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-I MAIN REPORT

APPENDIX-I

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

VOLUME I
MAIN REPORT
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Report for Hydro-meteorological and Water Resources Development Plan

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1.1 Installation of the Meteorology and Rain Gauge Stations

1.1.1 Sitting of the Meteorology and Rain Gauge Stations

In order to collect accurate meteorological data for Atari, Sironko and Namatala area which were selected as sites for F/S, Phase2, it has been deemed necessary to install equipments within or nearby the target areas and within or nearby corresponding the watersheds. For the selection of the appropriate space for the installation of the equipment, sit visits were conducted together with the DAO of each target site to ascertain space with the corresponding for criteria reflected below. Through discussions with representative stakeholders on the space and details on the location for installation, for example security situation, the sits for the installation of the equipment were decided upon.

To ensure the sustainability of the observation, DAO in each of the district where the equipment is installed is responsible for collection data, and management and maintenance of the equipment.

Table 1.1.1 Selection Criteria of the Location of Meteorological Station and Rain Gauge

	Meteorological station	Rain gauge
Selection Criteria	Located nearby the target areas Appropriate observation environment is ensured (far enough from the buildings and shielding, that could affect the observation of Solar radiation, wind speed, and rainfall) No theft, and breakage risk of equipment Easy accessibility	Located within or nearby the watershed of target area High altitude Appropriate observation environment is ensured (far enough from the buildings and shielding, that could affect the observation of rainfall) No theft, and breakage risk of equipment Easy accessibility

1.1.2 Location of the Installation Sites

Selected sites for the installation of the meteorological and rain gauge stations are listed below.

Table 1.1.2 Location of the Meteorological Station and Rain gauge

	Project Site	Name of Place	District of Location	Coordinates	Elevation
Meteorological Station	Atari	Atari Health Center II	Bulambuli	N 1°29'53.18" E 34°26'36.65"	1,086m
	Sironko	Bukalu Health Center III	Bulambuli	N 1°18'23.30" E 34°15'22.93"	1,091m
	Namatala	Kamonkoli Sub-county LGO	Budaka	N 1°04'53.60" E 34°05'10.24"	1,109m
Rain gauge station	Atari	Kapchorwa District LGO	Kapchorwa	N 1°23'36.97" E 34°27'02.82"	1,961m
	Sironko	Kyagalanyi Coffee Ltd in Busulani Sub-county	Sironko	N 1°09'18.91" E 34°21'48.57"	1,286m
	Namatala	Bufumbo Sub-county LGO	Mbale	N 1°05'20.35" E 34°15'26.01"	1,536m

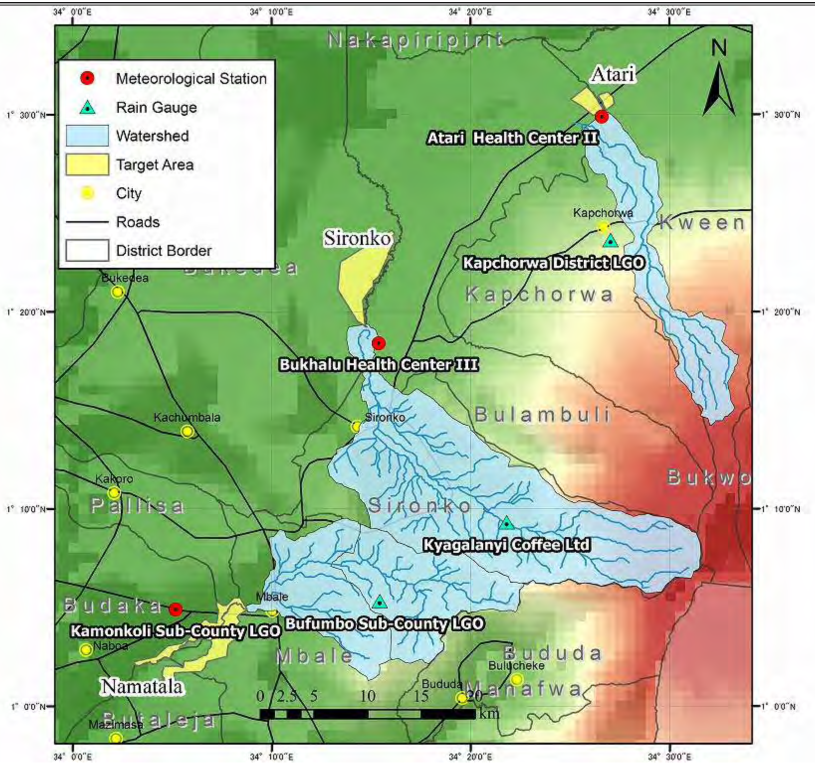

Figure 1.1.1 Location Map of the Meteorological and Rain gauge stations

1.1.3 Specification of the Equipments

The meteorological station consists of data logger, temperature and humidity sensor, pyranometer sensor, wind speed sensor, rain gauge sensor. The data logger and sensors were mounted on the metal tripod and fixed at appropriate height. The observed data is received at PC through the exclusive cable from data logger. Specification of the meteorological station is detailed below.

 Data Logger (Onset Computer Corporation: HOBO Micro station H21-002) Memory is 512K nonvolatile flash data storage. Four standard AA alkaline batteries. 1 year typical use (up to 4 sensors with 1 minute or longer logging interval)	 Temperature and Relative humidity sensor (Onset Computer Corporation: S-THB-M002) Sensor is established at a height of 1.5m from the ground and is recording at an average of every 10 minutes.

Silicon Pyranometer Sensor (Onset Computer Corporation: S-LIB－M003)
Sensor is established at a height of 1.9m from the ground and is recording at an average of every 10 minutes.

Wind speed Sensor (Onset Computer Corporation: S-WSA-M003)
Sensor is established at a height of 2.0m from the ground and is recording at an average of every 10 minutes.

Rain Gauge Sensor (Onset Computer Corporation: S-RGB-M002)
Diameter of the receiving orifice is 157mm. Sensor is established at a height of 1.8m from the ground and is recording the total rainfall at every 10 minutes.

Whole view of observation system

Type of the rain gauge is tipping bucket and micro data logger is contained in the housing. The observed data is received at PC through the exclusive cable from data logger. Specification of the rain gauge is detailed below.

Data Logging rain gauge (Onset Computer Corporation: RG3-M)

Diameter of the receiving orifice is 157mm. Sensor is established at a height of 1.5m from the ground and is recording the total rainfall at every 10 minutes. Tipping occurs every 0.2 mm of rainfall and cumulative tipping number of times and its time is recorded.

1.1.4 Condition of the Installed Equipments

Conditions of the installed equipments are shown below. In order to prevent from theft, mischief and damage caused by animals, meteorological stations are fenced 10m × 10m × height of 2m fence and rain gauges are fenced 5m × 5m × height of 2m fence.

 Atari area Meteorological station Atari Health Center II Observation start from February 25, 2015	 Atari area Rain gauge Kapchorwa District LGO Observation start from February 23, 2015
 Sironko area Meteorological station Bukhalu Health Center III Observation start from February 26, 2015	 Sironko area Rain gauge Kyagalany Coffee Ltd. in Busulani Sub-County Observation start from February 25, 2015
 Namatala area Meteorological station Kamonkoli Sub-county LGO Observation start from February 25, 2015	 Namatala area Rain gauge Bufumbo Sub-county LGO Observation start from August 24, 2014

1.1.5 Field Practice for Data Collection from Data Logger

After installation of the equipment and launch the data logger of meteorological and rain gauge stations, Explanation of each sensors, maintenance method of equipments, observed data collection through laptop PC and confirmation of remaining battery and memory were explained to DAOs. Persons in charge of regular data collection and maintenance for each equipment are listed below.

Table 1.1.3 Responsible Officers for Data Collection and maintenance of equipment

Equipment	Name of Place	Name of responsible officer of data collection and maintenance	District	Title
Meteorological Station	Atari Health Center II	Mr.Tsekeli Alfred Dr. Wonekhe Deo	Bulambuli	District Agricultural Officer Veterinary Officer
	Bukhalu Health Center III			
	Kamonkoli Sub-county Office	Mr. Mugoga Geoffrey	Budaka	District Agricultural Officer
Rain Gauge Station	Kapchorwa District LGO	Mr. Apil Nelson	Kapchorwa	District Agriculture Officer
	Kyagalanyi Coffee Ltd in Busulani Sub-county	Mr. Halasi Gidongo	Sironko	Agriculture Officer
	Bufumbo Sub-county LGO	Mr. Namakhola Rajab	Mbale	District Senior Agriculture Engineer


Filed practice for data collection by using laptop PC (Mr.Alfred and Dr. Wonekhe from Bulambuli District)


Not only DAO but also Sub-County Chief and LCIII Chairperson participated to the explanation of the equipment in Kamonkoli Sub-county

1.2 Installation of the Water Level Gauge

1.2.1 Sitting of the Water Level Gauge

Currently, MWE observes water level in a limited number of rivers in eastern Uganda and the most of those observations are conducted manually. Therefore, it is difficult to obtain the accurate and hourly water level data for the design of irrigation facility, flood protection dike and other related facility.

In order to collect accurate data of the river discharge and high water level at the time of flooding for Feasibility Study of selected three sites, it was deemed necessary to install an automatic water level gauge in the three rivers of interest (the Atari, Sironko and Namatala Rivers).

