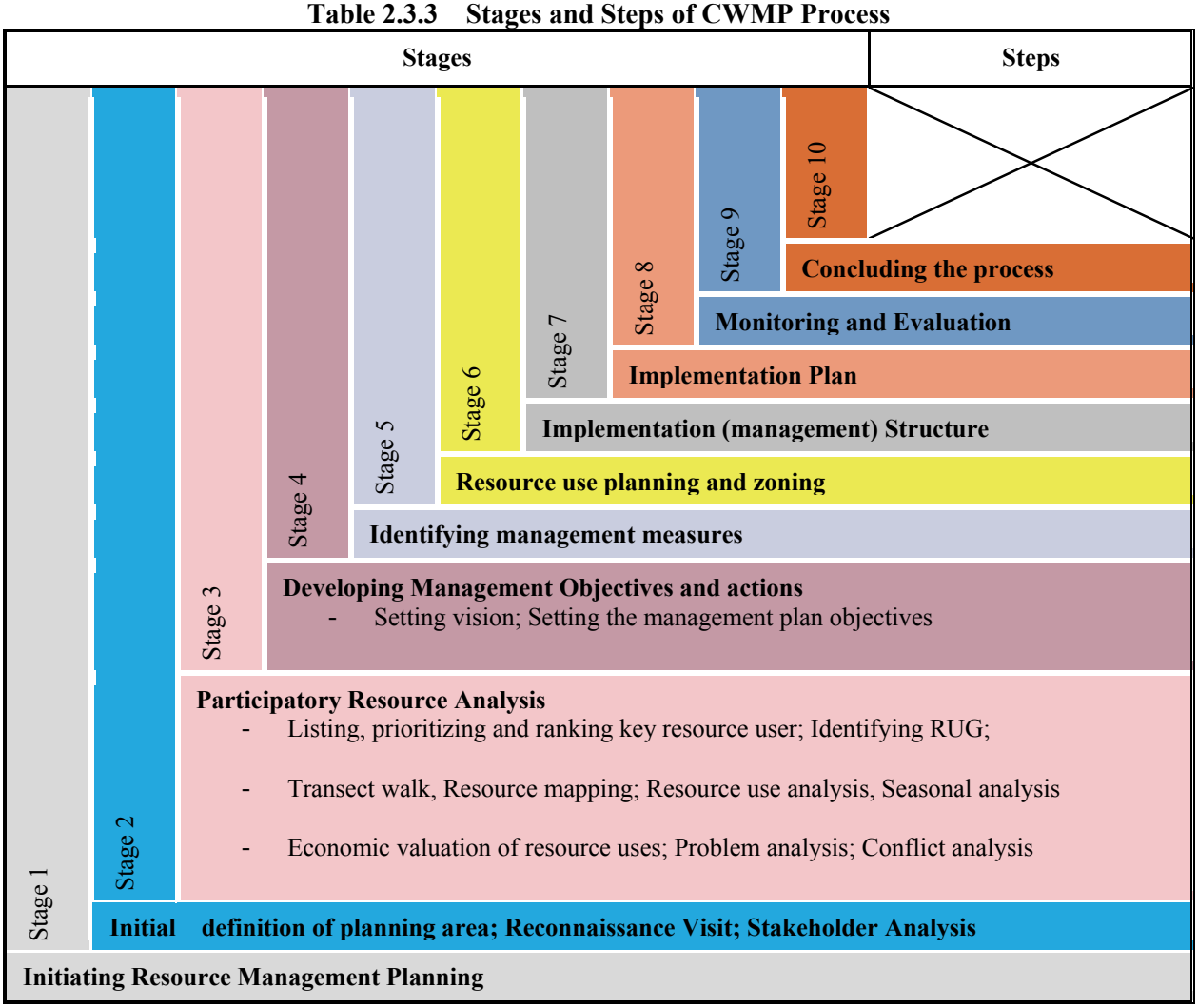
It can be said that the current and past river course is the results and evidence related to the topographic and geological formation of the ground. Considering these conditions, JST proposed the following five alternative plans on how to set the alignment of protection dyke based on the current and old river course. Table 2.3.4 shows the result of comparison of alignment of protection dyke and protection area. Allowable dimension can be calculated by flood discharge, river slope and roughness coefficient. The design flood discharge of 38 m^3/sec and river slope of 1/275 is applied in the determination of allowable dimension.

ALT-P3 is the most optimum alternative considering the above six consideration points which are enough to prevent the flood damage and preserve important environmental condition and recourses for livelihood in the riparian area.

(3)Related Regulation and CWMP

It is stipulated by "The National Environment Regulation" to have protection zone of 100 m from highest water mark for the river which is designated in schedule 6 of the regulation and 30 m for others. In addition to this, Wetland Management Department (WMD) of MWE, which is responsible for managing and preserving wetland status according to this regulation and other laws, has a position and acknowledgement to permit the certain width of protection zone in case if the consensus is built through the development of CWMP. CWMP in Atari had been developed and formulated by the community in the target area through several workshops among the stakeholders according to the Wetland Management Planning Process Manual. It is a participatory process involving all identified stakeholders at local / community, sub-county, district and central government levels at the various stages of preparing the management plan mainly in a form of meetings, workshops and consultations. The necessary stages and steps to follow in the preparation of CRMP are depicted in Table 2.3.3.

Table 2.3.3 Stages and Steps of CWMP Process



As part of generating information for the CWMP planning process from the potentially affected/interested communities, the study team conducted surveys highlighting key social economic issues including demographic characteristics of the communities, poverty and wealth distribution, fiscal and social community life, land use trends / related challenges over the years and better resource management options.

The exercise was also part of a consultative process intended to:

- ✓ Understand the social impacts and mitigation measures from the potentially affected communities themselves;
- ✓ Assess the pre-project socio-economic conditions;
- ✓ Collect baseline information from the current resource users for purposes of monitoring their future livelihood.
- ✓ Determine the acceptability, demographic environment, socio-political and cultural related effects.

Both quantitative and qualitative data collection methods were employed and they included:

1. Literature/documentary reviews of especially the Uganda Constitution 2005; National and international wetlands policies, legislations, guidelines and the Wetland Management Planning Process Manual (2015); various District Development Plans (DDPs), district wetland action plans (DWAPs), sub-county wetland action plans (SWAPs), etc.
2. Transect walk and Resource Mapping which were made with communities to gather information on socio-economic activities, the topography of the area and enhance community awareness and appreciation of the planning process for their respective areas/ communities. This paved way for production of village resource map, captured some aspects on boundaries, zoning, available and use of resources as well as creating a sense of ownership of the planning process.
3. Participant observations (looking, listening, asking questions and keeping detailed field notes) which enabled collection of data in-depth understanding of peoples' motivations and attitudes towards the resource management plan.
4. A user questionnaire was administered to members of PACC and various wetland/resource users to collect/cross-check data/information about the direct benefits from the project area from the resource users.
5. Community meetings which brought out / discussed and generated most of the wetlands management;

Detail results of the surveys and workshops are described in Annex-III-6.

The resource users group, which is representative of all stakeholders, agreed to maintain buffer zone with 5 to 20 m width. CWMP was formulated with the participation of District and sub-county officers and sharing information with regional officers of WMD and it was approved by related District, sub-county and Community Wetland Management Committee under the witness of Regional Wetland Management officer of eastern Region in May 2016. In addition, a Memorandum of Understanding (MoU) to manage and implement this CWMP was agreed between related Districts and Community Wetland Management Committee.

Since CWMP is the output under the participation and discussion among various stakeholders considering the natural resources and social condition along the Atari River which is the project site, the agreed width for protection zone shall be referred for determination of necessary buffer zone width.

(4)Allowable Dimension against Flood Flow

Basic Development Concept of this project was discussed during Phase1 of this study and it is set as "Harmonized Irrigation Development". Since the target areas are within the wetland, the plan should consider both preservation and development under wise-use of development reflecting issues and concerns of many stakeholders. High valued land use is one of the strategies to achieve Basic

Development Concept and flood protection is one of the key approaches to improving the land value. Installation of protection dyke, catch drain along the main and the periphery road, and construction of the main drainage in the study area are proposed among several methods of mitigating flood damage. Accordingly, the necessary cross section that allows the flow of design flood discharge is calculated to study different cases from the viewpoint of the balance between the preservation of natural environment and the mitigation of social impact to evaluate the best and appropriate width of the buffer zone.

The current river course is regarded as a low flow channel and the basic data applied for uniform flow calculation is as below.

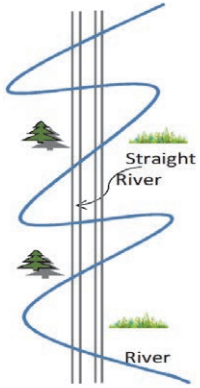
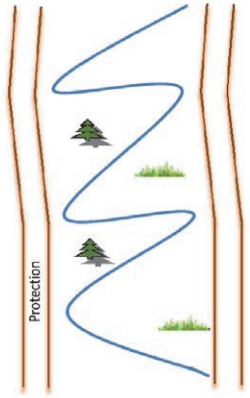
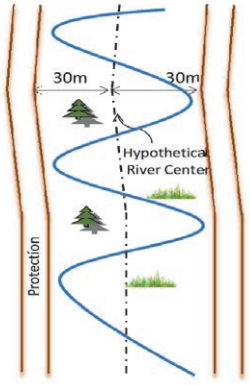
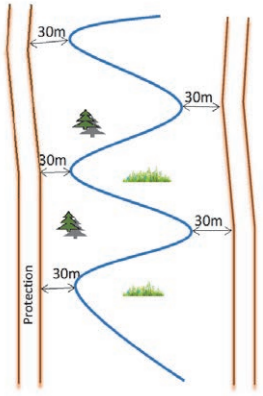
- ✓ Mean velocity formula — Manning's equation
- ✓ Design flood discharge — 38 m^3/sec (10 year availability)
- ✓ Slope of river bed — 1/275
- ✓ Roughness coefficient — 0.05
- ✓ Cross section of current river course — Width 2.0 m, Height 1.8 m, side Slope 1:0.8
- ✓ Width of high water channel — Mean width of each alternative plan

Table 2.3.4 shows the results of calculation. Consequently, ALT-P2 has 55 m width of the buffer zone and 1.5 m height of protection dyke while ALT-P3 has 60 m width and 1.4m height. ALT-P3is more economical than the other alternative since it has a narrow width and lower height of dyke. Moreover, there is no much difference between ALT-P3 and ALT-P2 from the viewpoint of environment conservation since the area left as a buffer zone is almost the same, current riparian forest can be conserved and there are no resettlements by the installation of protection dyke.

On the other hand, ALT-P4 will create an exaggerated area of the buffer zone of 99 m with protection dyke of 1.3m height which is almost same height as ALT-P2. Furthermore, the loss of agricultural land is larger than ALT-P3 by about 16ha and existing 32 buildings must be relocated for the case of ALT-P4. Therefore, ALT-P4 is not a recommended plan considering the balance of environment and social considerations.

Hence, it seems reasonable to propose ALT-P3 which has 30 m width from river centre and is the best plan among the possible alternative plan from the point of view of the environment and social balance.

Table 2.3.4 Alignment of Protection Dyke and Protection Area

Alternative	ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
Plan name	Linear river by bank protection	Envelope shape covering river curvature	Leaving 30 m wide area from hypothetical river centre	Leaving 30 m wide area from river curvature	Zero Option
Image					
Outline of the Plan	River improvement by a straight line with bank protection and no protection dyke against the flood. Therefore more land resource can be available for development.	To install protection dyke along the current river curvature to prevent the flood flow. Even in this case, more space is needed for buffer zone than the 5 to 20 m which are agreed on CbWMP	To install protection dyke leaving 30 m wide area from hypothetical river centre. The alignment and necessary space are almost the same as ALT-P2.	To install protection dyke leaving 30 m wide area from river curvature. The National Environment Regulation suggests taking 30 m from the river bank.	Nothing shall be done, so no protection dyke and no buffer zone.
Length of Dyke	3.65km	3.84km	3.66km	3.88km	0 km
Area of BZ (buffer zone)	0 ha	21.2ha	22.5ha	38.5ha	0 ha
Mean width of BZ	—	55m	61m	99m	—
Area of PZ (protected zone)	3.3ha	35.4ha	35.6ha	54.1ha	0 ha
Mean PZ width	0 m	92m	97m	139m	0 m
HH in PZ	0HH	0HH	0HH	32Buildings, 20huts	0HH
Flood Control	Design discharge can be drained by low flow channel within a short	Installed protection dyke can protect the farmland and residential area from	Installed protection dyke can protect the farmland and residential area from	Installed protection dyke can protect the farmland and residential area from	Flood shall overflow the river course and affect to the farmland.

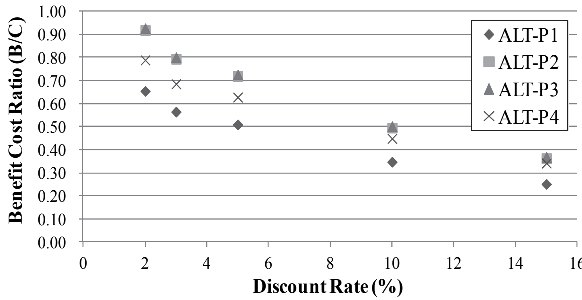
Alternative	ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
	period. As the velocity of flood flow is around 4.0 m/sec, it has a risk of taking away human life.	flood damage. Necessary height of FPD is 1.5m inclusive of extra banking for settlement.	flood damage. Necessary height of FPD is 1.4m inclusive of extra banking for settlement.	flood damage. Necessary height of FPD is 1.3m inclusive of extra banking for settlement.	
	point = 2	**point = 5**	**point = 5**	**point = 5**	**point = 1**
River Slope	1/275	1/275	1/275	1/275	1/300
River bed width	6.5m	2.0 m	2.0 m	2.0 m	2.0 m
Height of low flow channel	2.3m	1.8m	1.8m	1.8m	1.8m
Width of BZ	-	55m	60 m	99m	-
Height of dyke	-	1.5m	1.4m	1.3m	-
Max Velocity	4.02m/sec	0.94m/sec	0.91m/sec	0.75m/sec	1.1m/sec
Environmental Impact	Seasonal water supply to aquatic habitats will be terminated resulting in reduced water and nutrients to flora and fauna species within the floodplain, lifecycle disruption, loss of spawning grounds fish and amphibians. River water quality will be affected by excavated sediment during construction works.	Seasonal water supply to aquatic habitats within buffer zone will be available resulting in the supply of water and nutrients to flora and fauna species within the enclosed floodplain. Areas with invasive species will be disturbed during construction of the dyke leading to dispersal and proliferation. River water quality will be affected by excavated sediment where the dyke intersects the river meander during construction of the dyke.	Seasonal water supply to aquatic habitats within buffer zone will be available resulting in the supply of water and nutrients to flora and fauna species within the enclosed floodplain. Areas with invasive species will be disturbed during construction of the dyke leading to dispersal and proliferation. River water quality will be affected by excavated sediment where the dyke intersects the river meander during construction of the dyke.	Seasonal water supply to aquatic habitats within buffer zone will be available resulting in the supply of water and nutrients to flora and fauna species within the enclosed floodplain. Areas with invasive species will be disturbed during construction of the dyke leading to dispersal and proliferation. River water quality will be affected by excavated sediment where the dyke intersects the river meander during construction of the dyke.	Current status unchanged. This will lead to continued cultivation up to the river banks and a higher risk of soil erosion and silt deposition into the river. There will be a loss of macrophytes which contribute to the proper functioning of the river including, silt filtration, cover and spawning ground for aquatic fauna.
	point = 1	**point = 3**	**point = 3**	**point = 3**	**point = 2**
Biodiversity	Not suitable design because it would eat into an immediate riverside land cover that is a more stable	Suitable because the design considers protection of the river banks including old river course and river banks	Suitable because the design considers protection of the river banks including old river course and river banks	Suitable in terms of conservation of biodiversity because it gives chance for restoration	Not suitable for biodiversity conservation because it does not give any consideration for

Alternative	ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
	environment than the wetland areas further afield from the river, for wetland species of plants and animals.	vegetation thus conserving biodiversity therein. Allows for the restoration of spawning grounds for fish and amphibians.	vegetation thus conserving biodiversity therein. Allows for the restoration of spawning grounds for fish and amphibians.	of the river banks vegetation in a wider area that has been severely degraded through cultivation. Allows for the restoration of spawning grounds for fish and amphibians.	conservation of biodiversity along the river. Flood intolerant vegetation and flora shall be destroyed and replaced by that with more tolerance to water logging conditions.
	point = 1	**point = 3**	**point = 3**	**point = 3**	**point = 2**
Water quality and purification	Reduced water quality due to sediment load and low purification capacity.	Good water quality due to sediment deposition, vegetation filtration, increased residence time hence better purification capacity.	Better water quality due to sediment deposition, vegetation filtration, increased residence time hence better purification capacity.	Best water quality due to sediment deposition, vegetation filtration, and increased residence time hence better purification capacity.	Current status unchanged. Water quality continues deteriorating due deposition of eroded silt and nutrients from cultivated plots.
	point = 1	**point = 3**	**point = 4**	**point = 4**	**point = 3**
Environmental condition within protection zone	Encroachment of vegetation into the river flow section. Accumulation of river bed sediment (especially in the dry seasons) which used to be deposited in the floodplain – raising the river bed and increasing the potential for flooding – reduced flow river cross sectional area.	All buffer zone within river corridor contains identified the location of invasive species (when such sites are disturbed, the invasive species tend to increase in abundance). Seasonal flooding in the buffer zone and continued occurrence of seasonal aquatic habitats. Allows for regeneration of riverine vegetation and in time restoration of spawning grounds for fish and amphibians.	All buffer zone within river corridor contains identified the location of invasive species (when such sites are disturbed, the invasive species tend to increase in abundance.), seasonal aquatic habitats. Seasonal flooding in the buffer zone. Allows for regeneration of riverine vegetation and in time restoration of spawning grounds for fish and amphibians.	All buffer zone within river corridor contains identified the location of invasive species (when such sites are disturbed, the invasive species tend to increase in abundance.), seasonal aquatic habitats. Seasonal flooding in the buffer zone. Allows for regeneration of riverine vegetation and in time restoration of spawning grounds for fish and amphibians.	Current status unchanged. Continued cultivation up to the river banks and a higher risk of soil erosion and silt deposition into the river.
	point = 2	**point = 4**	**point = 4**	**point = 4**	**point = 2**
Effect to the downstream	Chance of sediment deposition into Ramsar site, High floods with more energy will be conveyed to	Formation of sand bars and reduced sediment transport to Ramsar site. Dumped flood flows.	Formation of sand bars and reduced sediment transport to Ramsar site. Dumped flood flows.	Formation of sand bars and reduced sediment transport to Ramsar site. Dumped flood flows.	Current status unchanged. The swamp created due to current diversion will continue to render the land