In the case of the Sironko and Namatala Rivers, the water level gauges are installed inside the observation pipe to the river in the existing stations. New gauging station was established at the downstream of junction of the Atari River and Muyembe - Namalu- Nakapiripirit road. The pressure gauge is installed inside the piping which reaches the river.

To ensure the sustainability of the observation, Kyoga Water Management Zone Office (KWMZ) under MWE is the responsible for data collection, management and maintenance of the equipment after the end of the study.

1.2.2 Location of the Installation Sites

Selected places for the installation of the water level gauge are listed below.

Table 1.2.1 Location of the Data Loging Water Level Gauge

	Project Site	Name of Place	District of Location	Coordinates	Elevation
Water Level Gauge	Atari	Atari River water level monitoring station	Kween	N 1°30'05.21" E 34°26'44.04"	1,088m
	Sironko	Existing the Sironko River water level monitoring station	Sironko	N 1°14'09.94" E 34°15'25.96"	1,118m
	Namatala	Existing the Namatala River water level monitoring station	Mbale	N 1°06'31.10" E 34°10'21.50"	1,100m

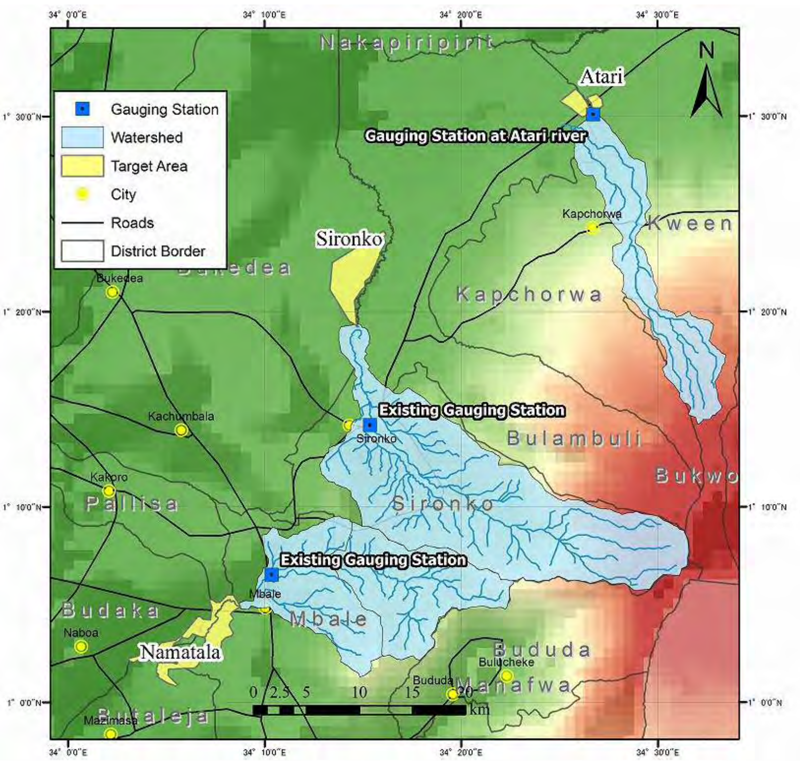

Figure 1.2.1 Location Map of the Water Level Gauge stations

1.2.3 Specification of the Equipment

Automatic water pressure sensors with data logger are installed for the observation of the water level. The observed data is received at PC through the exclusive cable from data logger. Specification of the automatic water pressure gauge is detailed below. After the vandalism of the water pressure gauges in the Sironko and Namatala River at the beginning of February 2016, JST installed new pressure gauges for both rivers at the end of April 2016.

	
Water pressure sensor with data logger (STS Sensor Technik Sirnach AG: DL/N 70 10m PUR cable) Shown on the left in the photo is pressure gauge and data logger and on the right is the battery box. Average water pressure at every 10 minutes is recorded and water level is calculated from observed pressure.	Water pressure sensor with data logger (STS Sensor Technik Sirnach AG: DL.OCS/N 10m PUR cable) Shown on the left in the photo is pressure gauge, data logger and the battery box. Average water pressure and water temperature at every 10 minutes is recorded and water level is calculated from observed pressure.

1.2.4 Condition of the Installed Equipments

Conditions of the installed equipments are shown below. Before installation of the water gauge to the existing gauging station, sedimentation in the vertical pipe in the station is flashed and cleaned.

 Atari area water level gauging station	 Atari area existing gauging station the Atari River, Kween District Observation start from March 2, 2015
 Sironko area existing water level gauging station	 Sironko area existing gauging station the Sironko River, Sironko District Observation start from February 26, 2015

 Namatala area existing water level gauging station	 Namatala area existing gauging station the Namatala River, Mbale District Observation start from February 26, 2015

1.2.5 Field Practice for Data Collection from Data Logger

Hydrologist in the Lake Kyoga water management zone was assigned to person in charge of regular data collection and maintenance for water pressure gauge. After installation of the equipment and launch the data logger of water level gauge, explanation of equipment, maintenance method, observed data collection through laptop PC and confirmation of remaining battery and memory were explained to him.

 Filed practice to downloading the data from water level gauge at the Sironko River gauging station	 Person in charge of the equipment practiced how to replace the battery before installation

Chapter 2 CAPACITY DEVELIOPMENT FOR CONTENTIONS OBSERVATION

2.1 Training on the Interpretation of Observed Meteorological Data

To foster ownership through understanding of the way of interpretation of observed meteorological data and the way of maintenance, the training titled "Training on the Interpretation of observed meteorological data" was held on 13th March 2015 for the whole day. The venue for training was boardroom of Wash & Will hotel located in Mbale District. Participants are the same as in Table above.

The original part of the training includes explanation of sensors and maintenance method, the same explanation as in the field practice. This is to enable participants understand better to be able to explain the function of equipment to their colleagues and relevant persons in their office. The participants learned and practiced how to confirm the downloaded meteorological data by using dedicated software and how to export daily data to MS Excel file. Latter parts of training were generating the daily data graph and practice of how to organize the monthly daily data table and graph.

Although PC and Excel skill of participants generally was not high, all the participants were able to concentrate during the training. In the last exercises, participants had reached the level that they would be able to generate graphs of each assignment by themselves.

In order to minimize the risk of losing the observation data, such as breakage of PC, Participants were requested to organize the daily data in each month based on learned methods during the training, and print out the summary of daily data by every month in the future.

Training constituted lecture and practice by using laptop PC.

2.2 Training on the Utilization of Observed Meteorological Data

To foster ownership through understanding of the way of utilize observed meteorological data, the training was held on 11th May 2016 for the whole day. The venue for training was boardroom of Wash & Will hotel located in Mbale District. participants are the same as last training. Additionally, an officer from MAAIF and an officer from MWE DWRM are invited to the training to discus data management structure. .

The training started from the review of last training such as overview of the equipment, data conversion to MS Excel and data interpretation to daily and monthly data. After that, participants learned flow of calculation of water requirement and practiced how to calculate water requirement by using observed monthly data and FAO CROPWAT. At the end of the training, draft data collection, storage and management structure was discussed among the participants to ensure the sustainability of the observation and participants gave comments from their point of view.

From the result of the questionnaire after the training, Participants basically understand contents of training and they can interpret data and utilize based on their requirement by themselves. During the discussion, all the participants take the initiative in solving problems on the operation and maintenance matter. Conclusively, it seems that the objective of training was achieved due to the attitude to the lecture and discussion.

The day after the training, two C/Ps from MAAIF and MWE respectively visited the field to see the installed meteorological station near the F/S site and rain gauge in the watershed. They saw actual equipment directly and learned how DAOs download the data from equipment. This experience enriched their understanding of the activity.

Lecture session on the Training

Site visit for rain gauge

2.3 Data Collection, Storage and Management Structure

To avoid the risk of collected data loss, Data collection, storage and management structure was proposed by JST to the relevant parties. The diagram is shown in Figure 2.3.1. The collected data will be stored on the data base in relevant organization and the data will be utilized in the future for irrigation scheme development study and water resource assessment.

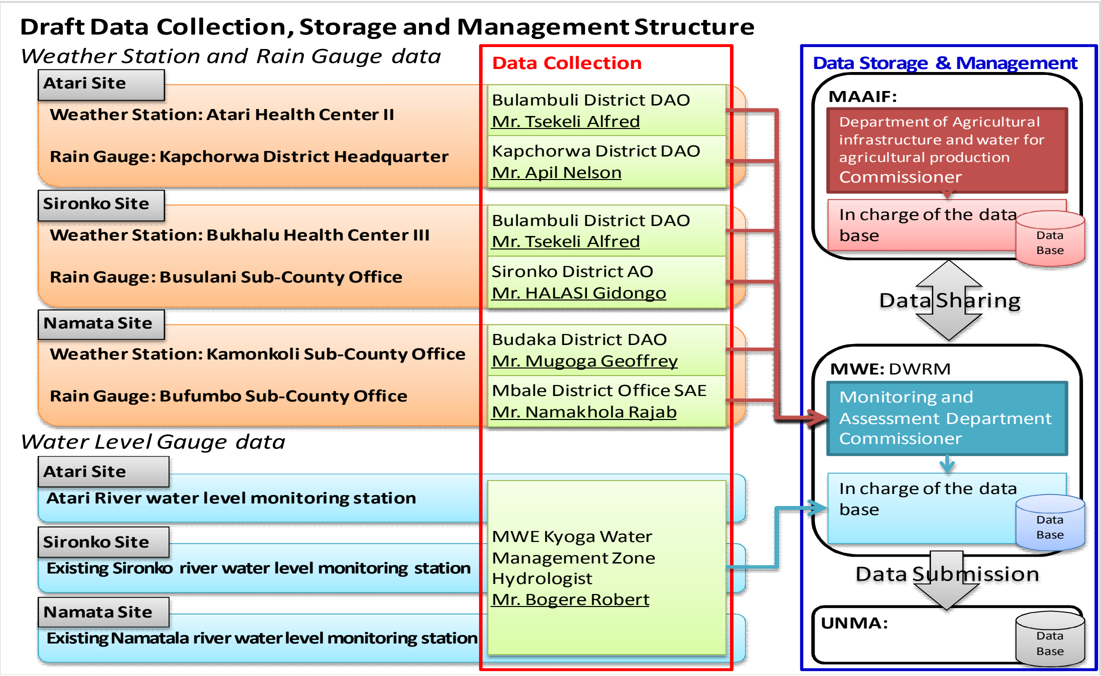

Figure 2.3.1 Data Collection, Storage and Management structure

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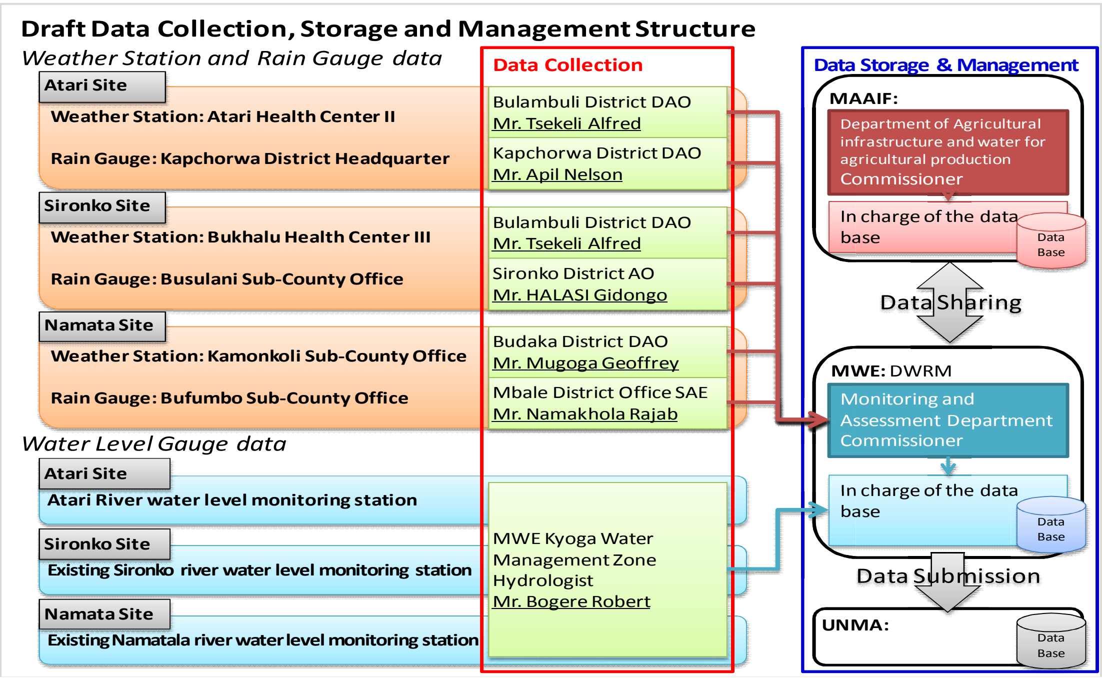


Figure 2.3.1 Data Collection, Storage and Management structure

Chapter 3 VERIFICATION OF H-Q (rating) CURVE

3.1 Introduction

H-Q (Rating) curve of each existing water level station has been generated by Ministry of Water and Environment (MWE).

According to the National Water Resource Assessment Report 2013 which is published by MWE, It is mentioned that "the rating curves do not adequately represent the actual stage-discharge relationship". It is assumed that main reason of incorrectness is due to the location of gauging station related to the river course, water flow and effect by back water. However it seems reasonable to suppose that long interval of updating the rating curve also affect to the incorrectness of rating curve as cross section of rive varies year by year. Therefore verification of the H-Q curve is needed to grasp the accurate amount of water resource for irrigation development in each river.

Current H-Q curve which is generated by MWE and update log are listed below.

Table 3.1.1 H-Q curve record of update

R. Sipi at Mbale - Moroto Road (82243) Unit; h:m, Q:m3/s

	H-Q equation	Start Date	End Date
Rating : A	Q = 7.210 (h -1.226) ^ 1.837	1952/Jan/1	1966/Jan/14
Rating : B	Q = 10.773 (h -0.760) ^ 1.700	1966/Jan/15	1994/May/19
Rating : C	Q = 1.674 (h -0.620) ^ 2.008	1994/May/20	Up to today

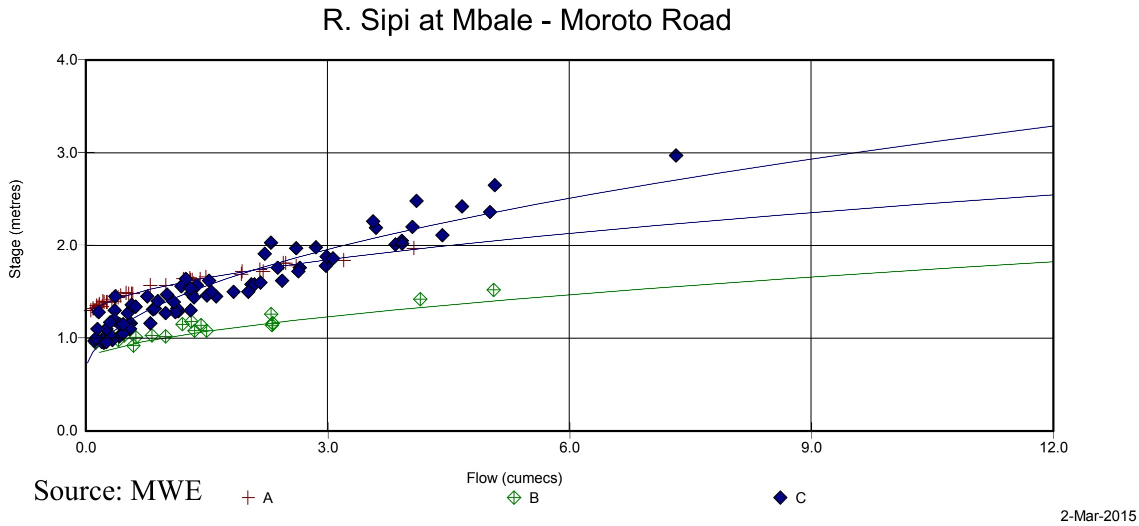
Station Name : R. Sironko at Mbale - Moroto Road (82240)

	H-Q equation	Start Date	End Date
Rating : A	Q = 5.308 (h -0.690) ^ 2.133	1953/Jan/1	1997/Jan/27
Rating : B	Q = 11.321 (h -1.038) ^ 1.382	1997/Jan/28	Up to today

Station Name : R. Namatala at Mbale - Road (82213)

	H-Q equation	Start Date	End Date
Rating : A	Q = 4.133 (h -6.802) ^ 1.568	1964/Dec/11	Up to today