Alternative	ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
	the Ramsar site.				unusable for farming.
	point = 1	**point = 3**	**point = 3**	**point = 3**	**point = 2**
Social Impact					
Social Impact	Gardens downstream will be impacted by larger magnitude floods. The land out of the project area to the northeast will have increased risk of flooding. Minimal buffer zone area protected thus availing high-value land for farming.	The land out of the project area to the northeast will have increased risk of flooding. Thus the productivity of the land will be compromised affecting a resource to support livelihood. For communities cultivating up to the river bank, less land will be available for cultivation. Reduced disease incidences attributed to the flooding.	The land out of the project area to the northeast will have increased risk of flooding. Thus the productivity of the land will be compromised affecting a resource to support livelihood. For communities cultivating up to the river bank, less land will be available for cultivation. Reduced disease incidences attributed to the flooding.	The land out of the project area to the northeast will have increased risk of flooding. Thus the productivity of the land will be compromised affecting a resource to support livelihood. For communities cultivating up to the river bank, less land will be available for cultivation. Reduced disease incidences attributed to the flooding.	The land out of the project area to the northeast will continue under the current seasonal flooding. Community land converted into a swamp due to current diversion will continue to be unusable for farming.
	point = 2	**point = 3**	**point = 3**	**point = 3**	**point = 2**
Land acquisition and its' impact	Minimal land to be acquired Increased difficulty of community mobility during construction.	Third largest land takes. Increased difficulty of community mobility during construction.	Second Largest land takes. Increased difficulty of community mobility during construction.	Largest land takes. Increased difficulty of community mobility during construction.	No land take
	point = 5	**point = 2**	**point = 2**	**point = 1**	**point = 3**
Involuntary resettlement within buffer zone	No resettlement within the buffer zone	No resettlement required within the buffer zone	No resettlement required within the buffer zone	No resettlement required within the buffer zone	Current status unchanged.
	point = 3	**point = 3**	**point = 3**	**point = 3**	**point = 2**
Impact to Local economy	A few farmers using river bed as source livelihood will be displaced. More land near the river channel to be developed for irrigation will require fertilizers – benefits of deposited alluvium. More land irrigated and thus better economic	A few farmers using river bed as source livelihood will be displaced. Benefits of deposited alluvium will be lost. Less land to gain the benefits of irrigation and corresponding better economic productivity. Economic loss due to	A few farmers using river bed as source livelihood will be displaced. Benefits of deposited alluvium will be lost. Less land to gain the benefits of irrigation and corresponding better economic productivity. Economic loss due to	A few farmers using river bed as source livelihood will be displaced. Benefits of deposited alluvium will be lost. Less land to gain the benefits of irrigation and corresponding better economic productivity. Economic loss due to	Farmers continue cultivating food crops in the old river bed as source livelihood since the diversion will stay. The land in Bulambuli will continue to be used on a seasonal basis thus limiting economic productivity. Economic loss due to

Alternative		ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
		productivity. Economic loss due to flooding minimized.	flooding minimized.	flooding minimized.	flooding minimized.	flooding will continue to occur.
		point = 5	**point = 4**	**point = 4**	**point = 4**	**point = 1**
Benefit, Cost and Environmental impact	Investment [1)]	USh 10,563,465,000	USh 6,253,774,080	USh 5,960,631,600	USh 6,318,917,560	-
	O&M cost	USh 316,903,950 /yr	USh 187,613,222 /yr	USh 178,818,853 /yr	USh 189,567,527 /yr	USh 729,315 /yr [5)]
	Benefit from Cropping [2)]	USh 545,514,706 /yr	USh 402,771,691 /yr	USh 375,495,956 /yr	USh 293,668,750 /yr	USh 117,509,276 /yr
	Benefits from Non-crop [3)]	USh 0 /yr	USh 45,219,273 /yr	USh 53,859,899 /yr	USh 79,781,775 /yr	USh 0 /yr
	Out of the BZ	60 ha	44.3 ha	41.3 ha	32.3 ha	60 ha
	Buffer zone	0 ha	15.7 ha	18.7 ha	27.7 ha	0 ha
	Total, wetland [4)]	60 ha	60 ha	60 ha	60 ha	60 ha
	B/C ratio	0.347	0.495	0.501	0.448	≫ 2
	Data and Assumption	**1)** Investment cost as direct construction cost for flood protection dyke alone, covering both left and right banks with given length (km), disbursed 50-50 % over 2years. Annual O&M cost is set uniformly as 3 % of the direct construction cost for all plans. **2)** Cropping values include lowland rice, maize, banana, beans, yams, cassava and vegetables (leafy) under Without Project condition; while only rice and maize included for With Project condition. Economic values referred to Table 1.3.5 (1.3.4 Wetland and Land Resource). The benefit per unit area (USh/ha/yr) estimated as summed individual economic values (USh/yr) divided by the total production area (ha), derived from the GIS image analysis. Net return values under With/Without Project, similarly applied in Chapter 6, were reflected in lowland rice and maize production. For annual crop benefit of the P5 ZERO OPTION, "0" benefit was applied (benefit is nil) for 10th, 20th and 30th year due to assumed serious damages by 1/10ye-probability flooding. **3)** Non-crop values contain; natural resources available within the BZ including building poles, roofing poles, reeds, grass for building, grass for livestock, fibres, water (domestic and livestock), herbs, fish and firewood. For calculation purpose, the BZ was defined more broadly by including areas of river/swamp/broadleaf. **4)** The total area of wetland assumed as 60 ha; 3,000 m (length, river-line) by 200 m (width, across the river), and set constant over different ALT plans for comparison purpose. The area of BZ was calculated using the mean width of BZ as presented above, then the Out of BZ area (for cropping) gained by subtracting the area of BZ from the total area of targeting wetland. Buffer zones for ALT-P1, P5 were assumed either as demolished due to land development or exploitation due to no protection from flooding/ human economic activities. **5)** O&M cost for P5, refined as environmental management cost, referred to Kakuru *et al.* (2013)[5] for an annual unit management cost (US$/ha) by					

[5] Kakuru, W., N. Turyahabwe and J. Mugisha (2013) *Total economic value of wetlands products and service in Uganda*. The Scientific Journal, Vol.2013, Article ID192656, 13pp. The cost used for Zero Option: (US$ 15,428 per yr ÷ 68,932ha) x 60ha x USh 3300/US$ + 137HH* USh 5000 /HH, referred to the total management cost on Kyoga plains of 68,932ha. Management cost includes

Alternative	ALT-P1	ALT-P2	ALT-P3	ALT-P4	ALT-P5
	the local government. **Note:** the B/C ratio calculated on the discounted values (present value) of benefit and cost components over a 30-year project life. Discounting rate of 10 % was applied as a normal discounting rate which would not favour private investment decisions by individuals; while, viewing a long-term support system of the wetland for ecosystem services (including water supply, fuel, materials and foods, therefore, both as non-cropping and cropping values). **Figure:** Changes in B/C ratio in accordance with different discount rates considered indicating all alternative plans (P1 to P4) involve similar trend of sensitivity for the B/C ratio in relation to the rate varied. Hasegawa *et al*. (2005)[6] suggested a need for cross comparison of evaluation for alternative projects by employing different discount rate from low to high to comprehend environmentally sound discounting factor. This will be critical when we see the relationship between environmental impact by the project and an aspect of long-term life support system of the environment. 				
	point = 1	**point = 3**	**point = 4**	**point = 2**	**point = 5**
Land use and utilization of local resources	More land near the river channel developed for irrigation. Fishing will be hampered by faster water flow and steep banks.	More land near the river channel in the buffer zone conserved and restricted for use. Better for fishing due to moderate flows, the presence of spawning grounds and accessible banks. Allows for regeneration of riverine vegetation that can be used as a renewable resource, medicinal and for craft raw materials.	More land near the river channel in the buffer zone conserved and restricted for use. Better for fishing due to moderate flows, the presence of spawning grounds and accessible banks. Allows for regeneration of riverine vegetation that can be used as a renewable resource, medicinal and for craft raw materials.	More land near the river channel in the buffer zone conserved and restricted for use. Better for fishing due to moderate flows, the presence of spawning grounds and accessible banks. Allows for regeneration of riverine vegetation that can be used as a renewable resource, medicinal and for craft raw materials.	Current status unchanged. Continued cultivation up to the river banks and a higher risk of soil erosion and silt deposition into the river and minimal fishing downstream in the wetlands.
Total Point	**24**	**36**	**38**	**35**	**25**
Evaluation	Very Bad	Good	Very Good	Fair	Bad

Source: JICA Study Team

government funding, local revenue and salary/allowance for staffs. Water user fee (communal contribution) also considered for current number of users (households).

6 Hasegawa, H., K. Mitani and C. Okano (2005) Methods and case-studies of economic evaluation on environmental impact of the agricultural and forestry projects in developing countries. Institute for International Cooperation, Japan International Cooperation Agency (JICA). (in Japanese)

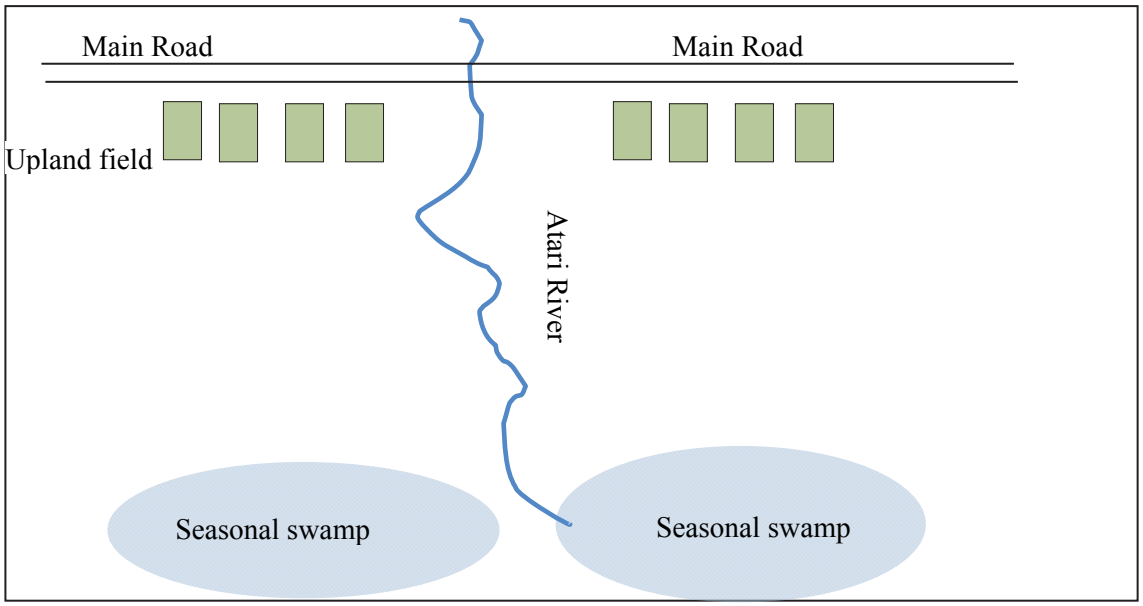
2.3.2 Comparison of Adjusting the River Course

In this section, the history of the Atari River is explained prior to considering the appropriate alignment of planned protection dyke since the Atari River has had various changes in course.

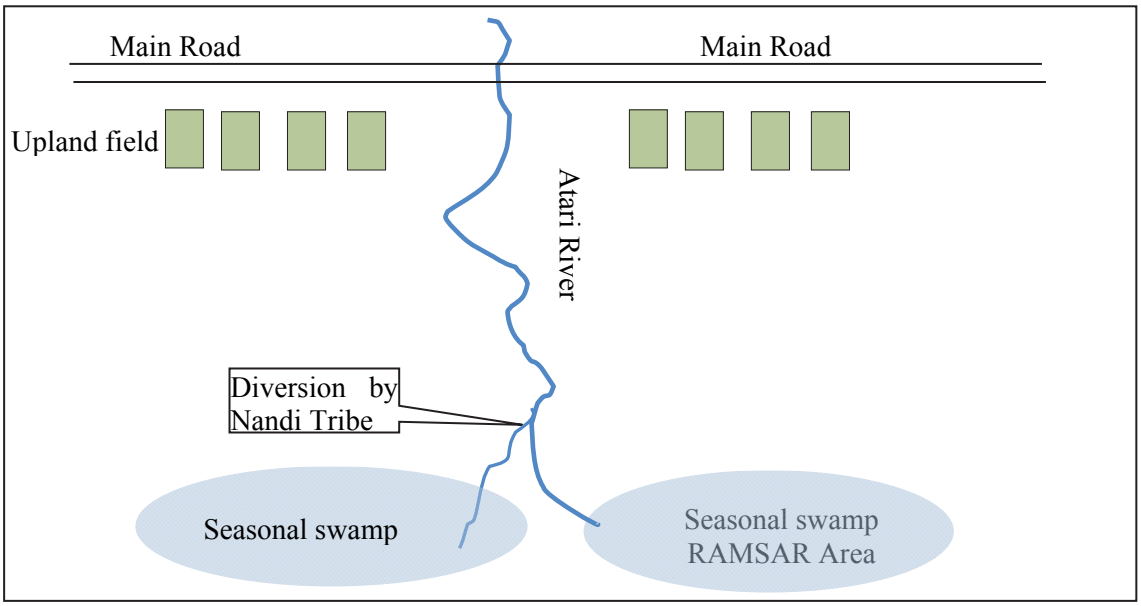
(1)Trend in Change of the Atari River

The history of swamp area and river course in Atari site is presented below:

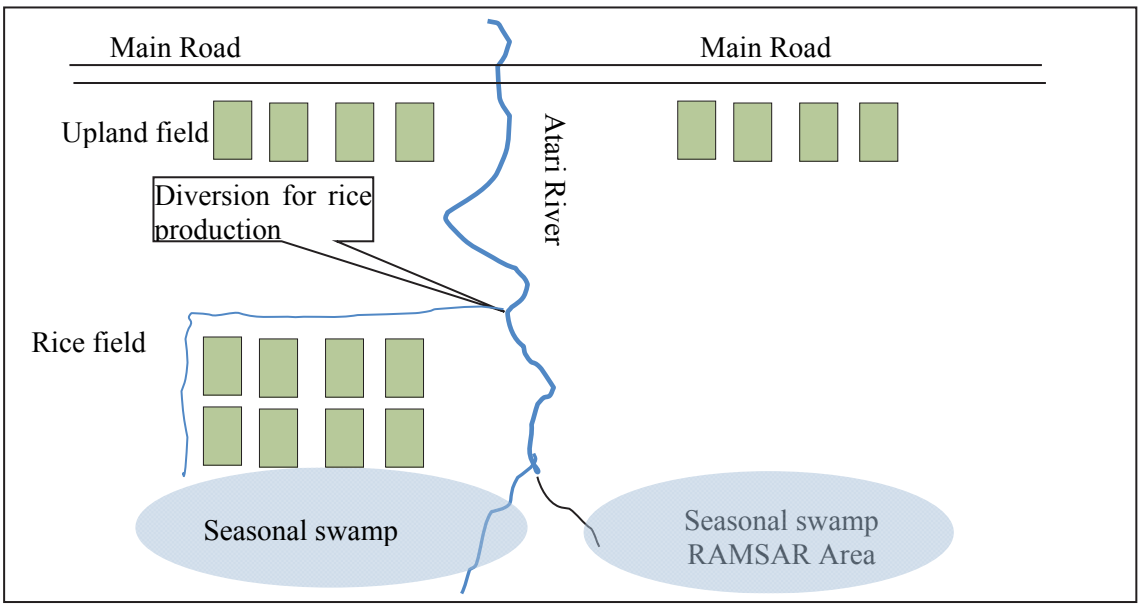
Before 1960's: According to the information collected from the area, before 1960's the course of the Atari River and its swamp is depicted in the illustration below



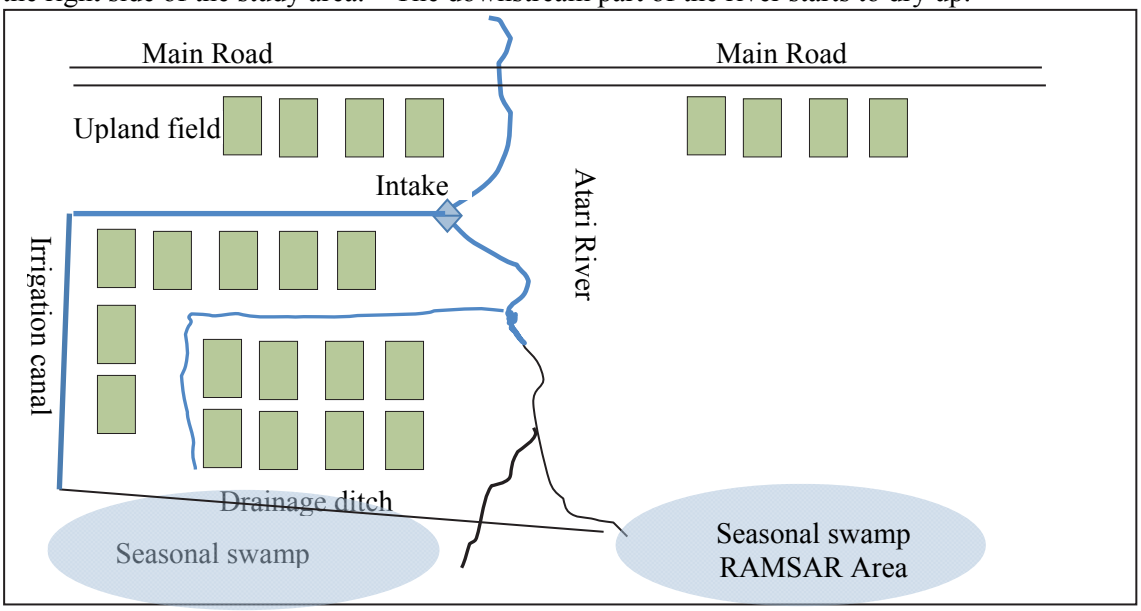
In 1960's: Nandi Tribe from Kenya diverted the river at downstream part for watering their cattle



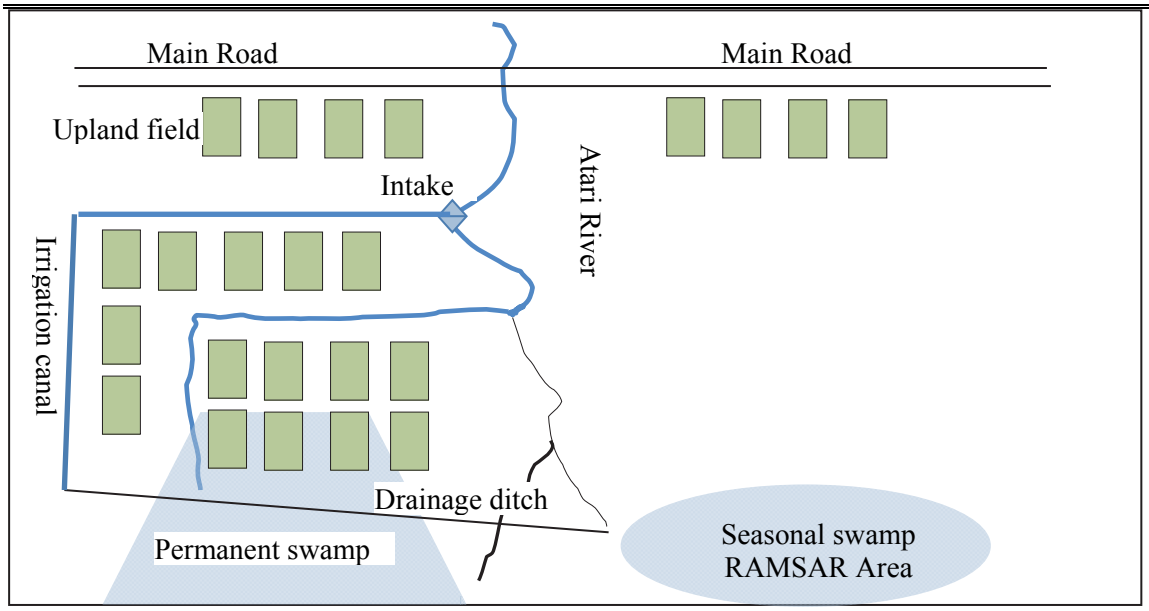
Around 1980's: A soldier from Doho area introduced rice production and opened small intake canal. The first river-course-change occurred during this period. The water stops reaching RAMSAR area (locally known as Mabono).