Source: MWE



Source: MWE

Figure 3.1.1 H-Q curve of the Sipi River

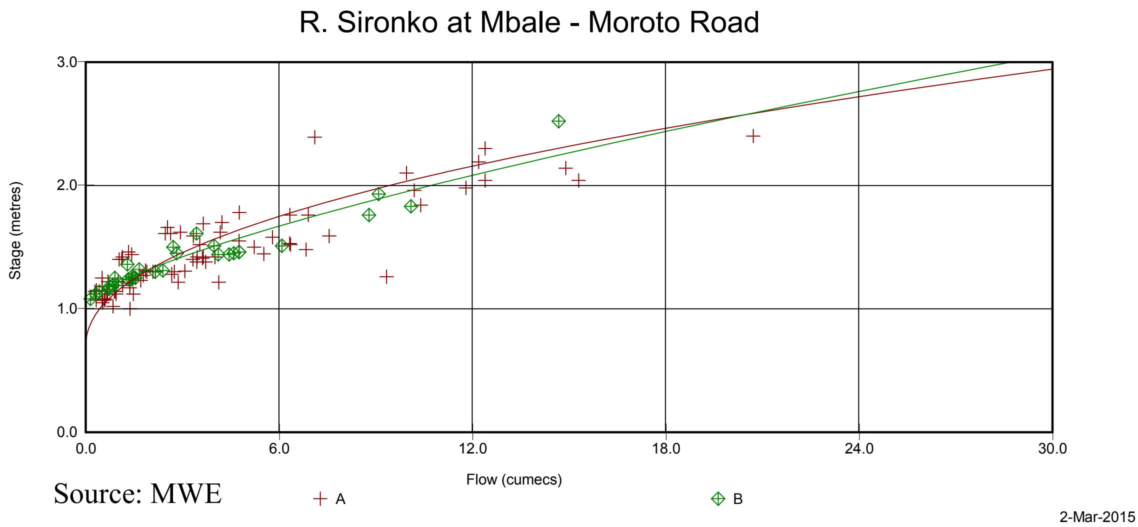


Figure 3.1.2 H-Q curve of the Sironko River

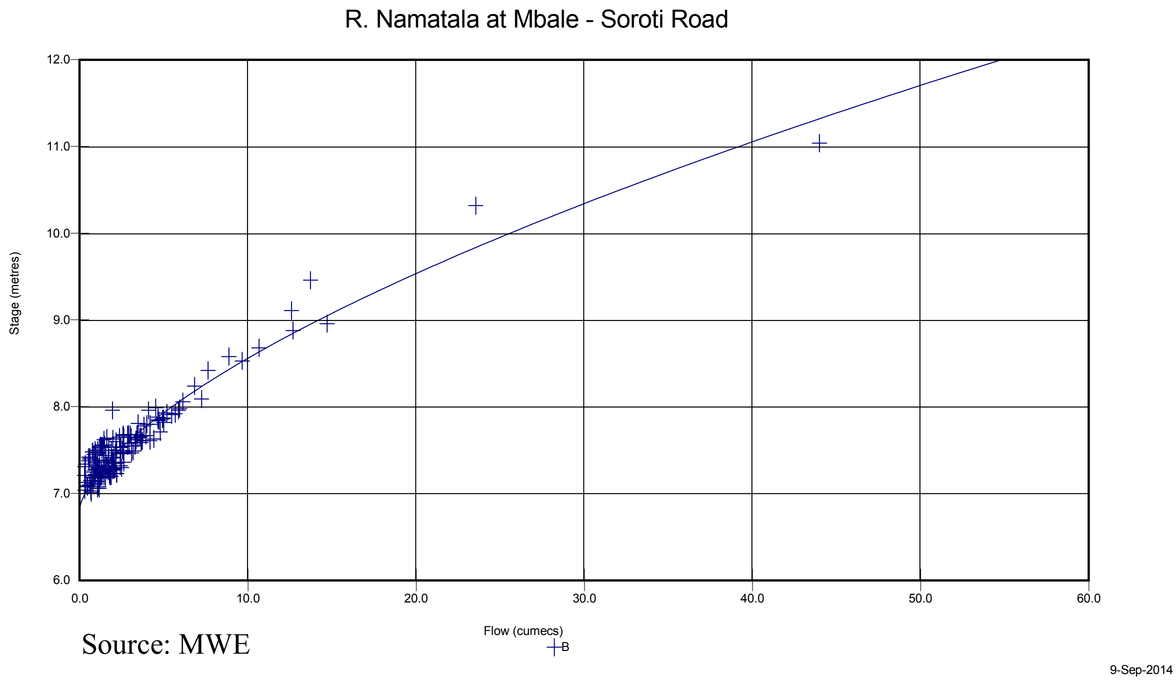


Figure 3.1.3 H-Q curve of the Namatala River

Since the facility for the measurement of river water level had never been installed before in Atari River which is the main water resource of the Atari irrigation scheme before, JST installed automatic water level gauge there.

Accordingly, H-Q curves for three rivers at the observation point of water level were generated by JST. H-Q curves were generated by the result of measurement of velocity of the river and area of river cross-section. The observation period is from March 2015 after the installation of the equipment to the end of October 2015.

For the purpose of confirmation of the Atari River discharge, H-Q curve of the Sipi River H-Q curve which is observed water level manually by MWE and located near the Atari River also confirmed, since past the Sipi River discharge is used to estimate past the Atari River discharge for water balance analysis.

H-Q curve is generally represented by equation below.

$$Q = a(h + b)^2$$

Where Q is River discharge (m3/s), h is river water level (m) and a,b are constants.

Constant a and b is obtained by following manner. Plot the square root of river discharge Q and water level h as scatter diagram. Linear equation of $\sqrt{Q} = Ah + B$ is obtained by the least-squares method, then $a = A^2,\ b = B/A$ is obtained

3.2 Methodology of Observation

When the river water level is not more than 1m, the velocity of the river is measured at one point at the depth of 60%. When the river water level is more than 1m, the velocity of the river is measured at two points at the depth of 20% and 80% from water surface. If the obtained result has some difference, re-measurement was conducted.

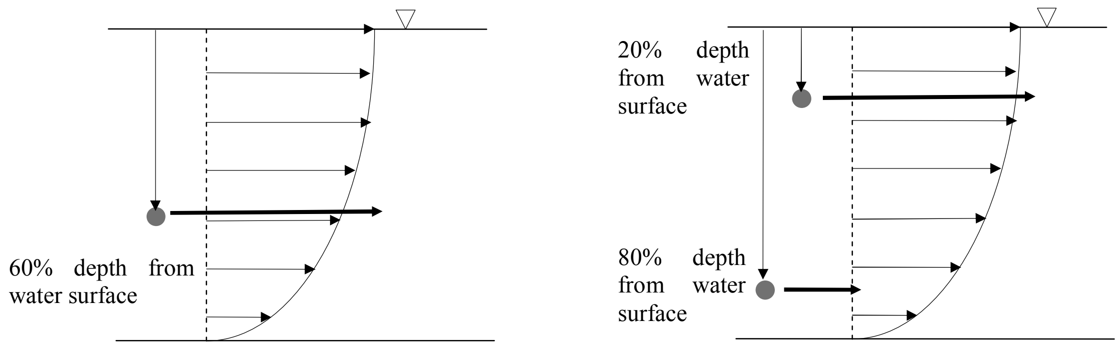


Figure 3.2.1 Depth of river velocity measurement

Digital current meter (MT precision CO. LTD: MTS-1) is used for measurement of river velocity. Velocity is measured by paddling of river when water level is low in dry season. Due to the high water level in rainy season, velocity and depth are measured from the top of the bridge to reduce the risk of incident.

Measurement of cross section of river is conducted at the same tine of every measurement of velocity. Point of measurement of velocity is same as measurement point of depth measurement. Depth of river is measured by using surveying pole measure in the dry season by paddling of the river. Current meter is used to measure depth of river from the top of the bridge.

River cross section is obtained by measuring of width and depth of river. Width of river is measured and interval of measurement of depth and velocity is adjusted depending on the width of river. The pitch should always be less than 1m.

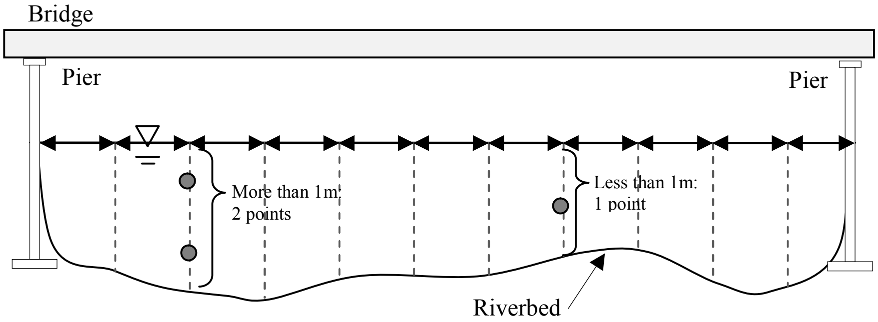


Figure 3.2.2 Interval of depth and velocity measurement of river

Measurement of width of water surface by using tape measure in dry season


Measurement of river depth in dry season

Measurement of river velocity in rainy seson.
To fix current meter at appropriate position, current meter is pulled by ropes from both banks upstream

Measurement of velocity and depth of river in rainy seson.
Due to the high water level it's not possible to measure velocity and depth by paddling of the river. Therefore measruement is conducted from the top of bridge.

Figure 3.2.3 Photo of filed activity

3.3 Results of Measurement of Velocity and Cross-section

3.3.1 Results of Measurement of Velocity and Cross-section of the Atari River

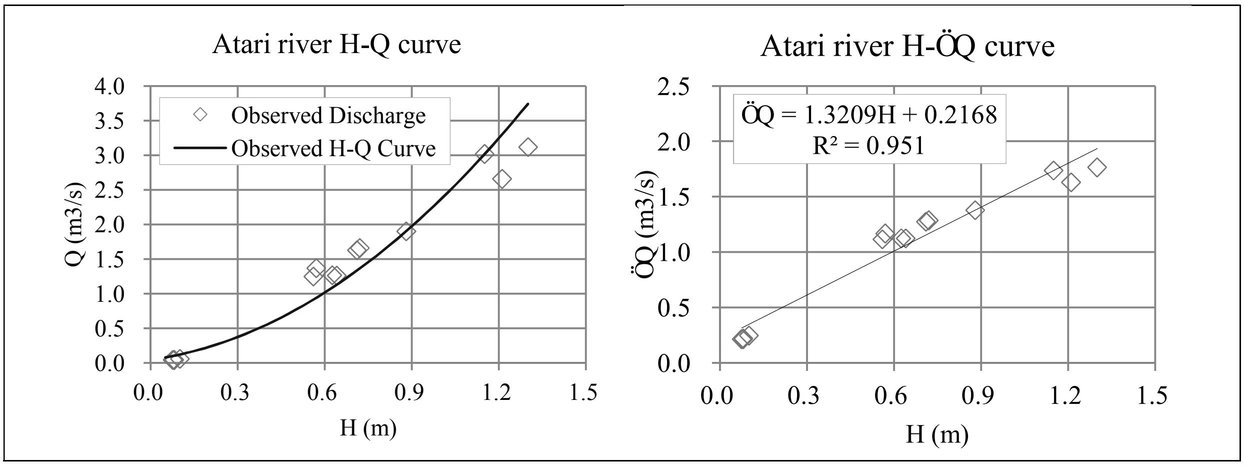
Measurement of velocity and area of cross-section was conducted 14times from March 2015 to end of July 2015.

Table 3.3.1 Results of Velocity and Area of Cross-section in the Atari River

No.	Date	Water Level Gauge (m)	Average Velocity (m/s)	Area of Cross section (m^2)	Observed Discharge (m^3/s)	ÖQ
1	09 Mar 2015	0.08	0.31	0.16	0.05	0.22
2	10 Mar 2015	0.08	0.27	0.18	0.05	0.22
3	11 Mar 2015	0.08	0.29	0.16	0.05	0.22
4	12 Mar 2015	0.10	0.23	0.25	0.06	0.25
5	22 Jun 2015	0.72	0.53	3.10	1.66	1.29
6	24 Jun 2015	0.71	0.51	3.11	1.63	1.28
7	25 Jun 2015	0.88	0.55	3.42	1.90	1.38
8	26 Jun 2015	1.21	0.56	4.59	2.66	1.63
9	29 Jun 2015	1.30	0.51	5.98	3.12	1.77
10	01 Jul 2015	1.15	0.53	5.37	3.02	1.74
11	13 Jul 2015	0.63	0.51	2.46	1.27	1.13
12	16 Jul 2015	0.57	0.51	2.66	1.37	1.17
13	20 Jul 2015	0.56	0.52	2.37	1.25	1.12
14	27 Jul 2015	0.64	0.48	2.61	1.266	1.13

Source: JICA Study Team

The results of measurement are plotted on the scatter diagram and shown below. Then, H-Q curve equation in the Atari River was obtained as $Q = 1.74478(H+0.16419)^{2}$.



Source: JICA Study Team

Figure 3.3.1 Relationship between H – Q and H -ÖQ in the Atari River

3.3.2 Results of Measurement of Velocity and Cross-section of the Sipi River

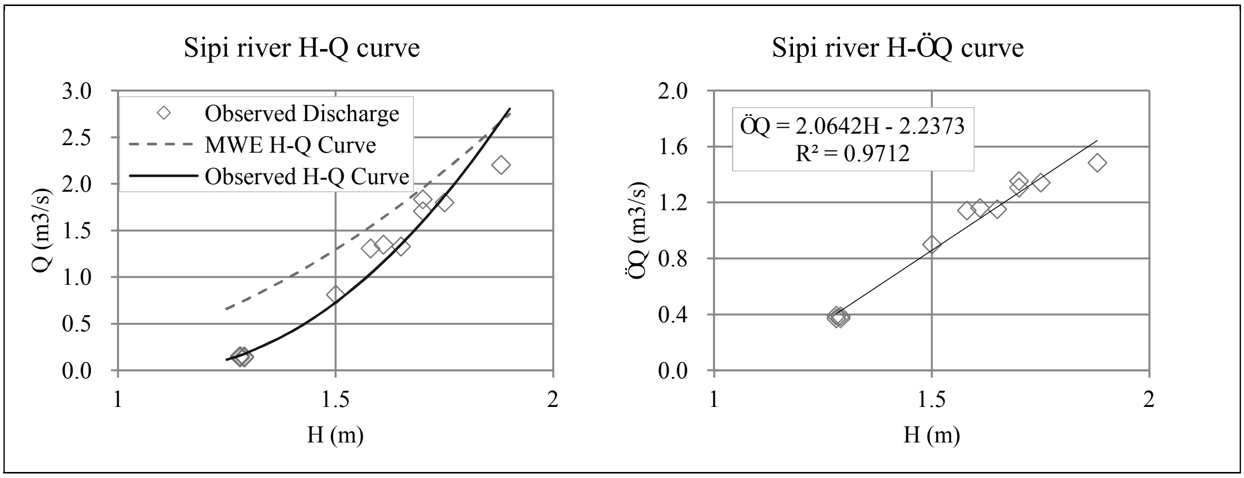
Measurement of velocity and area of cross-section in the Sipi River was conducted 12times from March 2015 to middle of August 2015.

Table 3.3.2 Results of Velocity and Area of Cross-section in the Sipi River

No.	Date	Water Level Gauge (m)	Average Velocity (m/s)	Area of Cross section (m^2)	Observed Discharge (m^3/s)	ÖQ
1	09 Mar 2015	1.29	0.30	0.38	0.149	0.39
2	10 Mar 2015	1.28	0.42	0.36	0.153	0.39
3	11 Mar 2015	1.29	0.39	0.35	0.137	0.37
4	12 Mar 2015	1.28	0.37	0.37	0.138	0.37
5	22 Jun 2015	1.58	0.48	2.61	1.307	1.14
6	24 Jun 2015	1.61	0.47	2.73	1.348	1.16
7	25 Jun 2015	1.65	0.47	2.78	1.328	1.15
8	26 Jun 2015	1.88	0.43	4.93	2.203	1.48
9	29 Jun 2015	1.75	0.47	3.64	1.799	1.34
10	01 Jul 2015	1.7	0.52	3.33	1.833	1.35
11	20 Jul 2015	1.5	0.35	2.17	0.810	0.90
12	11 Aug 2015	1.7	0.48	3.42	1.707	1.31

Source: JICA Study Team

The results of measurement are plotted on the scatter diagram and shown below. Then, H-Q curve equation in the Sipi River was obtained as $Q = 4.2092(H-1.0839)^{2.}$



Source: JICA Study Team

Figure 3.3.2 Relationship between H – Q and H -ÖQ in the Sipi River

3.3.3 Results of Measurement of Velocity and Cross-section of the Sironko River

Measurement of velocity and area of cross-section in the Sironko River was conducted 13times from March 2015 to end of July 2015.

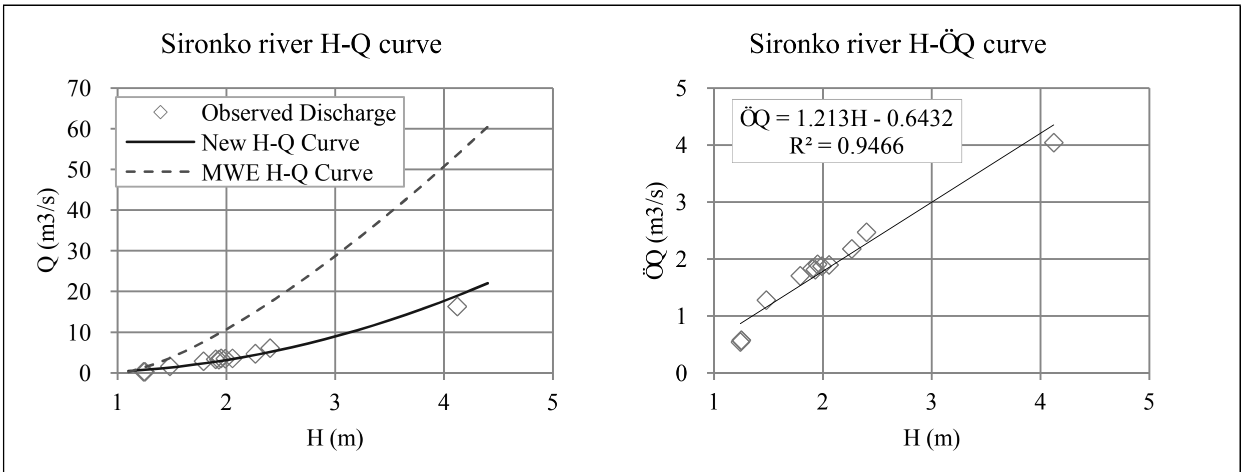
Table 3.3.3 Results of Velocity and Area of Cross-section in the Sironko River

No.	Date	Water Level Gauge (m)	Average Velocity (m/s)	Area of Cross section (m^2)	Observed Discharge (m^3/s)	ÖQ
1	10 Mar 2015	1.25	0.18	1.74	0.326	0.57
2	11 Mar 2015	1.25	0.18	1.78	0.335	0.58

No.	Date	Water Level Gauge (m)	Average Velocity (m/s)	Area of Cross section (m^2)	Observed Discharge (m^3/s)	ÖQ
3	12 Mar 2015	1.24	0.16	1.7	0.297	0.54
4	22 Jun 2015	1.79	0.45	5.73	2.909	1.71
5	24 Jun 2015	1.90	0.45	7.05	3.368	1.84
6	25 Jun 2015	1.93	0.40	7.17	3.294	1.81
7	26 Jun 2015	4.12	0.52	29.59	16.373	4.05
8	29 Jun 2015	2.40	0.36	14.45	6.116	2.47
9	01 Jul 2015	2.26	0.42	8.49	4.751	2.18
10	30 Jul 2015	1.48	0.42	3.29	1.636	1.28
11	31 Jul 2015	2.06	0.25	9.53	3.612	1.90
12	31 Jul 2015	1.99	0.41	7.49	3.527	1.88
13	31 Jul 2015	1.95	0.45	7.25	3.640	1.91

Source: JICA Study Team

The results of measurement are plotted on the scatter diagram and shown below. Then, H-Q curve equation in the Sironko River was obtained as $Q = 1.471369(H-0.53025)^{2.}$