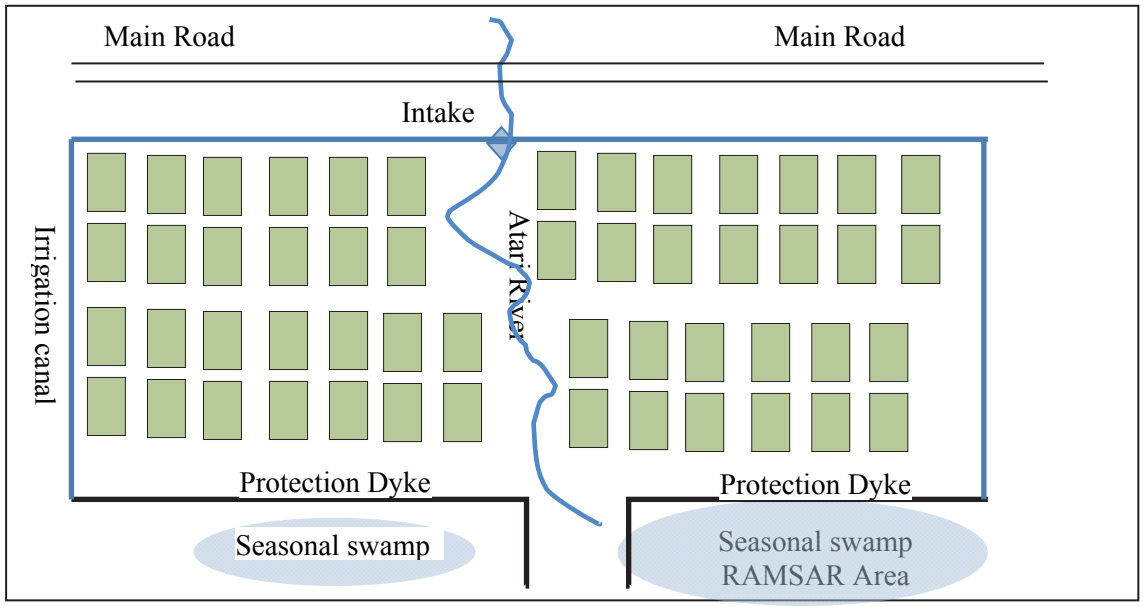
After 2006/7: The construction of an Intake by Action Aid brings an addition water extraction point to the right side of the study area. The downstream part of the river starts to dry up.



Around 2007: The effect of heavy rain in 2007: The deposition of soil material along the river course (at old intake point) and progressive erosion of old canal forced the river water to change its course completely as shown below. The downstream part of left side of the study area totally dries up with no river water flow since then.



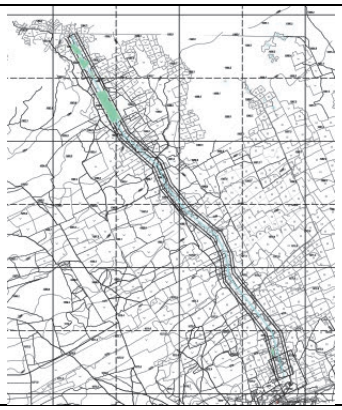
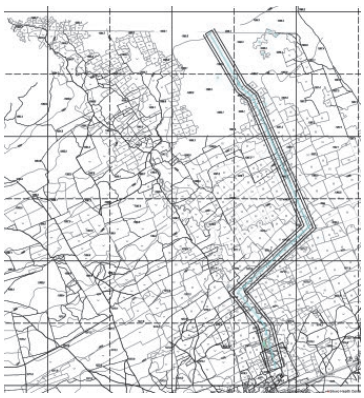
Future Plan



(2)Comparison of Alternative Plan for Water Course

Considering the above-mentioned history of the Atari River, three alternative plans are studied regarding river course as for show in Table 2.3.5. As described in the table below, ALT-L1 that is the plan to restore the original waterway and installing flood protection dyke along it is recommendable in this irrigation development project as the original river course before 1960's is the natural one, acts as administrative boundary, rich with original nature and considering equal distribution of irrigation water.

Table 2.3.5 Comparison of Alternative Plan for Water Course

Alternative	ALT-L1	ALT-L2	ALT-L0
Plan name	Restoration of original waterway	Construction of protection dyke along the existing waterway	Zero Option
Layout			
Outline of the Plan	This plan has an installation of flood protection dyke along the original waterway which is also the boundary of Kween and Bulambuli District. Protection zone shall be set at 30 m from the hypothetical centre line of the original waterway to preserve a buffer zone for purification of water and preserve existing natural forest along the old river course. Downstream part of the original river shall be restored by excavating about 30cm from existing river bed to maintain the waterway and convey the same capacity of discharge with upstream.	This plan has an installation of flood protection dyke along the existing river course which was a canal constructed to irrigate the right side of the Atari River. Protection zone shall be set with 30 m from the centre line of irrigation canal to preserve a buffer zone for purification of water.	Nothing shall be done. No regulation and wise-use of wetland become impossible. It is expected that planned CWMP will be implemented by the community together with related District and to realize wise-use of wetland.
Irrigation Area	680 ha	680 ha	450 ha
Length of protection dyke	3260 m	3244m	0 m
Acreage of Buffer zone	251,000 m^2	215,000 m^2	0 ha
Acreage of Natural Forest	25,730 m^2 (10.3 %)	640 m^2 (0.3 %)	-
Environmental Impact	Seasonal water supply to aquatic habitats within buffer zone will be available resulting in supply water and nutrients to flora and fauna species within the enclosed floodplain. Areas with invasive species will be disrupted during construction of the dyke. River water quality will be affected by excavated sediment where the dyke intersects the river meander during construction of the dyke.	Seasonal water supply to aquatic habitats within buffer zone will be available resulting in supply water and nutrients to flora and fauna species within the enclosed floodplain. Areas with invasive species will be disrupted during construction of the dyke. River water quality will be affected by excavated sediment where the dyke intersects the river meander during construction of the dyke.	Current status unchanged. The environment will not be controlled.
Biodiversity	This is necessary for terms of biodiversity because the old river course is still intact and some sections have riverine vegetation	Construction of a dyke is suitable in terms of conservation of biodiversity because it gives chance for restoration of the river	Current status unchanged and uncontrolled.

Alternative	ALT-L1	ALT-L2	ALT-L0
	that is degraded but it still holds reasonable biodiversity.	buffer zone that is usually degraded through cultivation	
Water quality and purification	Better water quality due to sediment deposition, vegetation filtration, increased residence time hence better purification capacity.	Better water quality due to sediment deposition, vegetation filtration, increased residence time hence better purification capacity.	Current status unchanged
Environmental condition within protection zone	The restoration of original environmental status is expected by restoring the old river course, such as regeneration of riverine vegetation and aquatic living things like fish and amphibians. Dyke installation will be positive to keep water for aquatic organisms, esp. during the wet season.	Restoration of the environment in the original part of the river is expected for riverine vegetation and aquatic organisms, but not much in the diverted part because of poorer ecological conditions compared with those in the original river part.	Current status unchanged
Effect to the downstream	Formation of sand bars and reduced sediment transport to Ramsar site is anticipated.	Formation of sand bars and reduced sediment transport to Ramsar site is anticipated. Increased flood protection for the plots on the both sides.	Less impact to Ramsar site as the river course does not reach to.
Social Impact	Better land productivity that used to be flooded. Increased difficulty of community mobility across restored river during construction.	Better land productivity that used to be flooded. The decrease of accessibility to the river.	Water allocation from the river is still uneven for both sides.
Land acquisition and its' impact	Land acquisition required. Increased difficulty of community mobility during construction.	Land acquisition required. Increased difficulty of community mobility during construction.	No land acquisition.
Involuntary resettlement within buffer zone	No resettlement within the buffer zone.	No resettlement required within the buffer zone.	No one has an impact.
Impact to Local economy	680 ha land to gain the benefits of irrigation and corresponding better economic productivity.	680 ha land to gain the benefits of irrigation and corresponding better economic productivity.	Only 450 ha land to gain the benefits of irrigation.
Land use and utilization of local resources	Land near the river channel conserved and restricted for use. However, extending the river course will give chance to local people for water use.	Land near the river channel conserved and restricted for use. However, extending the river course will give chance to local people for water use.	Inefficient land use and local resource utilization continue.
Judgment and reason	**Adopted** The river course restoration and protection dyke installation will contribute to the local productivity in term of environmental and social aspect. Flood mitigation will be attained. Restoration of water flow in the downstream will hydrate the Ramsar site that prevents farmer's invention to the Ramsar site.	**Not adopted** The downstream part of the north-eastern direction of the study area will continue to dry up with no river water flow and it leads to dehydrate the Ramsar site that invites farmer's invention to the Ramsar site. Since existing waterway is an artificial canal, building the buffer zone does not have much positive impact in terms of environmental and social aspect.	**Not adopted** No flood control is realized and negative impacts on the area are maximum.

Source: JICA Study Team

2.3.3 Optimum Development Scale with Land Use

The following three cases were examined to evaluate optimum development scale. The condition of each case was set by the following basic idea and estimated irrigable area, direct construction cost and evaluated as shown in Table 2.3.6 below.

- Case 1: the maximum development area with double cropping by all paddy fields
- Case 2: the maximum development area with all paddy field in one season
- Case 3: same development area as Case2 and including upland crop inside study area

As the results of evaluation show, all cases have high economic value and are feasible. Among them, Case 2 is the most economical since development area and annual paddy command area is largest while construction cost per ha is lower. Case 3 was set in consideration of the beneficiaries' intentions; some part of the target area will remain as an upland field, mainly for maize. The project serves supplemental irrigation for upland crops during consecutive dry days to increase yield. Case 3 is the second option which has second highest NPV and EIRR after Case 2. Since some community members have the intention and need to continue the cultivation upland crops such as maize and economic value is not so much different between Case 2 and Case 3, Case 3 with 680 ha development area is proposed and applied as optimum development scale in Atari site. Main and secondary canal shall be designed to flow maximum design discharge for paddling water as land use can be changed according to the water plan of WUA

Table 2.3.6 Comparison of Optimum Development Scale

2.4 Water Resources Development Plan

2.4.1 Water Resource Plan

The main source of irrigation water for the study area comes from the Atari River. Although the Atari River has a small headwork constructed by NGO (Action Aid) in around 2007, the gate lift and skin plate of the gate had broken and it is now operated using a local material such as branch and grass to stop the leakage past gate. Moreover, the intake was installed to supply water to the right-hand side and farmers on the left side are taking water to their field by handmade earth canal. Therefore, it is essential to install a new and integrated intake facility at the site so that adequate management of limited water resource and operating the gate to control intake water for equal distribution and management of the river discharge is possible. Since gravity irrigation is reasonable considering the

operation cost, main canal and secondary canal shall be provided to convey the irrigation water to distribute to the farm through the tertiary canal.

(1)Water Permit and Water Right

For the irrigation scheme development, surface water permit, construction permit and dreading permit are needed to be issued before starting the construction. According to the interview on the ground of the officers in Directorate of Water Resource Management (DWRM) which is responsible for issuance and management of water permit, existing surface water permit holder in the Atari River was not identified for both of upstream of the study site and downstream of the study site.

(2)Planning Standard

Generally, planning level shall be determined considering the balance of cost-benefit analysis of the project. Since Government of Uganda (GoU) has no standard guide for the planning of medium and large-scale irrigation scheme, JST set a Return period of the discharge as indicated below considering the conditions and standard of similar project scale.

Return period for River plan	10year
Return period for draught/ Agriculture	5 year

(3)Decision of Design Year for River Plan

Table 2.4.1 shows an example of return period standard in Japan. Reasonable return period was determined considering the balance of the construction cost and flood damage expenditures. JST had set the return period for flood protection dyke as a **ten year** because the river can be categorized as excavated river that means the water level is below ground level, and the target site is located in rural area.

Table 2.4.1 River Type and Project Scale

(Unit: year of return period)

Area Classification		**Excavated River Channel**		Dyked River Channel		Landside River	
		Standard	Provisional	Standard	Provisional	Standard	Provisional
Urban Area	Dense	100	50	150	50	100	30
	General	50	30	100	30	50	30
Residential Area		30	10	50	30	30	10
Rural Area		**10**	3	10	5	10	3

(4)River Maintenance Flow

In this study, a hydrologic method is applied to identify the environmental maintenance flow by using observed river discharge data by MWE from 2003 -2012. Three types of hydrologic approach were considered in this study and results are listed below.

Table 2.4.2 Results of Consideration by Hydrologic Methods

Type of calculation	Environmental maintenance flow (m^3/sec/100 km^2)	Environmental maintenance flow at intake site (m^3/sec)
Minimum Discharge in the record	0.122	0.126
Minimum Drought discharge in the record	0.140	0.144
Ten(10) year probability Drought discharge	**0.166**	**0.171**

Since the water levels are recorded manually, there is a risk of erratic observation. It's thought that hydrologic frequency analysis is able to minimize the influence of human error and ten (10) year probability drought discharge is the highest among the three. Therefore, ten (10) year probability drought discharge was adopted as the environmental maintenance flow and it was considered for water balance analysis in this study.

2.4.2 Plan for Irrigation Water Requirement

Water requirement for paddy planting is determined using penman's method taking into account evapotranspiration, crop factor and other meteorological data. Water balance is studied comparing water requirement and half month's river discharges similar to 5 year return period drought year taking rainfall and river maintenance flow into consideration.

(1)Determination of Basic Factor

Basic factors related to the irrigation water requirement have been set as shown in Table 2.4.3 referring to the manual of Crop Water Requirements of Irrigation and Drainage Paper by FAO and other documents.

Table 2.4.3 Applied Basic Factor for Irrigation Water Requirement

Item	Adopted Value	Remarks
1. Crop coefficient（kc）	Paddy rice: 1.05, 1.10, 0.95 Maize: 0.30, 090, 1.20, 0.35	FAO
2. Reference crop evapotranspiration (ET_0)	Tororo Meteorological station (Mean of 1969-1978)	The Development Study on Water Resources Development and Management for Lake Kyoga Basin
3. Percolation (mm)	1.0 mm	Clay
4. Puddling water	Puddling period: 15 day Puddling water: 150 mm	Typical value in clay
5. Effective rainfall	Less than 5 mm: 0 mm Not less than 5mm and less than 80 mm: 80 % of the daily rainfall More than 80 mm: 64mm	Typical method in Japan
6. Irrigation efficiency	60 %	National Water Resources Assessment,2013

Irrigation water requirement for every half month from 2000 to 2012 was estimated in accordance with the following procedures and conditions.

(2)Crop Evapotranspiration (ETc)

The crop evapotranspiration, ETc, is calculated by multiplying the reference crop evapotranspiration, ETo, by crop coefficient, Kc.

Since necessary climatic variables are not fully measured to calculate reference crop evaporation based using the Penman-Monteith method, reference crop evaporation is assumed to be the same as observed Pan evaporation at Soroti meteorological station. The following table shows the averaged daily evaporation data that is used for the water balance calculation.

Table 2.4.4 Average Daily Evaporation by Month in mm at Tororo Meteorological Station

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Evaporation (mm/day)	5.9	6.1	6.1	5.3	4.4	4.5	3.8	4.2	5.0	5.0	5.2	5.6

To determine the crop coefficient, Kc of paddy rice and maize, reference is made to the existing data of MWE. Kc for water balance calculation is calculated based on the existing data.

Table 2.4.5 Crop Coefficient, Kc for Paddy Rice and Maize

Period (day)	Basic Kc for Rice	Basic Kc for Maize
20	1.05	0.30
30(Rice) 35(Maize)	1.10	0.90
40	1.20	1.20
30	0.90	0.35

→

Period (day)	Calculated Kc for Rice	Calculated Kc for Maize
15	1.05	0.30
15	1.07	0.39
15	1.14	0.75
15	1.20	1.05
15	1.20	1.20
15	1.20	1.20
15	1.12	1.15
15	0.97	0.78
5	-	0.35

Source: JST calculated by proportional distribution based on the basic value of FAO Manual

(3)Rainfall

The observation of rainfall data was started from the end of February 2015 at Atari HC II. Figure 2.4.1 shows the results of observation of rainfall data after installation of the rain gauge station. The figure shows that the trend of rainfall in Soroti station is more similar to Atari than that in Tororo since both Atari station and Soroti station experience peak rainfall in June but Tororo station has much rainfall in April and May. As a result of this observation from the newly installed station in the study area, JST decides to apply the 10 years rainfall data collected from Soroti to estimate the water balance of Atari site, although Tororo data was applied during Phase 1 of this study. Basically, the amount of annual rainfall in Soroti is smaller than that in Tororo. Therefore, the result of calculation became a more safe side.

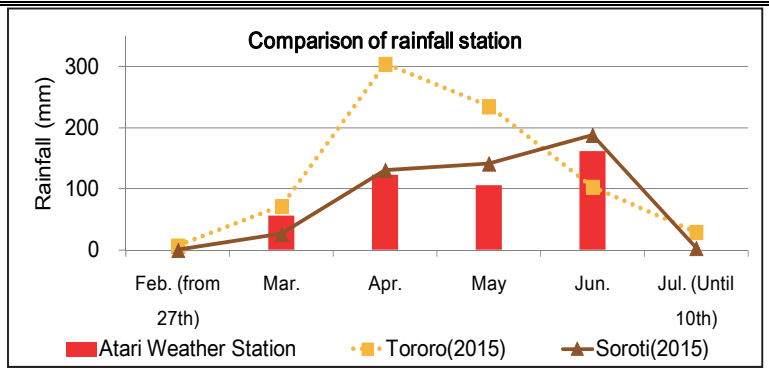


Figure 2.4.1 Comparison of Rainfall Station

Missing data is complemented by using data of complete year to calculate the average daily rainfall in each month.

(4)Effective Rainfall

By using complementary daily rainfall data, effective rainfall is calculated in the following manner. A daily rainfall less than 5mm is neglected. If a daily rainfall exceeds 5 mm/day and less than 80 mm/day, 80 % of the daily rainfall is considered to be effective. If a daily rainfall exceeds 80 mm/day, the effective rainfall is considered to be 64 mm/day.

(5)Land Preparation Water

Puddling water is determined as 10 mm /day for 15 days. Percolation is considered to be 1 mm/day. Management water requirement in the puddling period is assumed the same as ETc.

(6)Irrigation Efficiency

A diversion water requirement was estimated by taking into account seepage loss, loss from the canal and related structures, and operational loss between intake and field. The overall irrigation efficiency was determined at 60 % of the water at intake.

(7)Cropping Calendar

Since the pattern and amount of the discharge of the river vary greatly year by year, water balance is calculated in the two cases of the cropping calendar as shown in Table 2.4.6.

Table 2.4.6 Cases of Cropping Calendar

	Case 1	Case 2
First cultivation	Late April to early in July	Early in May to late August
Second cultivation	Late August to early in November	Early in September to late December

(8)River Discharge at Intake Site

Long-term river discharge data is necessary for water balance analysis but observation for the Atari River was just started from the beginning of 2015. The Sipi River is observed by MWE for long-term and the Sipi River is located near to the Atari River. Then, the Atari River discharge and

the Sipi River discharge were compared to verify the possibility to estimate the Atari River discharge from the Sipi River discharge.