Source: JICA Study Team

Figure 3.3.3 Relationship between H – Q and H -ÖQ in the Sironko River

3.3.4 Results of Measurement of Velocity and Cross-section of the Namatala River

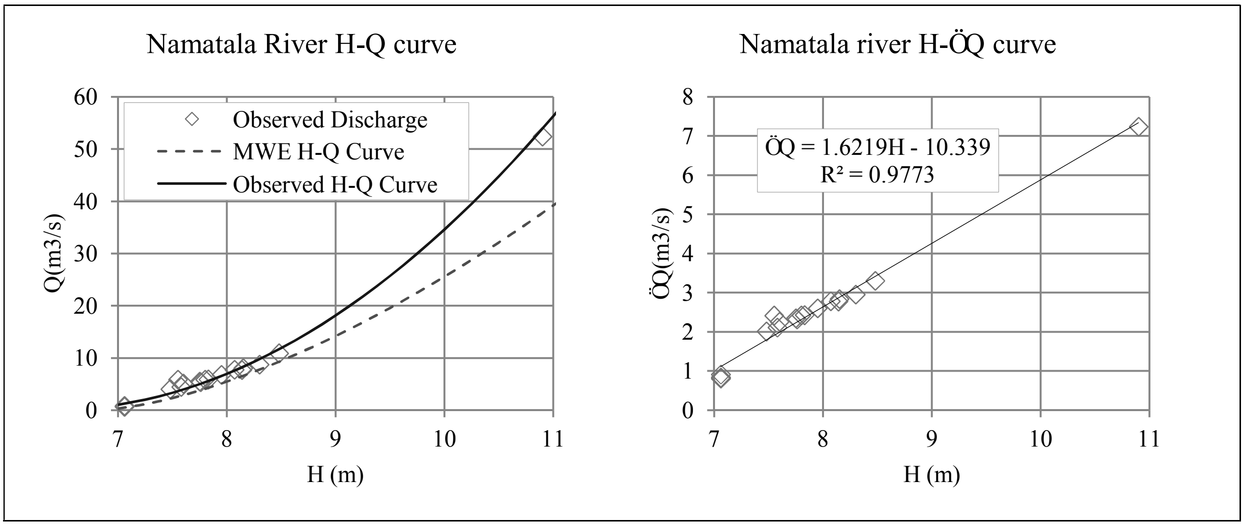
Measurement of velocity and area of cross-section in the Namatala River was conducted 19 times from end of August 2014 to end of October 2015.

Table 3.3.4 Results of Velocity and Area of Cross-section in the Namatala River

No.	Date	Water Level Gauge (m)	Average Velocity (m/s)	Area of Cross section (m^2)	Observed Discharge (m^3/s)	ÖQ
1	28 Aug 2014	8.30	0.78	11.28	8.72	2.95
2	05 Sep 2014	8.15	0.81	10.02	8.06	2.84
3	10 Sep 2014	7.80	0.83	7.08	5.87	2.42
4	12 Sep 2014	7.95	0.81	8.34	6.76	2.60
5	15 Sep 2014	7.58	0.82	5.40	4.44	2.11
6	18 Sep 2014	7.48	0.86	4.66	4.04	2.01
7	29 Sep 2014	8.48	0.86	12.79	10.90	3.30
8	01 Oct 2014	8.14	0.78	9.94	7.71	2.78
9	02 Oct 2014	8.07	0.84	9.35	7.74	2.78
10	14 Oct 2014	7.83	0.81	7.29	5.88	2.43
11	23 Oct 2014	7.75	0.82	6.66	5.50	2.35
12	09 Mar 2015	7.06	0.52	1.54	0.82	0.91
13	10 Mar 2015	7.06	0.45	1.47	0.68	0.82
14	11 Mar 2015	7.06	0.45	1.43	0.65	0.80
15	12 Mar 2015	7.06	0.45	1.50	0.70	0.83
16	22 Jun 2015	7.76	0.76	7.81	5.36	2.32
17	24 Jun 2015	7.60	0.80	6.72	5.09	2.26
18	25 Jun 2015	7.55	0.95	6.30	5.84	2.42
19	22 Oct 2015	10.90	1.54	34.44	52.39	7.24

Source: JICA Study Team

The results of measurement are plotted on the scatter diagram and shown below. Then, H-Q curve equation in the Namatala River was obtained as $Q = 2.63056(H-6.37462)^2$.



Source: JICA Study Team

Figure 3.3.4 Relationship between H – Q and H -ÖQ in the Namatala River

3.4 Modification of the River Discharge for Water Balance Analysis

3.4.1 The Sironko River Discharge

Although MWE H-Q curve was updated in 1997, it seems that MWE H-Q curve overestimates the discharge especially when the water level is high. That means there is a risk of lack of irrigation water if MWE H-Q curve is applied to the conversion of river discharge for water balance analysis. Therefore, in this study, observed discharge data in the Sironko River by MWE from 2000-2012 is converted to water level, then water level was converted to discharge again by using JST H-Q curve for water balance analysis.

3.4.2 The Namatala River Discharge

It seems that current MWE H-Q curve underestimate the discharge in the Namatala River compared to the discharge which is predicted by JST H-Q curve. Since MWE H-Q curve in the Namatala River was developed in 1964 and never updated since it seems that river cross section might have changed slightly over a long period of time. Therefore, in this study, JST H-Q curve is applied for conversion of water level to discharge in the same way as the Sironko River.

3.4.3 The Sipi River Discharge

The Figure 3.4.1 shows time series variation of minimum water level in the Sipi River from 2000-2012. Basically minimum flow is observed in dry season such as in February to March and usually there is no big difference year to year. But there is a discrepancy between 2000-2006 and 2007-2012 and it seems to be due to the change of the cross section of rive probably due to sediment deposition from upstream by flood around 2006. Although there is some discrepancy between MWE H-Q curve and JST H-Q curve, MWE H-Q curve was applied for conversion of the discharge because of the reasons listed below.

- MWE H-Q curve was recently updated in 1994.
- 2004 corresponds to 1/5 year probability of drought year which is considered as design year for water balance analysis in this project. It is appropriate to apply MWE H-Q curve in most o the analysis period.
- Majority of the analysis period are appropriate to apply MWE H-Q curve.

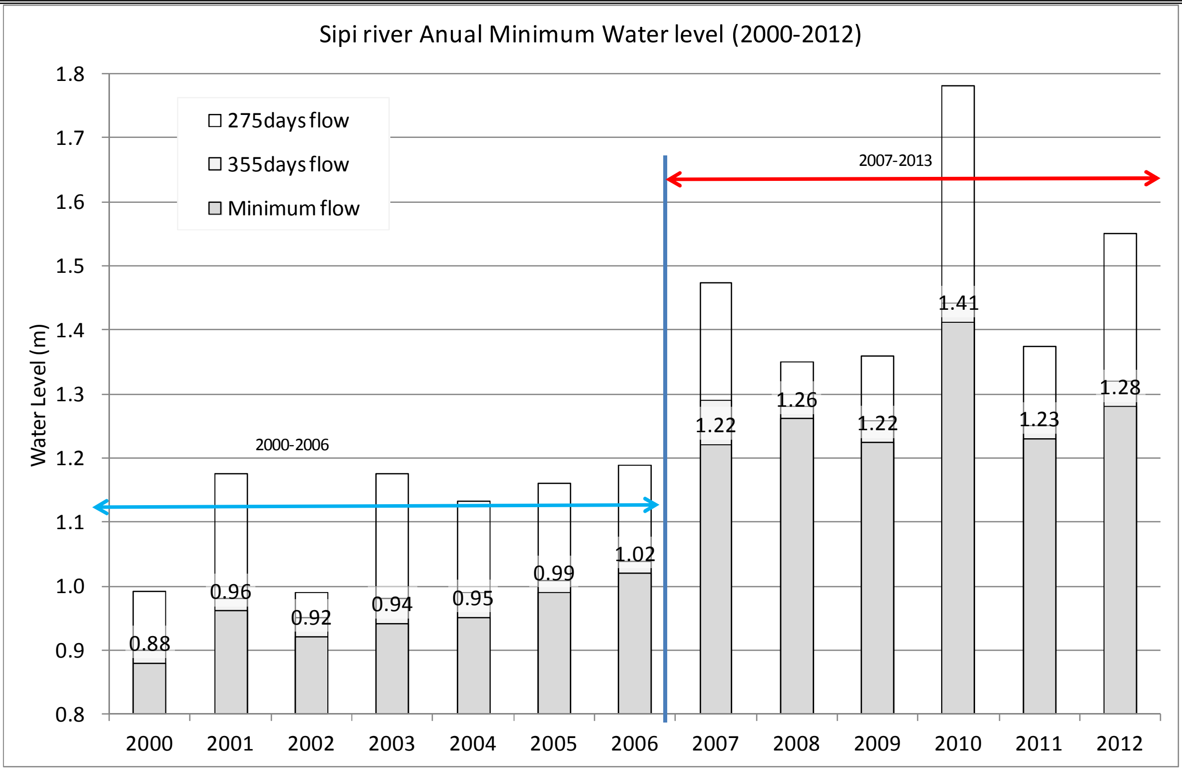


Figure 3.4.1 Time Series Variation of Minimum Water Level in the Sipi River from 2000-2012

3.4.4 The Atari River Discharge

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 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.