The water level in the Atari River which is observed by JST and water level in the Sipi River which is observed by MWE from March 2015 to August 2015 are shown in the figure below. The figure shows that changing trend of the Atari River water level is similar to the Sipi River water level. Therefore, it is appropriate to use the Sipi River discharge data to estimate the Atari River discharge.

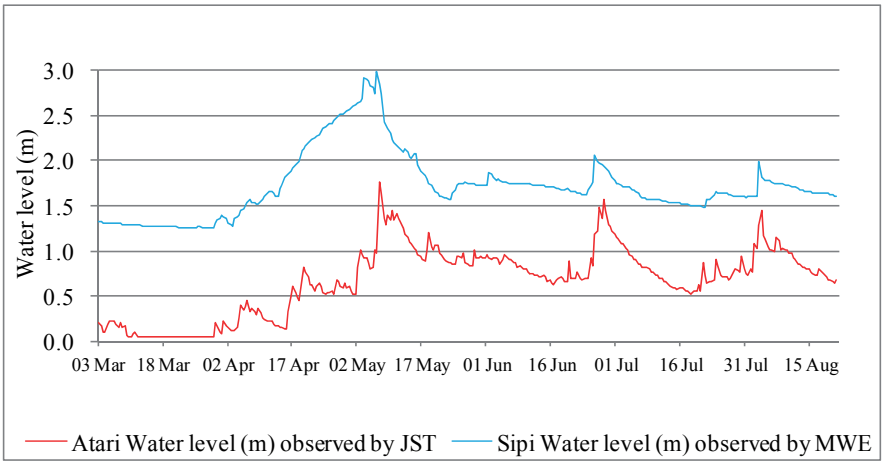


Figure 2.4.2 Change of Water Level in the Atari and the Sipi Rivers

Then, 15 days average of specific discharge for both rivers was compared and shown in the figure below. There is a correlation between Atari and the Sipi River specific discharge (R^2 = 0.846, R=0.920). Consequently, regression of the Sipi River specific discharge is applied to estimate the Atari River specific discharge.

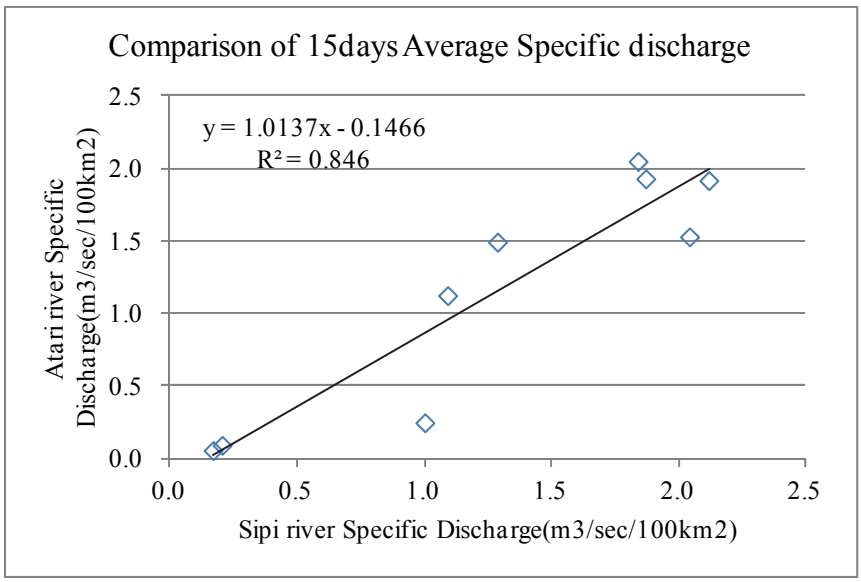


Figure 2.4.3 Comparison of 15 Days Average Specific Discharge

By using the result shown in above, 15days average specific discharge in the Sipi River from 2000 to

2012 was converted to 15 days specific discharge in the Atari River and then 15days average the Atari River discharge was applied to the water balance analysis. As the results of the discharge amount for the Atari Rivers have been reduced and the estimated irrigable areas have been reduced by about 70% from the Phase 1 study.

(9)River Maintenance Flow

River maintenance flow to downstream is determined at 0.064 m^3/sec/100 km^2 throughout a year referring to 1/10 year probability drought discharge.

(10)Domestic Water Requirement

Domestic water requirement from the Atari River is considered in water balance analysis. Demographic statistics and population growth rate were got from Uganda Bureau of Statistics (UBOS) census in 2014. Potential user is assumed to be the population in the village around the study area. Also, future demand around study area and net increment in the upstream area are considered up to 20 years hence.

Current population around study area is shown and the future population was calculated by using population growth rate for each district and shown in the table below. Future population around the study area for the water balance is determined as 15,092.

Table 2.4.7 Number of Current and Future Potential Domestic Water User in the Study Area

District	Present Population	Estimated population 5 years hence	Estimated population 10 years hence	Estimated population 20 years hence
Study area	6,533	8,007	9,836	14,941
Surrounding area	67	82	100	151
Grand Total	**6,600**	8,089	9,936	**15,092**

Source: UBOS (2014)

Likewise, current population in the upstream area of the Atari River is shown and the future population was calculated by using population growth rate for each district and shown in the table below. Net population increment in the upstream area is obtained as the difference between present population and estimated population 20 years hence and the obtained value is 28,741.

Table 2.4.8 Number of Future Potential Domestic Water User in Upstream of the Atari River

District Name	Present Population -2014	Estimated population		
		5 years hence	5 years hence	5 years hence
Kapchorwa	18,383	21,208	24,467	32,563
Kween	19,750	22,674	26,031	34,310
Total	**38,133**	43,882	50,498	**66,874**
Net population increment in the upstream area				**28,741**

Total population for consideration of domestic water in water balance analyse is obtained as a sum of the population in study area 15,092 and a net population of prospective domestic water user in upstream of the Atari River 28,741. The total population is 43,833≒44,000.

Water consumption rate is picked from National Water Resource Management Report (MWE, 2013) and water consumption rates for the rural and urban area are listed below. For water balance analysis, domestic water demand is calculated to satisfy the future demand for improvement of water supply system. Therefore, consumption rate for private connection in a rural area was applied.

Table 2.4.9 Life Water Requirement for Study Area 20 Years Hence

Area	Water Consumption Rate (L/day)	Population	Life Water Requirement (L/day)
Rural	40	44,000	1,760,000
Total			1,760,000

(11)Livestock Water Requirement

Water requirement for livestock was estimated as products of different livestock and Tropical Livestock Unit (TLU). One TLU is equivalent to an animal of 250 kg and the following conversion factors are used for animals in Sub-Saharan Africa. According to the National Water Resource Assessment Report (MWE, 2013), it's mentioned that One TLU consumes 50 lit/day.

The National Livestock Census Report 2008, MAAIF and UBOS (2010) was referred to various livestock in the study area and listed below. Future demand is also considered by using population growth rate in each district to avoid the shortage of the water in the future. Statistical data in former Sironko District (including current Bulambuli District) and former Kapchorwa District (including Kween District) were utilized for estimation of livestock water requirement.

TLU in study area including surrounding area was calculated by using the density of the TLU and multiplied by the area of study area including surrounding area. As a result, Water requirement for livestock in Atari site is determined as 86,000 lit/day.

Table 2.4.10 Density of TLU and Water Requirement for Livestock

District Name (as of July 2007)	Density of TLC/km^2	Area of study area including surrounding area (km^2)	TLU in study area (TLU)	Water requirement for livestock (lit/day)
Sironko	172	10	1,720	86,000
Kapchorwa				

2.4.3 Water Balance Calculation Results

(1)Procedure

The river discharge and water demand were compared in the following manner.

The calculated half month water requirement at intake site was compared with mean half month amount of available river discharge for agriculture. Available river discharge for agriculture was estimated by reducing maintenance water flow, drinking water, and water for cattle from observed river discharge. If the result of calculation shows the deficit of water, irrigation area is reduced until the deficit is eliminated.

(2)Potential Irrigable Area

Based on the procedures mentioned above, the irrigable area was calculated and the result is listed in Annex. The variation of the total irrigable area is 310 ha (2002 Case 2) to 7,805 ha (2010 Case 2).

Table 2.4.11 Potential Irrigable Area in Each Year

Year		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Total irrigable area (ha)	Case1	592	1,634	341	1,002	1,403	561	4,097	1,317	1,973	1,164	4,231	4,459	4,212
	Case2	335	1,780	310	1,610	1,285	535	2,380	1,570	1,210	1,340	7,805	2,790	5,085

(3)Determination of the Reference Year

The design year for the plan is determined based on the comparison of the probability analysis of the irrigable area, annual rainfall, annual discharge and drought water discharge (355 days flow) similar to 5 year return period drought year. The design year for the plan is determined as 2004. Therefore, maximum Irrigable area for each season in design year is 680 ha (First season: Beginning of April to the middle of August), and 573 ha (Second season: Middle of August to Beginning of January), respectively for paddy cultivation. Irrigation facilities will be designed for this objective area.

(4)Water Balance Calculation for Optimum Development Scale

.In this F/S, the Study Team examined various cases to find out economically feasible plan. The irrigable area in Atari site based on the water balance calculation is determined as shown in Table 2.4.12. This is designed from the point of view of water balance related to available river discharge and irrigation water requirement and following points;

- ✓ Case 1 has set in the viewpoint of cropping intensity, which is 200 % for paddy rice.
- ✓ Case 2 was the maximum irrigation area per a year.
- ✓ Case 3 was set considering several land use for agriculture, not only paddy rice but also upland crops reflecting demands from the community.

As described in Chapter 2.3.3, Case 3 was adopted for Atari Irrigation Scheme.

Table 2.4.12 Case Study for Comparison of Irrigation Area and Land Use

	First season		Second season		Development Area
	Paddy	Upland (Maize)	Paddy	Upland (Maze)	
Case 1	573ha		573ha		573ha
Case 2	680 ha		573ha		680 ha
Case 3	570 ha	110 ha	570 ha	110 ha	680 ha

(5)Expected Water Intake Volume and Effect to Downstream

The following Table 2.4.12 shows the estimated water intake from the Atari River for the period of calculated years of 12 years, the design year of 2004 and maximum and minimum year of the water resources during 12 years. This calculated result was submitted to the Nile River Basin Initiative

(NBI) which is an intergovernmental partnership of 10 Nile Basin countries, namely Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, The Sudan, Tanzania and Uganda.

According to the State of the Nile River Basin 2012, Annual discharge of the Nile River is 84 billion m^3. The ratio of annual discharge of Nile River to the amount of intake to the scheme is about 0.01 %. Therefore, the effect of irrigation development to the Nile River Basin is regarded to be negligible.

The water balance shows that in average 9 % of the total river flow will be taken and consumed in the irrigation area for the crop. The during a drought year in the design year, about 18 % of the total river discharge and wet year in 2010, about 3 % will be consumed by the irrigation area. The water intake amount will be reduced of flow into the Lake Opeta. According to the Ramsar Convention of the Lake Opeta, 689 km^2 as shown in the Annex III-8 Table 1.1.19 c has registered for the Lake Opeta wetland area. The water level reduction by the water intake for irrigation in an average year of 7.2 MCM, it is expected about 1.0 cm will be reduced the water surface which will be almost negligible small because water surface of the Lake Opeta will be fluctuated by flood and drought year to year. When the rainfall amount and river flow is abundant year water level of the Lake Opeta will be recovered.

Table 2.4.13 Expected Water Intake Volume in Case 3

Items	Equation	Unit	Atari Irrigation
River name of the discharge record			The Sipi River
Period of record: from - to			2000-2012
Number of years observed			13
Catchment Area at Gauging Station		sq.km	92
Applied rating (H-Q) curve	Sipi: Q=1.674×(H-0.620)^2.008 (MWE) Atari Specific Discharge =1.014×(Sipi Specific Discharge) -0.147		
Catchment Area at Head works		sq.km	103
Average annual runoff volume for all of records	(1)	1,000 m^3	82,719
River maintenance flow to the river		m^3/sec	0.17
Domestic Water Requirement		m^3/sec	0.020
Average annual runoff for all of the records		m^3/sec	2.61
Design Year:			2004
Design Year annual runoff volume	(2)	1,000 m^3	50,799
Maximum Runoff Year:			2010
Maximum Runoff	(3)	1,000 m^3	187,700
Minimum Runoff Year:			2002
Minimum Runoff	(4)	1,000 m^3	21,764
Average of Calculation period			**2000-2012**
Average annual Intake for Irrigation Volume	(5)	1,000 m^3	10,307
Average annual Intake for Irrigation		m^3/sec	0.437
Return flow from the irrigation (30 %)	(6)=(5)*0.3	1,000 m^3	3,092
Net consumption by irrigation	(7)=(5)-(6)	1,000 m^3	7,215
Net annual Intake for Irrigation		m^3/sec	0.306
Ratio to the annual runoff	(8)=(7)/(1)	%	9 %
Design Year:			**2004**
Design Year Intake Volume for Irrigation	(9)	1,000 m^3	13,216
Average Annual Intake for Irrigation		m^3/sec	0.56
Return flow from the irrigation (30 % of Intake)	(10)=(9)*0.3	1,000 m^3	3,965
Net consumption by irrigation	(11)=(9)-(10)	1,000 m^3	9,252

Items	Equation	Unit	Atari Irrigation
Net annual Intake for Irrigation		m^3/sec	0.39
Ratio to the annual runoff	(12)=(11)/(2)	%	18 %
Maximum intake for Irrigation		m^3/sec	2.24
Maximum Year:			**2010**
Maximum Annual Intake for Irrigation	(13)	1,000 m^3	9,274
Average Annual Intake for Irrigation		m^3/sec	0.39
Return flow from the irrigation	(14)=(13)*0.3	1,000 m^3	2,782
Net consumption by irrigation	(15)=(13)-(14)	1,000 m^3	6,492
Net annual Intake for Irrigation		m^3/sec	0.28
Ratio to the annual runoff	(16)=(15)/(3)	%	3 %
Minimum Year:			**2002**
Minimum annual Intake for Irrigation	(17)	1,000 m^3	5,859
Average Annual Intake for Irrigation		m^3/sec	0.25
Return flow from the irrigation	(18)=(17)*0.3	1,000 m^3	1,758
Net consumption by irrigation	(19)=(17)-(18)	1,000 m^3	4,101
Net annual Intake for Irrigation		m^3/sec	0.17
Ratio to the annual runoff	(20)=(19)/(4)	%	19 %

2.4.4 Future Possibility of Upstream Irrigation Development by Local Peoples

There is a flat area in the upstream of the Atari River from Moroto road to the foot of Mt. Elgon for about the length of 2km and covers about 500 ha. In future Atari Irrigation Scheme will be implemented and the economic viability and increasing of the farm income will be realised by local peoples and this farmland in the upstream area will also be starting irrigation development taking water from the Atari River by local farmers. It will be necessary and important to study beforehand about possibilities of upstream area development in future and forecast influence of upstream water intake to the PISD Atari Irrigation Scheme area. On the other hand in the downstream area of the Atari site, the Ramsar Convention area is located about 500 m downstream and the agricultural activities will be prohibited.

In the upstream flat area from the Moroto road, the Atari River course becomes deeper and deeper for about 8 m from the surface of the flat area to the point of the foot of Mt. Elgon. There is a collapsed concrete weir near the foot of the mountain without any usage of the intake water. In the upstream area, the river course flows in the deep place which irrigation water intake by gravity will be very difficult. There is a fixed small pump station in the upstream area irrigating tomato and vegetable for about 1 ha only. It will be possible to introduce additional pumping stations to

Table 2.4.14 Possible Additional Irrigation Area in the Upstream

The Cropping Calendar is different from Downstream

	1st Crop (ha)	2nd Crop (ha)	
2000	0	523	
2001	383	540	
2002	0	0	
2003	768	0	
2004	25	4	Design Year
2005	0	1,139	
2006	0	3,114	
2007	350	350	
2008	0	1,908	
2009	0	801	Draughtiest Year
2010	3,503	4,602	
2011	0	3,648	
2012	2,064	1,658	
Average(ha)	546	1,407	

take water from the Atari River for irrigation. There will be very difficult to introduce large pump stations in the upstream area by local farmers. In future, there will be a possibility to irrigation about 10 ha by pumps and it might be affected by the Atari Irrigation Scheme area. So that in future it will be carefully observed in the upstream area irrigation development and negotiate with the farmers to modify water intake pattern and cropping calendar.

In order to find the potentiality of additional irrigation area development in the upstream area, the water balance analysis has been made to utilize remaining water after intake for Atari site. When the proposed cropping calendar is the same as PISD for the upstream area, the intake pattern becomes the same as the PISD site; the water will not be enough to irrigate the additional area.

On the contrary, the cropping calendar for the upstream area is different from the PISD area it can be expected more irrigable area as shown in the Table 2.4.14. Based on analysis of about 3 years which include the draughtiest year and design year, it can be forecasted that there will be no more additional irrigation area but about 350 ha to 500 ha will have a potential to be irrigated in average years in the upstream area. Accordingly, when irrigation water intake will be observed in future, it is necessary to negotiate with the upstream farmers for changing cropping calendar and intake water patterns. If possible it will be recommendable to form WUA in the upstream farmers and negotiate with groups of farmers.

2.5 Countermeasures for River Flood and Setting of Buffer Zone

2.5.1 Estimation of Flood Capacity

Peak flood discharge analysis has been made for the Atari River by unit hydrograph analysis derived from 1/10 year return period of daily rainfall data. The hourly rainfall distribution has been analysed based upon the observed 10 minutes record of automatic rain gauge installed by the JST in the year 2015. The hourly rainfall distribution has been derived from early peak rainfall patterns to set 6 o'clock within 24-hour rainfall distribution by hyetograph.

The obtained peak flood discharge has been estimated by unit hydrograph method for 1/10 year return period. The flood peak discharge was analysed at proposed head works point of the Atari River.

(1)Probable Maximum Daily Rainfall

Since there is not only hourly rainfall data but also daily rainfall data in the study area, daily rainfall data in south-eastern and eastern Uganda is applied for flood discharge analysis. As a result of the field observation of the rainfall from March 2015 in the watershed of the study area, data in Soroti meteorological station is similar to Atari site rainfall pattern. Therefore, long-term rainfall data in Soroti meteorological station was applied to Atari site for flood discharge analysis in this study.

The daily maximum rainfall in each year is extracted from the long-term observed data from 1992 to 2013 by Uganda Meteorological Authority. Probable maximum daily rainfall was calculated by using Iwai method. The results of the calculation are shown in Table 2.5.1. Return period for river

plan had been set as 10years.

Table 2.5.1 Probable Maximum Daily Rainfall in Study Area (1992-2013)

Return period		2 years	5 years	10 years	20 years	100 years	200 years
Probable maximum daily rainfall (mm/day)	Tororo	75	95	**107**	119	144	154
	Soroti	71	93	**111**	131	188	217

Source: Uganda Meteorological Authority

(2)Rainfall Intensity Formula

Rainfall intensity is calculated using Talbot equation and calculated probable daily rainfall. coefficient *b* and *r* in Talbot equation are determined as 2 and 0.25 respectively since observed rainfall showed high intensity and a short period of time rainfall and the peak of rainfall was dominantly in the first half of each rainfall event. The result of calculation is shown in Figure 2.5.1. Those results were applied as design rainfall pattern for calculation of flood discharge.

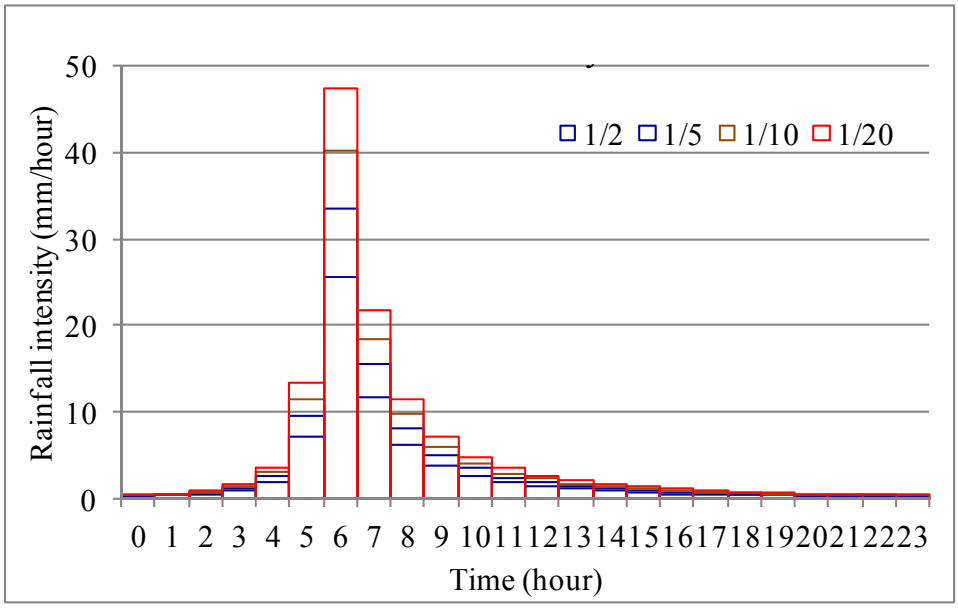


Figure 2.5.1 Calculation Result of Rainfall Intensity

(3)Calculation of Effective Rainfall

For calculation of effective rainfall by using the result of rainfall intensity equation, the relationship between observed cumulative rainfall and a cumulative loss of rainfall which were obtained by observed rainfall in the watershed and river discharge at gauging station was compared and shown in Figure 2.5.2.

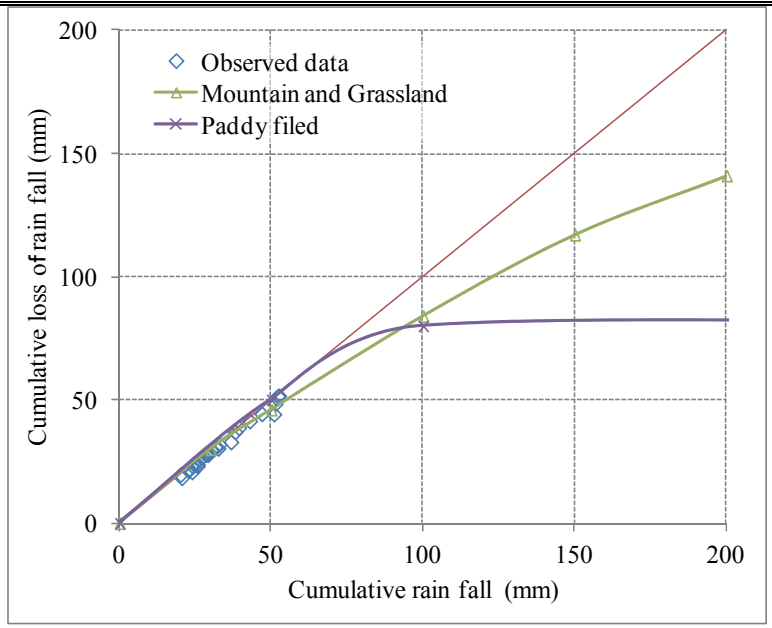


Figure 2.5.2 Relationship between Observed Cumulative Rainfall and Cumulative Loss of Rainfall

Table 2.5.2 Applied Relationship between Cumulative Rainfall and Cumulative Loss of Rainfall for Mountainous Area and Grassland

Cumulative Rainfall (mm)	Cumulative Loss of Rainfall (mm)
0	0
30	30
50	46
100	84
150	117
200	141

(4)Calculation of flood Discharge by Unit Hydrograph

Flood discharge was calculated by unit hydrograph method in this study. Characteristics of the river at each section for calculation are listed in Table 2.5.3 and those were applied for calculation. Calculated flood discharges by unit hydrograph using observed top tree heavy rainfall data were compared to observed flood data for each event to confirm the verification of the calculation. Then, a parameter of unit hydrograph was adjusted to optimize the result. The results of calculated flood before and after adjustment of the parameter are shown in Figure 2.5.3.

Table 2.5.3 Information on the Watershed for Calculation of Flood Discharge

Name of Site	Location	Catchment area (km2)	Length of river (km)
Atari site	Gauging station	103	40.6
	Proposed intake site	103	40.6

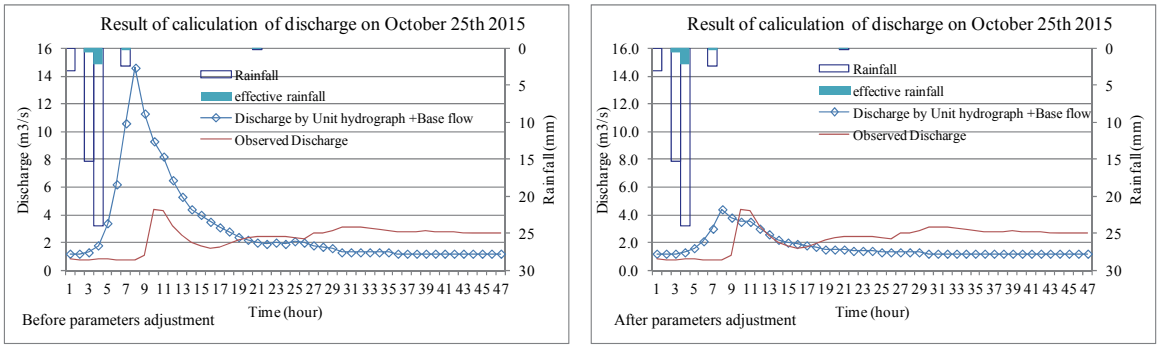


Figure 2.5.3 Comparison of Result of Calculated Flood Discharge before and after Adjustment of Parameters

By using optimized unit hydrograph and design rainfall pattern, flood discharge for each rainfall probability is calculated. The result of calculation is shown in Figure 2.5.4 and peak discharge is listed in Table 2.5.4.

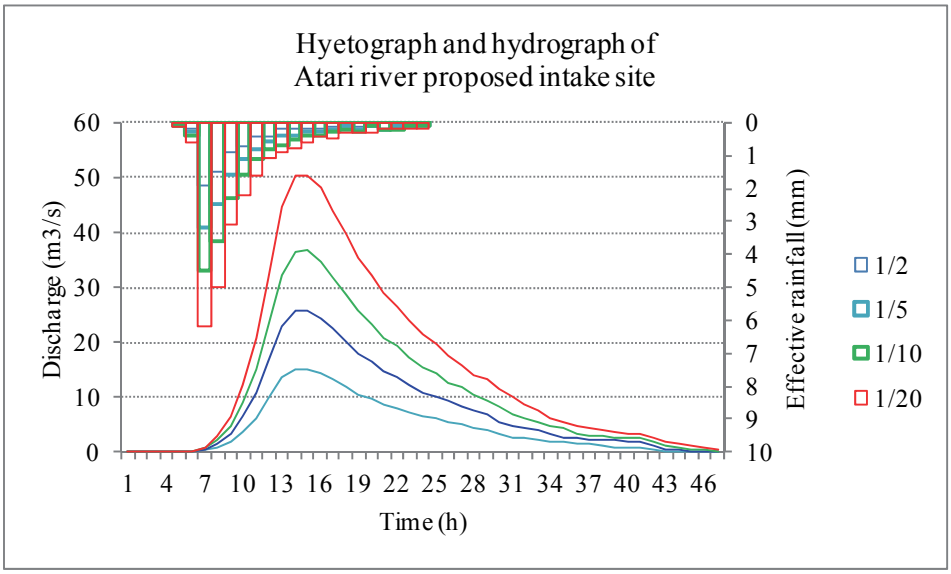


Figure 2.5.4 Hyetograph and Hydrograph of the Atari River at Proposed Intake Site

Table 2.5.4 Result of Flood Discharge

Location	2 years	5 years	10 years	20 years
Atari River Proposed intake site	15.2	25.8	**36.7**	50.4

(5)Consideration of Base Flow

Base flow in rainy season is considered using observed discharge data obtained by the automatic water level gauge in 2015. In this study, base flow in the rainy season was assumed as the average of 10 days minimum discharge in the rainy season (Figure 2.5.5). Calculated base flow at gauging station is converted to each location by the ratio of the catchment area. Calculated base flow for each location is shown in Table 2.5.5.

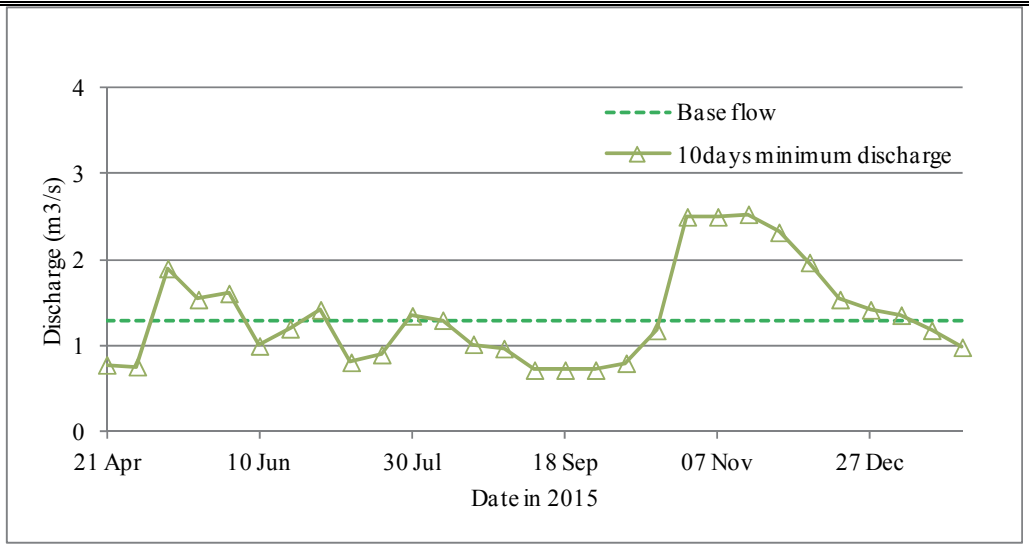


Figure 2.5.5 Observed 10 Days Minimum Discharge and Calculated Base Flow

Table 2.5.5 Calculated Base Flow for Each Location

Name of Site	Location	Catchment area (km^2)	Base flow (m^3/sec)
Atari site	Gauging station at the Atari River	103	1.3
	Proposed intake site	103	1.3

(6)Determination of Design Flood Discharge

Design flood discharge is assumed as a sum of flood discharge calculated by unit hydrograph and base flow in the rainy season. The results of calculation were shown in Table 2.5.6.

Table 2.5.6 Design Flood Discharge for Each Location

Unit: m^3/sec

Location	Flood discharge (1/10 Probability)	Base flow in rainy season	Total	Design flood discharge (Rounded up the decimal places)
The Atari River proposed intake site	36.7	1.3	38.0	**38**

2.5.2 Width of Buffer Zone and Flood Water Level

(1)Flood Protection Dyke

Flood protection dyke shall be provided along rivers and at the lower end of farmland in order to avoid intrusion of the flood into farmland. A road paved with laterite will be provided on the top of the flood protection dyke.

The height of flood protection dyke will be decided to detect past highest flood record by hearing from dwellers along the river. In order to adopt the buffer zone regulation, it is extremely difficult to set the width of 30 m from the maximum flood water level in the river. This is riparian because the river course meanders a lot due to the characteristics of the surrounding condition of the river.

As a result, the buffer zone width has been decided on the basis of following two conditions:

- To preserve the environment in the riparian zone as much as possible. The full meandering river course and all ox-bow lake area along the old river course area where biodiversity is abundant shall be preserved. These areas will be very important to conserve natural environment of the buffer zone. Therefore the riparian areas including the original river courses have been included in the buffer zone.
- One of the most important functions of the buffer zone is that it allows the flow of flood water safely to downstream area. The buffer zone together with a height of flood protection dyke has been considered to have enough capacity to flow the peak flood discharge which is expected to occur once in 10 year return period at each point of the river confluence points.
- Considering the above two conditions, the flood protection dyke shall be provided along rivers and at the lower end of farmland in order to avoid intrusion of the flood into farmland. A road paved with laterite will be provided on the top of flood protection dyke and the width of the dyke shall be 5 metres with 4m road carriageway width.
- The height of flood protection dyke has been decided on the basis of conveying safely the peak flood discharge of 10-year probability. And also the height has been checked by detecting past highest flood record through hearing from dweller along the rivers taking freeboard and settlement of embankment into consideration.

(2)Proposed Layout of Protection Dyke Considering the Meandered River Course

The Study team proposes the following basic policy to set the alignment of Flood Protection Dyke taking into consideration the river scale and condition on the ground.

Basic Policy for Layout of Protection Dyke

- Alignment of flood protection dyke shall be along river course
- Width of flood protection dyke shall be in the range of 30 m to 60 m which are almost the same width of current meandering river course of the Atari River
- Protection dyke shall be set at least 5m from river bank considering bank protection
- Protection dyke shall cover the old river course as much as possible since these areas have various high-value biodiversity to be conserved
- Protection dyke shall be installed to avoid resettlement considering social issue
- The old Atari River course shall be dredged to relocate the original river course in the downstream part where it had changed

(3)Old River Course Excavation

As previously mentioned in chapter 2.2.3, the Atari River has changed its river course and utilization

of swamp area variously and river course will be restored to the original river course.

The artificially diverted river course crossing the farmland and riparian area has not been considered environmental conservation works. In order to recover proper river flow into Ramsar area and return to the original river course, the old river course is planned to be excavated and riparian area setting a buffer zone bounded by flood protection dyke connected with the upstream area of the river course. The capacity of newly excavated river course should have enough capacity to discharge 1/10 year return period of peak flood discharge of 38 m^3/sec.

Since the cross-section of downstream does not have enough area to flow the flood currently, it is planned to excavate 50cm below to maintain current dimension. As the height of bank differs between right and left-hand side, the cross-section of the low flow channel is regarded 30cm below from current river bed for the hydrological calculation.

(4)Setting of Buffer Zone in the Meandering River Course

As previously mentioned in chapter 2.2, the alignment of protection dyke had taken into consideration several points of views such as environmental and social impact, allowable dimension against flood flow and regulations. Therefore the width of the buffer zone is set leaving 30 m wide area from hypothetical river centre to preserve the existing meandering river course.

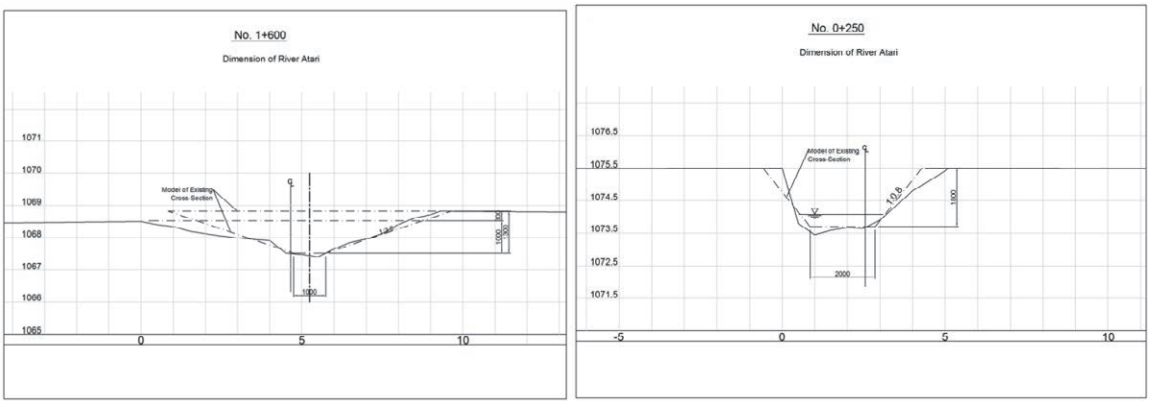
(5)Current Condition of the Atari River and Design Condition

The current condition of Atari River is summarized in Table 2.5.7 below. The information is organized using a topographic map, Shuttle Radar Topography Mission (SRTM) and field survey. Design discharge of the river is calculated according to the unit hydrograph method and design discharge of road project is estimated using TRRL Eastern African Model by UNRA. The current cross-section is surveyed on several points and evaluated for the possible maximum flow of cross-section. One typical cross-section is selected as a representative of the upper stream and the downstream area along the original river course.

Table 2.5.7 Features of the Atari River

Item	Features	Remark
River slope	1/300	Source; SRTM Data
Ground slope	1/275	Source; Topographic Map
Maximum water discharge	12.8 m^3/sec	Referred R. Sipi
Catchment area at intake point	103 km^2	
Design Discharge	38 m^3/sec	10 years probability
Design Discharge of Road Project	100 m^3/sec	25 years probability by UNRA
Dimension of Upper area	B=2.0 m, H=1.8m, Slope =1:0.8	Surveyed
Dimension of Down area	B=1.0 m, H=1.5-1.8m, Slope =1:3	Surveyed

Source: determined by JST



No.0 – No.0+630 No.0+630 – No.3+220

Figure 2.5.6 Typical Cross-section of the Atari River

(6)Design Height of Flood Protection Dyke

The current river course is regarded as a low flow channel and necessary height of flood protection dyke was designed by applying uniform flow calculation to convey the design flood discharge of 10year probability. The basic data applied for calculation is shown below. With regard to the design height of bank, free board and extra banking have been taken into consideration since flood protection dyke will be constructed near the river bank. The extra banking has been set as 20cm height considering consolidation and subsidence that might occur in the future.

- ✓ Mean velocity formula Manning's equation
- ✓ Design flood discharge 38.0 m^3/sec (10 year probability)
- ✓ Slope of river bed 1/275
- ✓ Roughness coefficient 0.050
- ✓ Cross section of current river course Width 2.0 m, Height 1.8 m, side Slope 1:0.8
- ✓ Width of high water channel 60 m
- ✓ Free board 60 cm
- ✓ Extra banking 20 cm

The results of calculation are presented in Annex 4 and the necessary height of protection dyke shall be 1.4 m high for the design flood for both upstream section and a downstream section. It was confirmed that design discharge of road project with 25 years probability can be passed within this designed dimension under the free board.

2.6 Agricultural Development Plan

2.6.1 Basic Policy of Agricultural Development

The main purpose of the irrigation scheme development is to serve proper water condition suitable for lowland rice production. Rice is recognized as a much profitable crop compared to other upland

crops such as maize, cassava and beans. The demand of rice in Uganda and neighbouring countries has been increasing in a decade. Therefore, rice is placed as the main target crop of the project. The main target of the project is to increase cropped area, yield and cropping intensity of lowland rice. For this purpose, technical and financial support shall be provided to the beneficiary farmers.