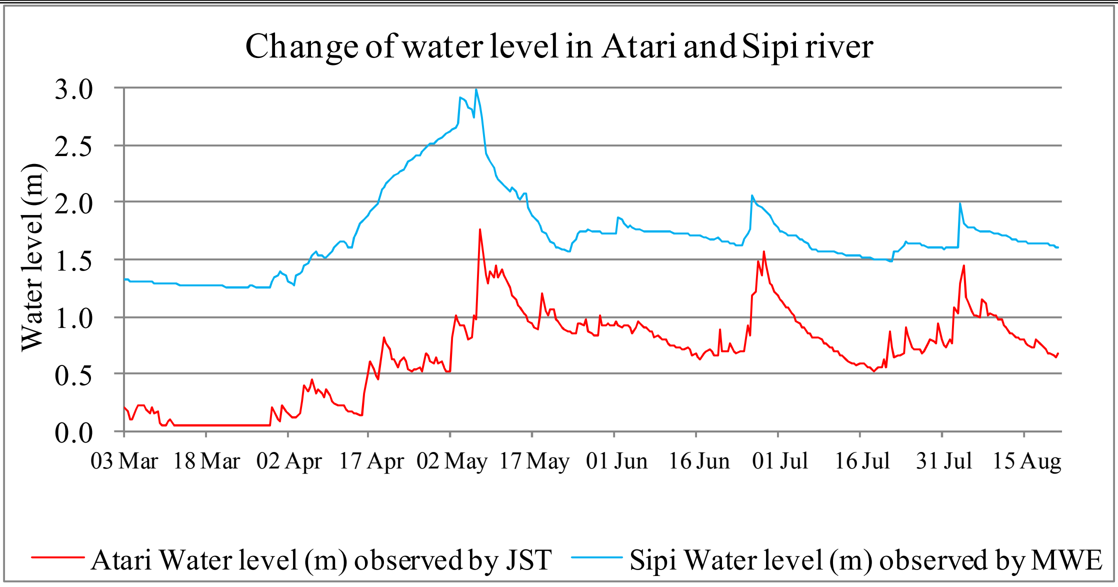


Figure 3.4.2 Change of Water Level in Atari and the Sipi River

Then, 15 days average of specific discharge for both river was compared and shown in the figure below. There is a correlation between the Atari and 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.

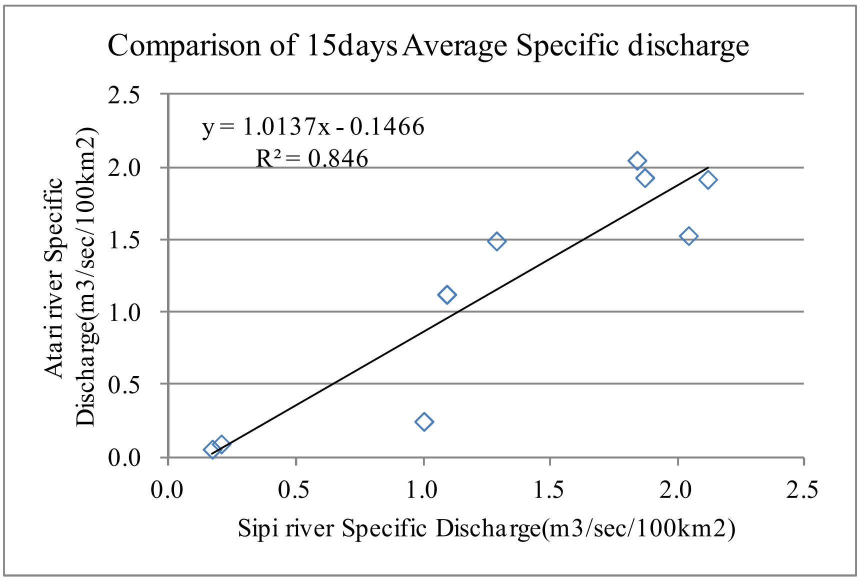


Figure 3.4.3 Comparison of 15 Days Average Specific Discharge

Chapter 4 SUMMARY OF OBSERVED DATA

4.1 Summary of Observed data in the Atari River

The summary of observation in the Atari River is listed below. The observation in the Atari River is on going without any gap from the beginning of the observation.

Table 4.1.1 Result of the Atari River Observation in 2015

	Water level at Bridge (m)			Discharge at Bridge (m3/sec)			Remark
	Average	Max	Min	Average	Max	Min	
January							
February							
March	0.09	0.42	0.04	0.12	0.60	0.07	Observation started from 2nd March
April	0.43	1.36	0.08	0.71	4.04	0.10	
May	1.03	1.93	0.50	2.57	7.66	0.76	
June	0.87	1.59	0.59	1.96	5.39	1.00	
July	0.75	1.20	0.52	1.50	3.22	0.81	
August	0.83	1.45	0.58	1.78	4.54	0.97	
September	0.57	0.85	0.48	0.95	1.78	0.72	
October	0.81	1.87	0.48	1.81	7.19	0.72	
November	1.23	1.82	1.03	3.41	6.85	2.50	
December	0.95	1.50	0.74	2.18	4.81	1.44	

Source: JICA Study Team

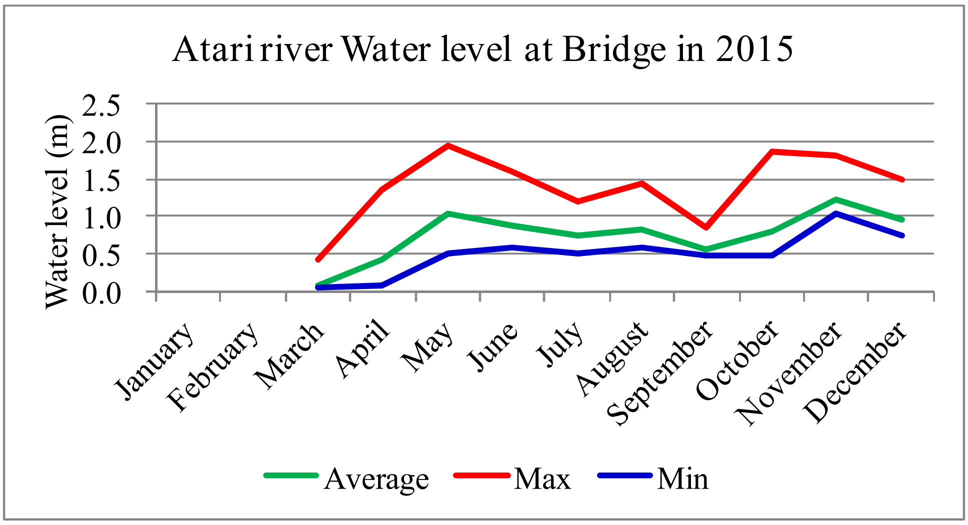


Figure 4.1.1 Monthly Average, Min. and Max. water level in the Atari River

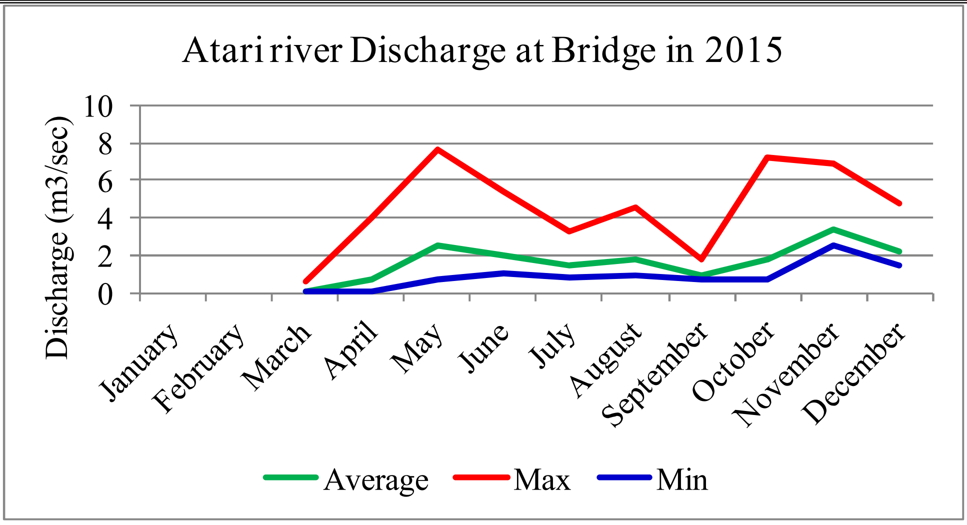


Figure 4.1.2 Monthly Average, Min. and Max. Discharge in the Atari River

4.2 Summary of Observed Data in the Sironko River

The summary of observation in the Sironko River is listed below. The observation stopped due to vandalism of the equipment on 1st February 2016 and the data from 2nd December 2016 was lost. After the short term intervention by MWE, New water pressure gauge was reinstalled in the Sironko River on 25th April in 2016.