In consideration of the beneficiaries' intentions, some part of the target area will remain upland field, mainly for maize. The project shall serve supplemental irrigation for upland crops during consecutive dry days to increase yield.

The paddy field shall be developed in the whole target area of the scheme. The beneficiaries need to perform crop rotation of lowland rice and upland crops by season in order to share limited irrigation water source among them. Proper coordination of cropping schedule shall be necessary for each irrigation block.

Farmers' cooperatives and WUAs shall be formulated by the beneficiaries' groups to operate and maintain the facilities properly and to maximize their profit from rice production. The capacity of those organizations shall be built under government support.

In addition, special attention to impact to the environment in wetland shall be paid in farming in the irrigation area. Fertilizers should be applied properly within paddy field with firm bund, and agrochemicals are generally not recommended to use.

2.6.2 Land Use Plan

The present paddy field area in the study area of Atari irrigation scheme is 211 ha. The land use pattern is not changed significantly under without project condition. Considering trend of land use, however, the paddy field area will increase a little even under without project condition. Under with project condition, the whole target area will be transformed to lowland paddy field. The land use plan under without and with project condition is projected as shown in the following tables.

Table 2.6.1 Land Use Plan under without and with Project Conditions

(Unit: ha)

Name of Site	Condition	Total Area	Lowland Paddy Field	Upland Field	Grassland	Trees	Bush	Others
Atari	Without Project	680	220	220	190	2	24	24
	With Project	680	680	0	0	0	0	0

Source: JICA Study Team

2.6.3 Cropping Plan

Lowland rice and upland crops including maize, cassava, millet, etc. are cropped twice a year as much as available in water. The cropping area of lowland rice is estimated at 66 ha in the first season and 198 ha in the second season under the without-project condition, based on the present cropping pattern. The upland crops are planted in 220 ha in the first season and 132 ha in the second season. On the other hand, the cropping area of lowland paddy will increase significantly after implementation of the

project, which will provide preferable field water conditions with irrigation, drainage and flood protection facilities. The area of lowland rice production will be 570 ha in both first and second seasons. The upland crops will be cultivated on 110 ha in both seasons with supplemental irrigation water supply. This cropping pattern is proposed to sympathize with the beneficiaries who cling to their conventional staple food of maize, even though there is the potential for rice production in 680 ha in the first season and 573 ha in the second season.

Table 2.6.2 Cropping Plan under without and with Project Conditions

(Unit: ha)

Site	Condition	Total Area	Lowland Paddy-1	Lowland Paddy-2	Upland Crop-1	Upland Crop-2	Perennial Crops
Atari	Without Project	680	66	198	220	132	0
	With Project	680	570	570	110	110	0

Source: JICA Study Team

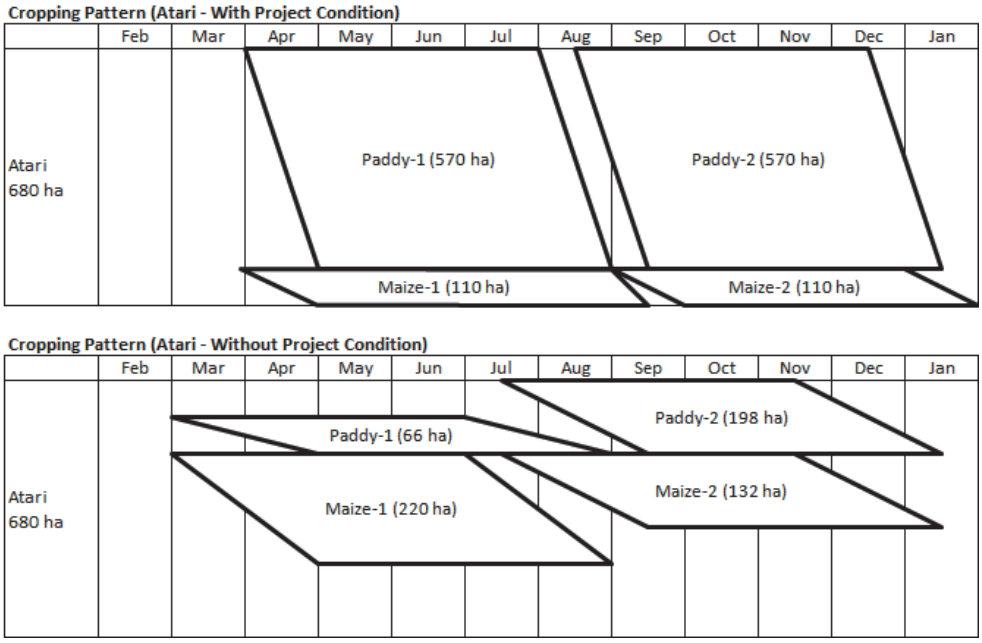


Figure 2.6.1 Cropping Plan under Without and With Project Conditions

2.6.4 Farming Management Plan

The production method of rice is expected to be improved because a preferable field condition is provided. For instance, farmers will manage rice more intensively and apply an adequate amount of fertilizer to maximize the productivity. Major issues of the farming improvement are summarized below.

- Rice variety and seeds:
  High-yielding and short- to medium-duration lowland rice varieties, such as Kaiso (K-85), NERICA-6 and WITA-9, will be introduced. In the case of double cropping, long-duration varieties, such as Super, are not appropriate.
  High-quality seeds will be maintained by farmers with removing contaminated varieties and

proper storage method.

- Land preparation:
  Proper schedule of land preparation shall be placed to maximum use of irrigation water in the whole service area.
  Double cropping of rice is also practised as much as possible.
  Mechanization, such as a tractor for ploughing and power tillers for puddling, is helpful to save time and to meet the possible shortage of labour at peak season.

- Nursery preparation and transplanting:
  Nursery period will be about 3 weeks.
  Seedlings will be transplanted with proper spacing; e.g., 20 to 25 cm distance between hills.

- Fertilizer application:
  Farmers shall use more fertilizer to obtain a higher yield of lowland rice because the effectiveness of fertilizer is highly assured after irrigation and drainage system is installed. The fertilizer application rate recommended by NaCRRI is 25 kg of DAP (18-46-0) and 50 kg of Urea (46-0-0) per acre, which is approximately equivalent to the nutrient composition of N: P_2O_5:K_2O = 70:30:0 kg/ha. An alternative selection of fertilizer can be 75 kg of Ammonium Sulphate (21-24-0) per acre (N: P_2O_5:K_2O = 40:45:0 kg/ha).

- Pest and disease control:
  Proper field management, for example, clearing of weeds and proper water control, can reduce damages by pest insects and plant diseases. The rice plants infested by Yellow Mottle Virus shall be removed from the field as soon as possible. To use tolerant varieties to the virus, such as WITA-9 and NERICA-6, is another way to mitigate the damages.

- Weed control:
  Timely weeding will be practised to reduce the population of weeds with minimum labour input. For instance, only 1 time weeding at about 3 weeks after transplanting is enough for 4-month rice varieties.
  Proper control of water level in plots is another way to reduce weeds, i.e., deep water prevents the growth of most kinds of weeds.

- Harvesting:
  Bird scaring and right time harvesting are the most important issues to maximize yield at the late stage.

2.6.5 Crop Production Plan

In the general crop production plan, lowland rice, maize and banana are selected as representative crops in the lowland, upland and perennial crop field, respectively. In case the irrigation project is not implemented, the yield of crops will not change significantly because farmers will not be

motivated to improve productivity. The yield of lowland rice and maize has been already at a high level in the country, i.e., 3.0 ton/ha and 3.5 ton/ha, respectively.

Under the with-project condition, however, the yield of lowland rice will increase gradually as a result of proper water management and improvement of cultivation method. The yield will reach to 5.0 ton/ha by 4th year after completion of construction of irrigation and drainage facilities. The yield of upland crops and perennial crops will not increase significantly. As shown in the following table, the annual rice production will increase from 792 ton to 5,700 ton.

Table 2.6.3 Cropping Plan under Without and With Project Conditions

(Unit: ha)

Name of Site	Condition	Crop	Area (ha/year)	Yield (ton/ha)	Production (ton/year)
Atari	Without Project	Lowland Rice	264	3.0	792
		Upland Crop (Maize)	352	3.5	1,230
	With Project	Lowland Rice	1,140	5.0	5,700
		Upland Crop (Maize)	220	4.0	880

Source: JICA Study Team

2.6.6 Farmers Organization

Percentage of participation in farmers' organization in Atari area is not so high, 27 %. Typical farmers group is small scale with about 20 members, independently works, charges a little membership fee (USh 5000-6000, about US$ 2 annually) but save USh 1,000 - 5,000 (about US$ 1.3 - 1.7) weekly. General penalty given to defaulters is withdrawal from the group. The function of credit and saving is considered very important.

Rice cultivation through groups is relatively popular and O&M of simple irrigation facilities by groups is common. The function of labour exchange is considered very important. The labour cost for farm work takes a large share of group's expenditure. Shortage of labour is one of the reasons to participate in group activities. 38 % of groups have received support from the government. In Atari, three types of support (technical, material, and financial support) are seen at the same frequency.

Rice is a very important crop to the farmers. In terms of marketing of rice, people make an effort to increase profit by joint milling or joint sales of a small portion of rice but active marketing promotion is not observed.

When large-scale irrigation system is developed in Atari area in the future, farmers' organizations are expected to play the following three roles to supervise large number of water users, (a) to O&M of irrigation facilities, (b) to produce agriculture product using irrigation water, and (c) to promote marketing of their products. Considering the above-mentioned situation of farmers groups, challenges that impede fulfilment of their tasks are summarized in Table 2.6.4.

Table 2.6.4 Challenges for Farmers Groups in Atari

Type of challenges	Descriptions
Challenges on management of organization	No experience in management of large-scale group Large-scale irrigation system requires coordination of interests of more than 1,000 beneficiaries. To do this, high communication skill such as making a consensus of members through several subordinate groups and quick notification of the official decision to all members is necessary. Actually, people in the area have a little experience in a group activity. There are some active groups but they are small-scale and independently operated. The setting of proper water user's fee and charging system are also required to manage irrigation system. Actually, people pay a little money for group activity. To charge a high membership fee, accountability on price setting is required. Also, management organization should be mandated to charge by law.
	No proper penalty against violation of non-paying The principle of irrigation system is the compulsory participation of all users to WUA. In the existing farmer's group, general penalty to defaulters is withdrawal. Withdrawal is the final measure of penalty for WUA.
Challenges for O&M of irrigation facilities	No experience in O&M of large irrigation facilities Some groups do O&M of simple irrigation facilities created with local techniques but no one has experience in large-scale facilities or planning of water distribution. External support in planning and implementation of O&M and is needed for the management organization to sustain the irrigation system by themselves. Support to the calculation of O&M cost is required to set appropriate water users fee.
Challenges on agricultural production	Shortage of labour and fund People in the area clearly experience the shortage of labour and fund for agricultural practice. The introduction of irrigation system will increase production as well as demand for labour, which could worsen the demand-and-supply balance of labour in the area. Mechanization would be a solution to this problem. The initial investment is critical to increasing production volume but the scale of credit and saving managed by existing farmers groups is quite small.
	Lack of extension service Improvement of skill is needed to increase agricultural production but a few people have access to extension services. Reconstruction of extension system has not been completed after dissolving of extension service section of NAADS and budget as well as a number of extension workers is limited. Drastic improvement in access to extension service is not expected.
Challenges on marketing	Shortage of fund for marketing In the marketing aspect, shortage of fund is a serious problem and this is evidenced by the heavy transport cost burden carried by farmers. Poor access to market and rice mills forces people to sell rice at a low price.
	Shortage of fund for marketing In the marketing aspect, shortage of fund is a serious problem. Especially transport cost is a heavy burden for farmers.

Proposed measures for above-mentioned challenges are summarized as below.

Table 2.6.5 Proposed Measures for Challenges of Farmers Group in Atari

Type of challenges	Proposed measures for challenges
Management of organization	➢ Training for leaders: Farmers are assumed to be members of a small group called Water Users' Group (WUG) consisting of 20 m. The leaders of WUGs receive training on facilitation skill to make a consensus of members and planning of activities. ➢ Involvement of existing farmers group: Existing groups have a certain experience in group management. WUG/WUA are formulated by upsizing or rebuilding these groups so that they can utilize their knowledge or experience. ➢ Accountability of price setting is ensured by systemizing the process of calculation of water users' fee. The basis of calculation and balance of payment should be open to all members to ensure transparency of accounting. WUA is given the power of collection by bylaw on condition of accountability for finance. ➢ Development of rules for violation such as defaulting: Rational penalties are developed basing on existing cases (e.g. warning, fine, halt of water distribution, temporal seizure of farmland, etc.)
O&M of irrigation facilities	➢ Water Users Committee (WUC), the top organization of O&M bodies, involves local government into its management structure. The local government complements O&M activity that goes beyond farmer's capacity. When high-skilled activity is necessary and it is beyond even local government capacity, WUC requests for support from the central government through local government. In this management structure, WUC plays roles listed below; ◆ Water control of whole facilities (planning and implementation of water distribution, operation of facilities, etc.) ◆ Daily maintenance of facilities. ◆ Technical guidance for O&M of marginal facilities maintained by farmers (WUA/WUG) ◆ Proper setting and charge of water users fee
Agricultural production	➢ Promotion of mechanization to improve shortage of labour: Introduction of the economic way of mechanization (e.g. rent or purchase of machine by group). Existing labour exchange system can also be promoted to complement the process of mechanization. ➢ WUA is expected to create credit scheme to support members to buy machines and agricultural input. It is, however, difficult for young organization to manage credit system. Until an organization gets mature enough to sustain credit scheme, support to access loans provided by a commercial bank or technical support to existing credit and saving system would be helpful. ➢ To complement public extension system, training system such as FFS (Farmers Field School) could be introduced to realize smooth diffusion of technology from farmers to farmers. Expected topics would be; double cropping, post-harvest technology and effective rice cultivation, etc.
Marketing	➢ The cost for marketing, especially for transport and milling, is quite high. So, improvement of access should be considered. ➢ There is little access to support of marketing skill. By including Farmers Business School (FBS) concept into FFS that is planned in the agricultural production sector, people shall have more chance to get training on cost management, marketing and quality control. ➢ There are good practices of Area Cooperative Enterprise (ACE), which is the secondary organization of Uganda Cooperative Alliance (UCA), specialized in marketing. Their experience in marketing promotion could be utilized to refine training contents. ➢ Expected that volume of rice for sales will increase, WUA conduct marketing activities including purchase of rice mill, maintenance of storage, joint sales of the product, and so on.

2.6.7 Agricultural Extension System and Plan

After NAADS program was dissolved in 2014, the Directorate of Agricultural Extension Service (DAES) was established in MAAIF. The mandate of DAES is to promote and support sustainable and market-oriented agricultural production, food security and household incomes. The DAES has two Departments; namely Department of Extension and Skills Management, and Department of Agricultural Investment and Enterprise Development. At the district level, the district Production and Marketing Officers are technically and administratively responsible for all agricultural programs, supported by District Agriculture Officer (DAO), District Veterinary Officer, District Entomologist and District Fisheries Officer. At sub-county level, three technical staffs will be recruited in areas of crops, livestock and fisheries for agricultural extension service delivery to farmers.

The recruitment of the permanent extension officers at sub-county level is going on but its progress is not satisfactory yet. As of the end of 2015, an extension officer in the crop is assigned to Bunambutye S/C, but he is responsible for 4 sub-counties. There is another crop extension officer for Sikwa S/C, but he is also responsible several sub-counties. To achieve the agricultural production plan in Atari area, it is crucial to assign the official crop extension officers for both Kween side and Bulambuli side.

A number of farmers require technical guidance on the development of paddy field, O&M of irrigation facilities, lowland rice cultivation and marketing, etc. The machinery service for land reclamation and provision of rice seed are also necessary for new rice growers. The extension officers shall be arranged necessary training for farmers fully using resources of the government agencies, universities, NGOs, donors, etc. NaCRRI under MAAIF could be the main agency to provide training on field development and rice crop techniques. For issues on irrigation and its management, Doho Rice Irrigation Scheme (DRIS) and Doho Irrigation Scheme Farmers Cooperative Society (DIFACOS) could be a model for field study.

Table 2.6.6 Pieces of training Necessary for Farmers

Subject	Period
Development of paddy field	During/ soon after construction
Construction of farm ditch	During/ soon after construction
Operation of irrigation and drainage facilities	Soon after construction
Maintenance of irrigation and drainage facilities	Soon after construction
Management of WUA	During/ soon after construction
Rice cultivation techniques	During/ after construction
Rice marketing skill	During/ after construction

2.6.8 Wetland Management Committee

During the course of the survey, the study team together with the project Task Force (C/P) have established PACC from within the communities which are responsible mobilizing the community and coordinating activities related to the F/S of the project. The members of PACC are representatives from the target parishes, villages and settlement patterns of the study area.

On the other hand, as part of the fulfilment of CWMP, the resource users in the wetland area are supposed to establish wetland management committee which is responsible for the implementation of the wetland management plan in collaboration with local government. According to the guideline of wetland management plan prepared by the MWE the composition of this committee should include among others the key resource users in the area, opinion leader, LC-1, representatives of women, youth and EVIs.

This committee and PACC can be integrated with the existing or newly formed groups to establish a strong WUA or organization that will be responsible for the sustainable operation and management of the irrigation system.

2.7 Irrigation and Drainage Plan

2.7.1 Basic Concept of Irrigation System

Generally, an irrigation system consisting of head works with diversion weirs, main canal, secondary canals and tertiary canals will be provided. The main canal and secondary canal will be lined by concrete block and are to be attached with maintenance road. Drainage canal is also to be provided in the farmland and catch drain canal surrounding study area will be included. Along the Atari River in the riparian area, the buffer zone will be established and clearly distinguished by flood protection dyke to protect against flood intrusion into farmland.

Irrigation system was designed considering following basic concept;

- An irrigation canal is a canal to convey mainly agricultural water and irrigation canals and drainage canals shall be separated from each other.
- The open channel type under the supply-oriented water management method was selected since water source is river course and gravity water supply can be applied.

2.7.2 Irrigation Layout Plan

The general layout plan for of Atari Irrigation Scheme Development Project (AISDP)is shown in Figure 2.7.1. New head works will be installed 140 m upstream of the existing intake and will divert the water to the target area inside Sikwa Parish and Buwebere Parish. Flood protection dyke will be installed along the Atari River following the original river course. Main canals are laid along the contour line to maintain the water head for distribution to the secondary canal. Secondary canals are set across the contour line to distribute to the on-farm facilities through the tertiary canal and division box. The drainage channel will be located between the secondary canal and along the periphery road. At the end of each drainage channel, drainage culverts will connect it to the main drainage facility which is set along protection dyke and all excess water shall flow back to the Atari River. All main canals, secondary canals and protection dykes have maintenance roads and these roads connect to the national road at two points.

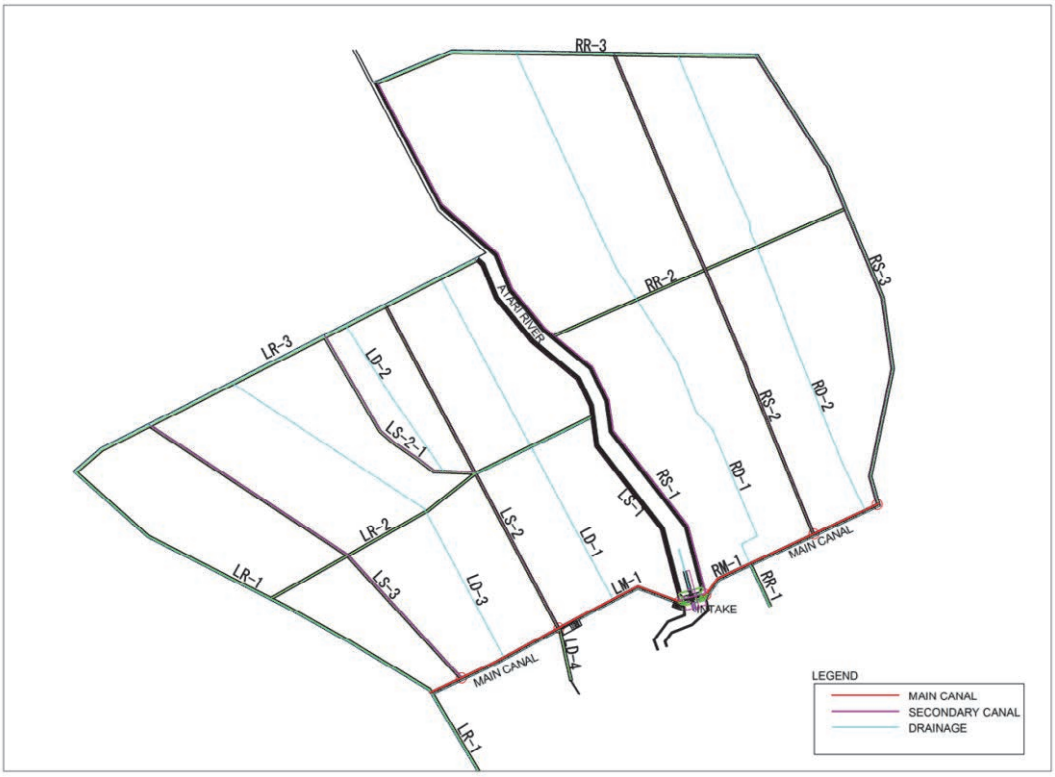


Figure 2.7.1 Layout of Facilities in Atari Site

2.7.3 Comparison of Layout

(1)Comparison of Headwork Layout

The headwork is planned to be constructed 140 m upstream of existing diversion weir considering the following points.

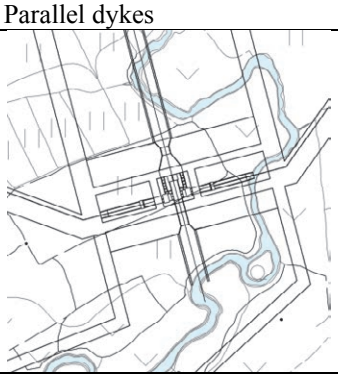
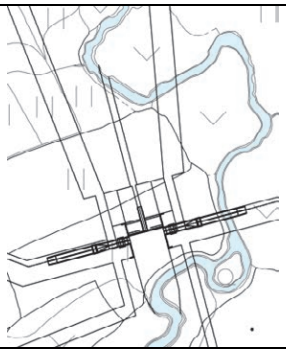
Intake unification: To integrate the existing locally made two intakes which are set at 70 m and 150 m upstream the existing headwork and to irrigate existing paddy from these intakes

- ✓ To provide as high a water head as possible
- ✓ Ease irrigation of left bank and right bank fields
- ✓ No resettlement

Since the site is suitable for construction under dry condition, there is no need of temporary work such as diverting the river during the construction. The site is located at the meandering point where it is suitable to straighten the river course after the construction of intake structure.

On the basis of the selected location, headwork layout plan is studied as shown in Table 2.7.1. As a result of the comparison, Plan 1 is recommendable and applied for this project since Plan 1 has the most advantage for traffic accessibility around the head works to connect the maintenance road on both sides and for the stability of flow in the inlet basin.

Table 2.7.1 Comparison of Intake Layout

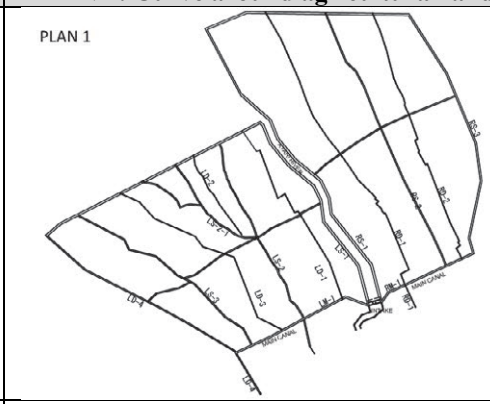
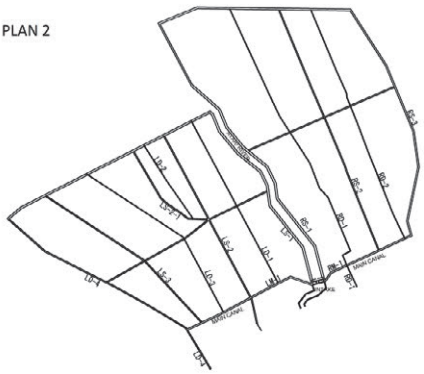
PLAN	PLAN 1	PLAN 2	PLAN 3
Plan name	Parallel dykes	Transition type	Fixed Weir
			
Outline of the Plan	Flood sluice gate which is installed in the single cross section at the head works shall be opened to help flow the flood to the downstream. Flood protection dyke shall be installed parallel to right and left bank at the head works.	Flood sluice gate which is installed in the single cross section at the head works shall be opened to help flow the flood to the downstream. Protection dyke shall be installed with the transition at the headwork site.	Diversion weir is the fixed type and flood flows over the weir. Protection dyke shall be installed with the transition at the headwork site.
Flood control	Gated weir shall be opened to help flow the flood to the downstream.	ditto	Flood flow over the weir
Sediment	It is assumed that sediment will be accumulated in front of diversion weir. Sedimentation in front of intake will not occur due to the high velocity of the concrete single section.	It is assumed less sediment comparing the PLAN1. Sedimentation in front of intake will not occur due to the high velocity of the concrete single section.	It is assumed that sediment will be accumulated in front of diversion weir. The accumulated silt might develop a new watercourse in front of diversion weir and which affects the fair distribution of water across the weir (to the canal and fishway).
Access Road	Maintenance bridge over the headwork and canal can be used as an access road between both sides.	ditto	As the width of the river is wide, another access road is necessary to connect both sides.
Maintenance	Dredging in front of diversion weir is necessary.	ditto	Dredging in front of intake is necessary.
Judgment	Although the land it claims is relatively larger, flood flow in front of inlet basin is most stable and traffic accessibility around the head works is most easy and comfortable than other plans. Therefore, this alternative plan is recommendable.	The land it claims is the smallest among all plans. However, traffic accessibility around the head works is not good and it is necessary to install revetment to protect the inlet basin against flood damage. Therefore, this plan is not recommended compared to PLAN1.	It is assumed that sedimentation will cause some problems such as an imbalance of intake water between both sides and difficulty for maintenance. Moreover, the access road is necessary just in case to connect both sides. Therefore, this plan is the least attractive.
Points	5	3	3

(2)Comparison of Alignment of Facility

JST surveyed for alignment of secondary canal considering topography, alignment of R. Atari, the

location of existing road and footpath, and the irrigable area which was determined by revised water balance calculation (refer to 2.2.2 Irrigation Planning). Initially, JST had set the alignment of the secondary canal, main drainage and farm road considering the above conditions as shown in Plan 1 in Table 2.7.2. However, JST discovered that most of the community (mainly PACC members) demanded to set the alignment to be straight for roads, main canal, and secondary canal as much as possible during the field survey made with PDCC and PACC members and during sensitization meeting. Therefore, JST considered these demands and arranged the alignment as shown in Plan 2 in Table 2.7.2. It is obvious that Plan 2 is more efficient from a perspective of energy loss, saving cost, easy access, O&M after completion of the project. However, Plan 2 has some demerit such as dividing the land of small landowners into two pieces which result in land acquisition and reallocation of the remaining small land difficult. JST cannot choose the alignment of facilities between Plan 1 and Plan 2 from the viewpoint of technical and cost efficiency alone without consensus building together with the community. Therefore, Plan 2 shall be taken as a basic concept of alignment for facilities basically and a small and partial arrangement shall be adjusted on the site during Abbreviated Resettlement Action Plan (ARAP) procedure if necessary.

Table 2.7.2 Comparison of Alignment of Canal and Road

Plan Name	PLAN 1: Curve around agricultural land	PLAN 2: linearly alignment
Layout		
Concept of plan	Alignment of the canal up to the on-farm facility should be along the current farm plot and the existing footpaths to avoid land acquisition as much as possible.	Alignment of the canal up to the on-farm facility to be a straight line as much as possible because it gives greater importance to easy access, ease and efficiency of maintenance of the facilities.
Facility plan	Alignment of Main and secondary canal follows along the current farm plot and footpaths. The length of the canal and drainage increase by 2 to 3 % compared to Plan2. Farm road shall be established by widening existing footpaths.	Alignment of main and secondary canal shall be straight line considering the ground slope. Maintenance road shall be constructed newly along the canal.
Length	Length of secondary canal: 15.4 km Length of drainage: 15.7 km	Length of secondary canal: 15.0 km Length of drainage: 15.2 km
Cost	Direct Construction Cost **101 %**	Direct Construction Cost **100 %**
Space	Required Land for Facilities **101 %**	Required Land for Facilities **100 %**
Evaluation	The inefficiency of maintenance and traffic due to the non-straight line of canal, drainage and road. It claims larger land for facilities which makes higher, project cost and lower, project	Efficient maintenance and traffic due to the straight alignment of canal, drainage and road will contribute to a further investment of agricultural materials and improve the accessibility of post harvesting.

Plan Name	PLAN 1: Curve around agricultural land	PLAN 2: linearly alignment
	benefit.	More encouragement and cooperation with the landowners is necessary because the remaining land will be irregular in shape.

(3)Comparison of Canal Type

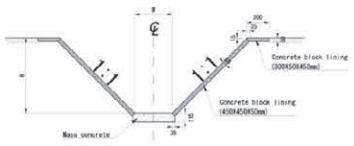
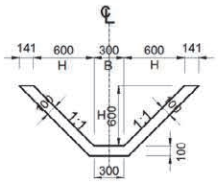
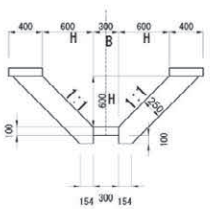
Since there is no much difficulty for land acquisition of right of way of the canal, shapes of the canal are to be a trapezoidal section with side slope in 1:1, which are more economical than a rectangular section.

Main and secondary canals are to be lined with hard materials such as concrete or wet masonry. Canals with precast concrete panel lining, with the cast in situ plain concrete lining and with wet masonry lining are proposed and compared in Table 2.7.3.

In the case of precast concrete lining, a concrete panel with 450x450x50 mm can be prepared at factory yard and transported to the site and set in designated section. Then, it takes rather short construction time compared with other methods. In addition to this, the precast concrete lining is cheaper than the other methods.

The precast concrete lining is to be applied to main and secondary canal lining.

Table 2.7.3 Comparison of Canal Type

Type	Concrete panel			Plain Concrete Lining			Wet Masonry Lining		
Figure (H=0.5m) (B=0.3m)									
Material	Concrete	Panel ,Transportation and Installation	Total	Concrete	Forms	Total	Concrete	Wet masonry	Total
Quantity	0.15*0.57=0.086 m^3	0.5*2*1.414=1.414m^2		0.1*0.5+0.141*0.5*2 =0.191m^3	1.414*0.5*2 =1.414 m^2		0.1*0.3+0.4*0.1*2 =0.11 m^3	(0.154+0.354)/2*0.2*2+0.354*0.5*2 =0.405 m^3	
Unit Price($)	215	22		215	15		215	173.7	
Total cost ($/ m)	18.49	31.11	**49.60**	41.07	21.21	**62.28**	23.65	70.35	**94.00**
Roughness Coefficient	N=0.016			N=0.015			N=0.025		
Easiness of Construction	Very easy			Very difficult			Difficult		
Speed of Construction	Very fast			Very slow			Slow		
To be applied	◎								

2.7.4 Irrigation Facility Plan

(1)Head Works

Head works consisting of diversion weir with gates, spillway and fishway and intake structure equipped with gates and settling basin will be provided. The width of diversion weir shall be wide enough to flush out flood discharge when the gates are fully opened. Gates will be manually operated and made of steel works and reinforced concrete. Headworks are designed considering the following functions and design policy;

- ✓ The spillway will be provided at diversion weir so as to avoid frequent adjustment of intake water level so often by opening or closing of gates.
- ✓ Types of gates shall be chosen to take into consideration the easiness of operation, sedimentation, the durability of material etc.
- ✓ Intake level shall be set at a proper elevation higher than the river bed so as to avoid the flow of suspended sediment or bed load into the main canal.
- ✓ The width of intake shall be decided appropriately so that it protects the flow of suspended sediments or bed load with water.
- ✓ At the entrance of the intake structures, gates shall be installed to adjust intake discharge and stop water flow when floods come.
- ✓ Downstream of the intake structure, settling basin shall be provided for sedimentation.
- ✓ The fishway shall be provided for unimpeded passage of small fishes through diversion weir.

The typical image of headwork is shown in Figure 2.7.2.

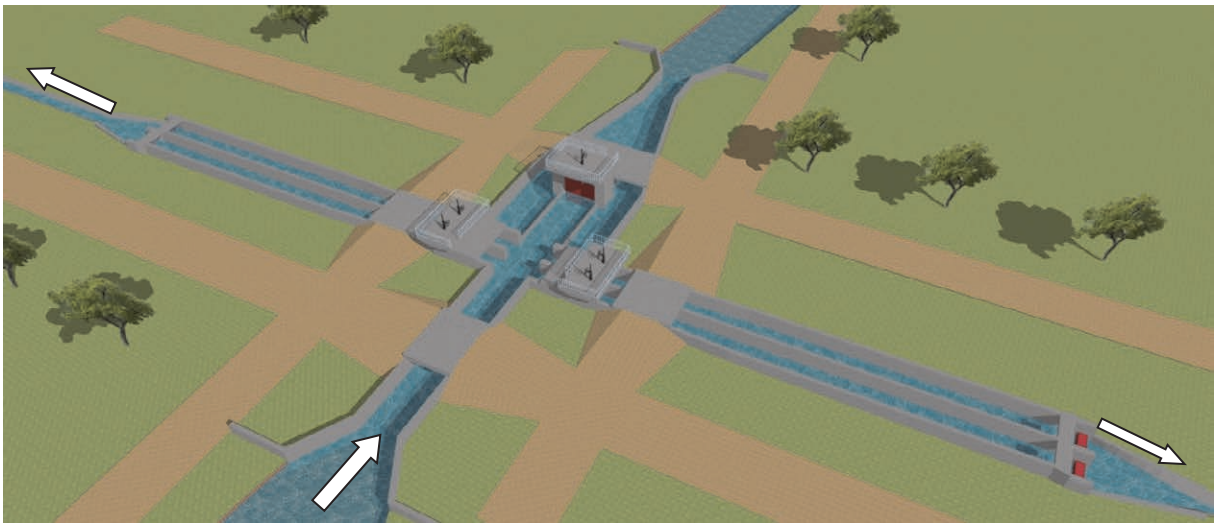


Figure 2.7.2 Image of Head works at Atari Site

(2)Main Canal and Maintenance Road

- ✓ The layout of the main canal will be set considering the gradient of the study area, the inclination of the canal, the location of dwelling area and existing road or boundary of plots of farmland as a rule.
- ✓ Where possible the alignment of the main canal shall be kept as straight as possible to avoid too many corners and reduce loss in flow (hydraulic) energy.
- ✓ Main canal route will be selected at highest location taking the gradient of the canal into consideration.
- ✓ The main canal shall be lined with proper materials such as concrete so as to avoid soil erosion from earth canal by the water flow.

(3)Secondary Canal and Appurtenant Facilities

- ✓ Secondary canal shall be lined with proper materials such as concrete so as to avoid erosion by water flow.
- ✓ Secondary canal shall be provided within 0.5 - 1.0 km intervals so as to limit lengths of tertiary canals up to 500 m long as a rule.
- ✓ Where possible the alignment of the secondary canal shall be kept as straight as possible to avoid too many corners and reduce loss in flow (hydraulic) energy.

(4)Tertiary Canal

- ✓ The size of farmland for tertiary network system shall be about 10 ha as a rule. Tertiary canal shall not be lined with concrete material.
- ✓ The length of the tertiary canal for each block shall be limited to 500 m at most.

(5)Flood Protection Dyke

- ✓ The top of the flood protection dyke will be used for maintenance road and rural community road. The width of the top of the protection dyke is 5 metres and road width is designed as 4 m with laterite pavement.

2.7.5 Drainage Plan

(1)Catch Drain along Main Canal

Catch drain along the main canal shall be provided to collect runoff from the upper area. Water from surrounding area outside of the study area shall also be drained by catch drain set along the surrounding peripheral area of the study area which will be connected with the main drainage canal at the downstream of the study area.

Discharge of drainage capacity has been analyzed by Kinematic wave method for slope area of grassland or upland crop area taking into consideration of 1/10 year return period of daily rainfall of

Soroti Meteorological station.

(2)Drainage Canal within Farmland

Drainage canal capacity has been decided as shown in the following flow chart (Figure 2.7.3) on the basis of Kinematic wave method combined with characteristics of paddy field storage functions on to the paddy plot derived from the once in 10 year daily rainfall amount to estimate hourly distributions of hyetograph. Drainage canal should have enough capacity to drain the excess water of once in 10 year flood in the project farmland. The drainage capacity has been analysed in accordance with the drainage system diagram of the study area. At the lower end of these canals, drainage culvert with gate shall be provided across flood protection dyke to prevent water intrusion from outside.

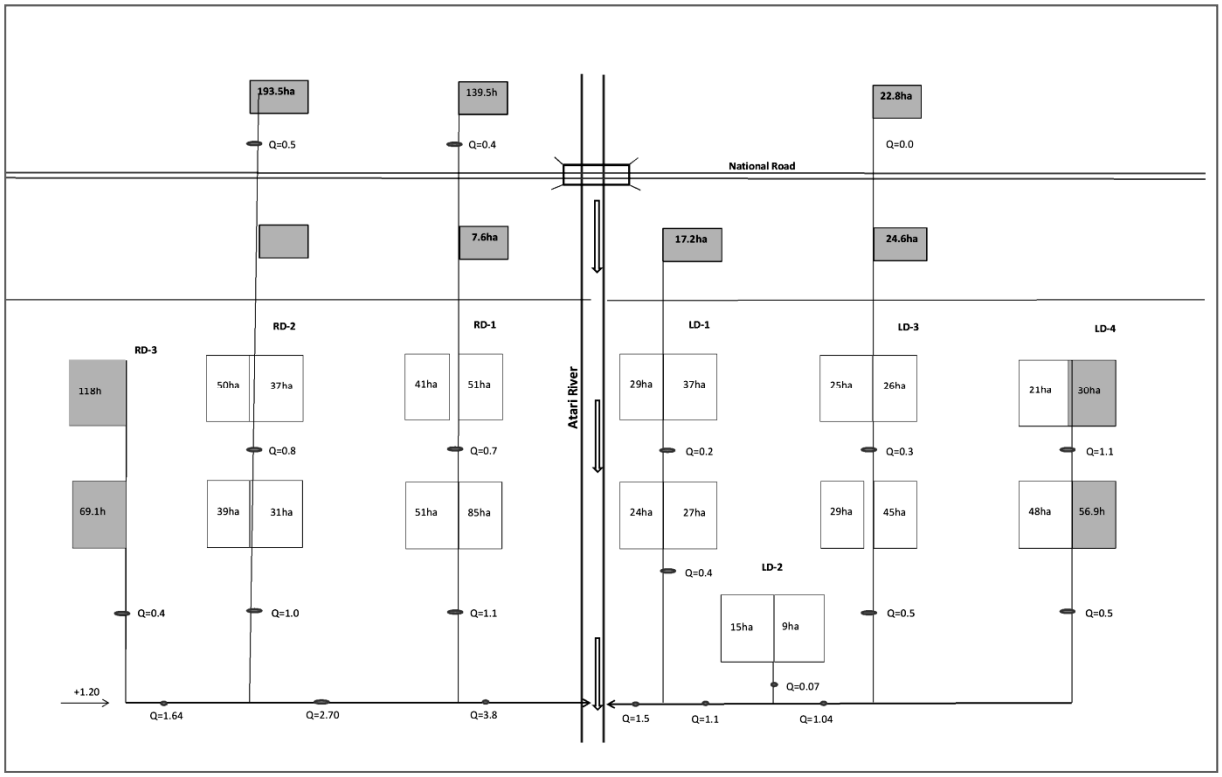


Figure 2.7.3 Design Discharge of Drainage Canal Capacity on 1/10 Years Return Period

2.7.6 On-farm Plan

(1)Facilities Plan of On-farm Development

The project will provide main canals, secondary canals and up to main farm ditch (tertiary canals) for the irrigation system and will construct main drainage canals from each block and catch drain. Land consolidation is not considered in the project since GoU does not have the experiences, implementation structure, and even laws/regulations to conduct land consolidation. Moreover, it is supposed that land consolidation needs a long period to make a consensus among the stakeholders and related arrangement of land plots, as many landowners did not know their exact acreage of their owned land. This was observed during the LABOS study and is suggesting the time is too short to

implement it in this project. Additionally, to encourage the communities and to promote agricultural technology for the farmers to sustain the project, it is recommendable that on-farm facility shall be developed by the farmers themselves with the cooperation of WUA and support from the project management office with extension office or training through demonstration farm.

On-farm facilities which will be constructed by farmers are:

- ✓ Supplemental farm ditch (4th canals);
- ✓ Farm ditch (5th canals);
- ✓ Farm drain;
- ✓ Farm plat development with bunds and land levelling.

(2)Comparison of On-farm Development Plan

As for intervals of turnout along the secondary canal, the following three cases are proposed:

- ✓ Case -1, Turnout gate will be provided at five irrigation blocks each
- ✓ Case-2, Turnout gate will be provided at three irrigation block each
- ✓ Case-3, Turnout gate will be provided at each irrigation block

Diagram of the three cases are shown in Table 2.7.4.

In accordance with the comparison table, Case-2 is to be applied in the project due to the following reason:

- ✓ In the case of Case-1 and Case-2, as the main farm ditch (tertiary canal) and a division box are located along the secondary canal, it is easy to be installed by the project. It is better to install the main farm ditch and division box to realize project benefit as soon as possible after the completion of the construction work in order to be developed farm ditch by the farmers.
- ✓ On the other hand, as for the Case-3, main farm ditches pass the inside of the individual plots. Therefore, it is supposed that determination of alignment will be very difficult and it might not complete on time of construction works since there are so many landowners inside and the shape of the plot is uniform. The alignment cannot be straight and the amount of construction cannot be estimated before starting the construction works. In Case-3, the main farm ditch should be constructed by the farmers themselves, however, it is assumed some main farm ditch will not be installed due to lack of arrangement.
- ✓ Case-1: a total length of main farm ditch for each block is 800 m, i.e. total length of earth secondary canal is 1,000 m in minimum and 1500 m at maximum. It is rather too long and it makes more difficult to maintain properly.
- ✓ Case-1: numbers of beneficiaries within WUG are about 83 families. It may make rather difficult to get consensus on water management and maintenance within each WUG.

- ✓ Case-3: numbers of WUG in each secondary canal will be around 20. It may make rather difficult to get consensus among WUG in each secondary canal.
- ✓ Case-3: tertiary canal shall be installed inside of the individual land plots.
- ✓ The difference between the cost of on-farm facilities between Case-1 and Case-2 is 81.6 $/ha and it is rather small.
- ✓ Case-2: numbers of beneficiaries within WUG are about 50 families and the number of WUG in each secondary canal will be around 7. Considering the water management and maintenance within and among WUG, the scale of the group is most appropriate in all cases. Therefore Case-2 was adopted for the scale of on-farm development in the project.

(3)Design of On-farm Facility

The basic concepts of on-farm facilities are following.

Size of block and plot are;

- ✓ An irrigation block is to be set at about 10 ha (500 m x 200 m) and irrigated through a division box which is to be provided in the main farm ditch (tertiary canal);
- ✓ The size of each farm plot surrounded by bunds will be about 1,000 m^2 each and size will be 25 x 40 m or 20 x 50 m.

On-farm irrigation facilities are:

- ✓ The main farm ditch will be provided along secondary canal and division box will be provided at 200 m intervals in the project;
- ✓ Canals within on- farm facilities which will be developed by the farmers are to be un-lined earth canals and maximum length of this canal will be 1,000 m at most.
- ✓ Supplementary farm ditch will be developed at an about right angle to main farm ditch and its length will be limited to about 500 m.

On-farm drainage facilities are:

- ✓ From supplementary farm ditch, farm ditch (5th canal) or farm drainage ditch will be developed at about 100 m intervals.
- ✓ At the end of these canals, a drainage canal will be provided at upstream of next supplementary farm ditch along this farm ditch.
- ✓ This drainage canal will flow into a lateral drain which will be provided by the project at parallel to the main farm ditch at the end of the supplementary canal.

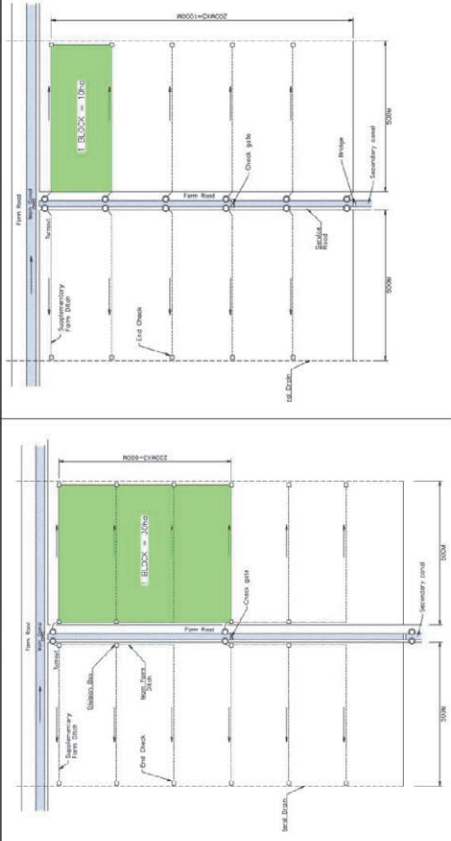
Item	Case1	Case2	Case3
Standard Plot Size	500m x200m	500m x200m	500m x200m
Standard Block Size	**500m x (200m x 5)**	**500m x (200m x 3)**	**500m x 200m**
Acreage controlled by a turn-out	50ha	30ha	10ha
Acreage controlled by a check gate	100 ha.	60 ha.	60 ha.
Plan			
Length of Main Farm ditch	800m	400m	0m
Size of Turnout gate	400x400	400x400	300x300
Direct cost (USD/ha)	**175.09**	**256.74**	**608.00**
No of beneficiary per Turn out	83	50	17
Size of WUG	WUG is formulated in every turn-out. Number of member is estimated around 83 in each WUG and too much members are difficult to be managed.	Number of member is estimated around 50 in each WUG which is formulated in every turn-out. It is supposed that this number is available to be managed.	Number of member is estimated around 17 in each WUG. It is the most appropriate number to be managed among three cases.
Size of WUA	Number of WUG in each secondary canal will be 4 and it is easy to manage and harmonize among WUA.	Number of WUG in each secondary canal will be 7 and it is easy to manage and harmonize among WUA.	Number of WUG in each secondary canal will be 20 and it is difficult to manage and harmonize among WUA.
Evaluation	Economically most feasible but size of WUG is too large to be managed. Therefore not viable.	The balance of WUG and WUG size is the best among three cases and it is economic and easy to O&M.	The size of WUA is too large to be managed and economically it is not feasible.

Figure 2.7.4 Comparison of On-farm Plan

2.7.7 Demonstration Farm Plan

(1)Purposes

Most of the communities in the study area and local government staff lack the experience of operation and management of irrigation scheme of such large-scale. In order to train and teach the modernized irrigation and drainage management technology from the level of farmers to the management officers of the project from central and district Level, demonstration farm shall be provided.

(2)Location and Size of the Demonstration Farm

One block of the farm is selected as demonstration field in Atari site. Proposed demonstration farm is located within the study area where supplied water is possible from the secondary canal, Left bank Secondary Canal-2 (LS-2), and drained to Left bank Drainage-1 (LD-1) with the size of 25ha of land.

(3)Functions

The proposed activities on the demonstration farm are the following:

- ✓ Training and diffusion of water management technology for irrigation and drainage system
- ✓ For whole irrigation system
- ✓ Drainage facilities/ Flood control measures
- ✓ Management of farm ditch at the On-farm level
- ✓ Training of farm plot development
- ✓ Diffusion, training, guide for method of paddy rice growing
- ✓ Paddy rice growing technology
- ✓ Growing Test

2.8 Community Development Plan

(1)Community Road Network Plan

Muyembe-Nakapiripirit Road (92km) is under construction works and is expected to complete by 2020. This road crosses the Atari River at Station No. 25+773 and Atari bridge will be constructed newly since road will be filled with 1.3 to 1.6 m height around the cross point. Protection dyke will be installed upstream of head works for the purpose of protection of back water from head works and to enable access from the national road to head works on foot.

Figure 2.8.1 shows road network plan in the project site. Farm road will be installed along all main canals, secondary canals and protection dykes for the purpose of accessing the field and maintenance of facilities. Farm road will be connected to the Muyembe-Nakapiripirit Road at the two points. Both sides of the Atari River will be connected by a bridge over the head works and at the end of the study area (downstream).

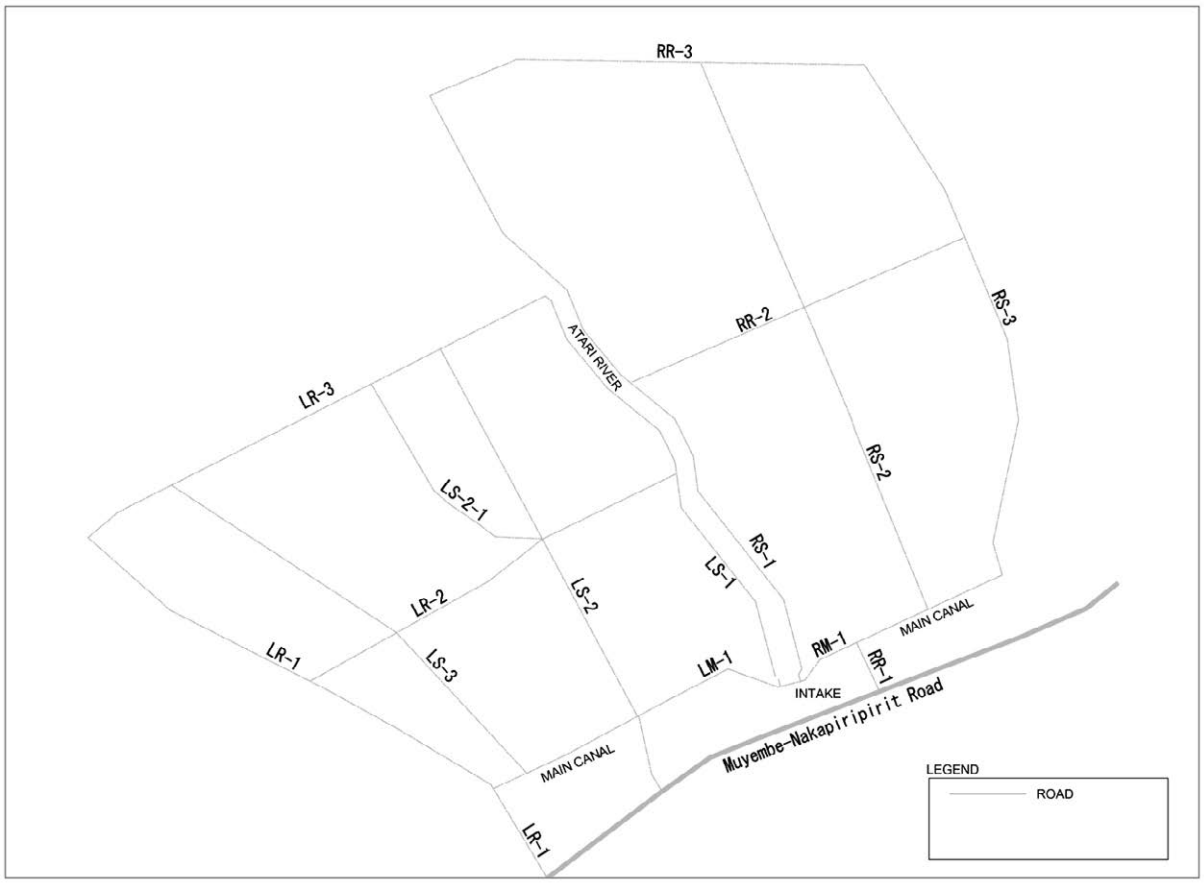


Figure 2.8.1 Road Network Plan

(2)Community Development Plan

Improvement of livelihood of the community is one of the project objectives. It is observed that the resources of land and water are used by communities not only for agriculture but also for domestic water and drinking water for cattle through the development of wetland management plan. Since development area shall be used as an agricultural land basically, the alternative and improvement of livelihood shall be installed outside of study area to harmonize between the agricultural use and domestic and animal use of resources. Therefore the following three components shall be installed for the purpose of improvement of livelihood of the community to mitigate negative impact for stakeholders.

- ✓ Washing Basin
- ✓ Cattle Trough
- ✓ Footbridge

(3)Postharvest Facilities and Marketing Plan

The project promotes rice production in the irrigated area. The present rice production is estimated at about 800 ton/year, while the rice production will be 5,700 ton/year in the full-development stage.

The increment amount of rice is about 5,000 ton/year. Especially, the first and second harvesting of rice will be 2,850 ton. Therefore, the capacity of post-harvest handling should be increased to enable proper marketing without losses.

The total area necessary for sun drying of 2,850 ton of paddy is estimated at about 8,000 m^2, assuming that 1) bulk density of paddy is 0.5 kg/m^3, 2) total drying period is 30 days, 3) days necessary for drying are 2 days, and 4) thickness of paddy in dry yard is 5 cm. The sun drying of paddy will be basically done by individual farmers, using some concrete floors or tarpaulins. In the case of rice grower cultivating 1 ha field, about 200 m^2 of drying space is required to dry 5 ton of paddy under the same assumptions.

The project will provide 2 drying yards with storages in the right and left bank sites of the study area. These facilities are designed to accommodate 10 % of first or second season paddy, i.e., drying yard with an area of 800 m^2 and storage with a floor area of 285 m^2.

The capacity of rice mills around the target area including Bulambuli, Sironko, Kween, Bukedea and Mbale Districts should be increased. The present milling capacity is estimated at about 19,000 ton in a year and maximum capacity is at about 140 ton a day. Under the present capacity, 21 days are necessary for milling 2,850 ton of paddy. Milling capacity should be increased and milled rice quality should be improved in future. In order to attain better marketing condition, stone-free milled rice should be achieved and rate of broken rice should be reduced. For this purpose, it is recommended to install high-performance mills together with destoner and grading machine.

The CAIIP under the assistance of AfDB has installed rice/maize mills in Ngenge S/C of Kween, Mwembe S/C of Bulambuli, and Kolir S/C of Bukedea Districts for the operation of farmers' cooperatives. However, their operation has not yet gone well even though the government has strongly supported the contractors and farmers. The reasons are 1) poor performance of machinery supplier; 2) long procedure of approval on mattes happened, 3) high cost of government officers for training, management, maintenance, etc., 3) lack of capacity of beneficiary farmers, and so on. On the contrary, the number of private rice mills has increased in this decade and the milling business has performed well. There are many small to medium scale rice/maize mills around the target area, for example, medium scale maize mill has been established in Bulambuli District for export of maize flour to Kenya. In this context, it is recommended that the private sector shall be involved for rice milling business.

2.9 Future Possibility of Upstream Irrigation Development by Local Peoples

There is a flat area in the upstream of the Atari River from Moroto Road to the foot of Mt. Elgon for about the length of 2km and covers about 500 ha. In future Atari Irrigation Scheme will be implemented and the economic viability and increasing of the farm income will be realised by local peoples and this farmland in the upstream area will also be starting irrigation development taking water from the Atari River by local farmers. It will be necessary and important to study beforehand

about possibilities of upstream area development in future and forecast influence of upstream water intake to the PISD Atari Irrigation Scheme area. On the other hand in the downstream area of the Atari site, the Ramsar Convention area is located about 500 m downstream and the agricultural activities will be prohibited.

In the upstream flat area from the Moroto road, the Atari River course becomes deeper and deeper for about 8 m from the surface of the flat area to the point of the foot of Mt. Elgon. There is a collapsed concrete wear near the foot of the mountain without any usage of the intake water. In the upstream area, the river course flows in the deep place which irrigation water intake by gravity will be very difficult. There is a fixed small pump station in the upstream area irrigating tomato and vegetable for about 1 ha only. It will be possible to introduce additional pumping stations to take water from the Atari River for irrigation. There will be very difficult to introduce large pump stations in the upstream area by local farmers. In future, there will be a possibility to irrigation about 10 ha by pumps and it might be affected by the Atari Irrigation Scheme area. So that in future it will be carefully observed in the upstream area irrigation development and negotiate with the farmers to modify water intake pattern and cropping calendar.

In order to find the potentiality of additional irrigation area development in the upstream area, the water balance analysis has been made to utilize remaining water after intake for Atari site. When the proposed cropping calendar is the same as PISD for the upstream area, the intake pattern becomes the same as the PISD site; the water will not be enough to irrigate the additional area.

On the contrary, the cropping calendar for the upstream area is different from the PISD area it can be expected more irrigable area as shown in the Table 2.9.1. Based on analysis of about 3 years which include the draughtiest year and design year, it can be forecasted that there will be no more additional irrigation area but about 350 ha to 500 ha will have a potential to be irrigated in average years in the upstream area. Accordingly, when irrigation water intake will be observed in future, it is necessary to negotiate with the upstream farmers for changing cropping calendar and intake water patterns. If possible it will be recommendable to form WUA in the upstream farmers and negotiate with groups of farmers.

Table 2.9.1 Possible Additional Irrigation Area in the Upstream

The Cropping Calendar is different from Downstream			
	1st Crop (ha)	2nd Crop (ha)	
2000	0	523	
2001	383	540	
2002	0	0	
2003	768	0	
2004	25	4	Design Year
2005	0	1,139	
2006	0	3,114	
2007	350	350	
2008	0	1,908	
2009	0	801	Draughtiest Year
2010	3,503	4,602	
2011	0	3,648	
2012	2,064	1,658	
Average(ha)	546	1,407	