Table 4.2.1 Result of the Sironko River observation in 2015

	Water level at gauge (m)			Discharge at Bridge (m3/sec)			Remark
	Average	Max	Min	Average	Max	Min	
January							
February	1.27	1.27	1.26	0.77	0.78	0.77	Observation started from 27th February
March	1.27	1.71	1.22	0.77	1.98	0.67	
April	1.73	3.75	1.32	2.37	14.76	0.89	
May	2.39	4.40	1.59	5.46	21.32	1.58	
June	2.29	4.44	1.61	4.84	21.68	1.66	
July	1.73	4.30	1.41	2.40	20.23	1.11	
August	1.92	4.56	1.44	3.13	23.08	1.17	
September	2.21	4.29	1.53	4.51	20.08	1.41	
October	2.48	4.67	1.51	6.27	24.34	1.36	
November	3.04	4.31	2.27	9.28	20.36	4.29	
December	2.71	3.48	2.46	6.84	12.35	5.31	Data are missing from 2rd December due to vandalism of equipment

Source: JICA Study Team

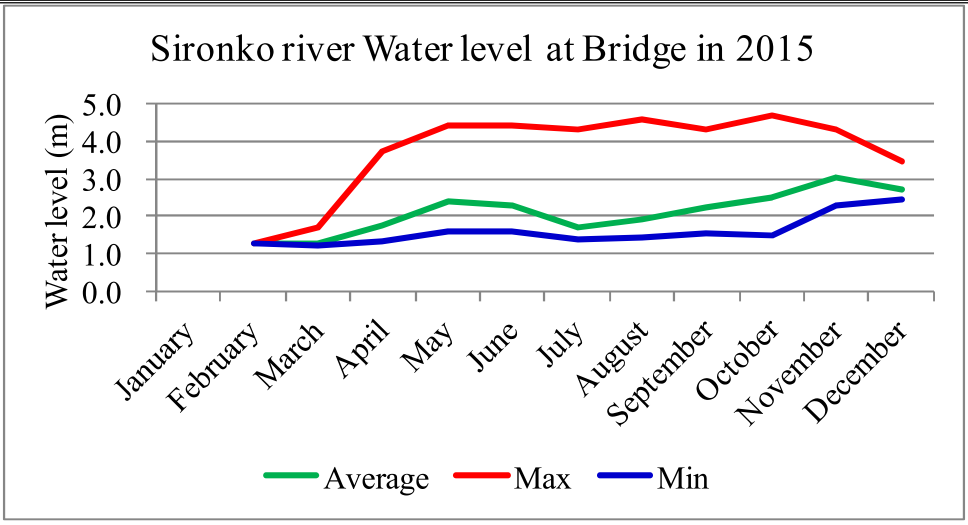


Figure 4.2.1 Monthly Average, Min. and Max. Water Level in the Sironko River

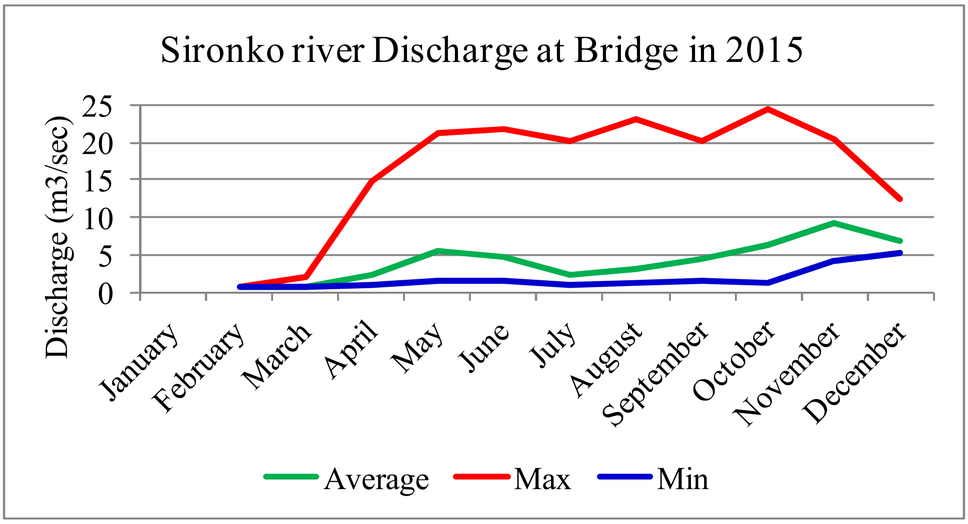


Figure 4.2.2 Monthly Average, Min. and Max. Discharge in the Sironko River

4.3 Summary of Observed Data in the Namatala River

The summary of observation in the Namatala River is listed below. The observation stopped due to mechanical issue on 23rd October and restarted on 2nd December 2015. The observation again stopped due to vandalism of the equipment on 27th January 2016 and the data from 3rd December 2016 was lost. After the short term intervention by MWE, New water pressure gauge was reinstalled in the Namatala River on 27th April in 2016.

Table 4.3.1 Result of the Namatala River Observation in 2015

	Water level at gauge (m)			Discharge at Bridge (m3/sec)			Remark
	Average	Max	Min	Average	Max	Min	
January							
February	7.08	7.10	7.05	1.31	1.39	1.21	Observation started from 27th February

March	7.09	7.71	7.01	1.35	4.68	1.08	
April	7.35	8.32	7.08	2.67	9.95	1.32	
May	7.80	10.65	7.29	6.02	47.99	2.18	
June	7.99	10.22	7.52	7.47	38.80	3.43	
July	7.51	9.26	7.24	3.77	21.92	1.99	
August	7.35	8.66	7.23	2.60	13.79	1.90	
September	7.48	9.11	7.23	3.39	19.70	1.94	
October	7.60	11.12	7.20	5.17	59.34	1.81	Observation Stopped from 23rd October due to mechanical problem
November							
December	7.52	7.75	7.37	3.51	4.96	2.61	Observation restarted on 2nd. Data are missing from 3rd December due to vandalism of equipment

Source: JICA Study Team

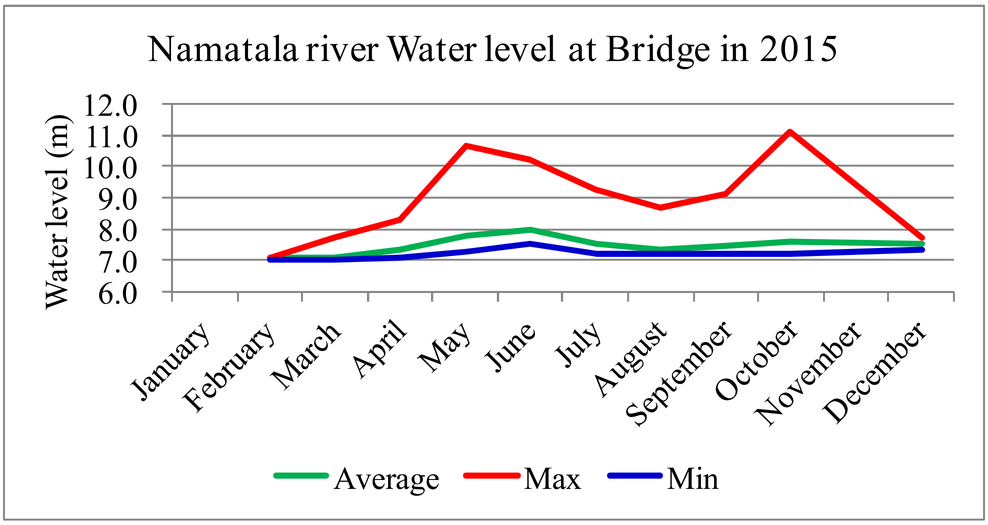


Figure 4.3.1 Monthly Average, Min. and Max. Water Level in the Namatala River

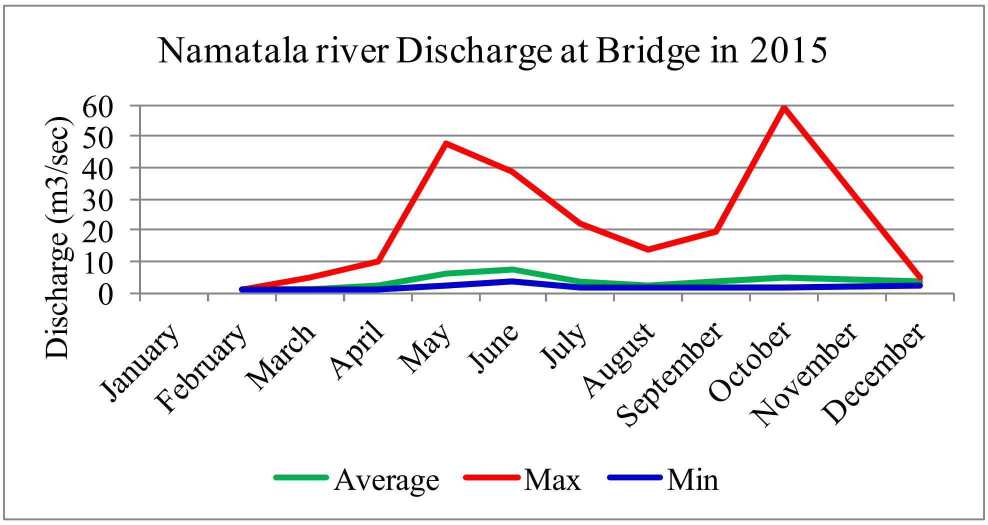


Figure 4.3.2 Monthly Average, Min. and Max. Discharge in the Namatala River

Chapter 5 HYDRO-METEROLOGICAL DATA UTILIZED FOR WATER BALANCE ANALYSIS IN PHASE 1

The Hydro-meteorological data such as rain fall, temperature, evapotranspiration and river discharge were provided by MWE DWRM and UNMA. Those data were used for water balance analysis in Phase 1 and were shown in Annex-1.

Tororo Average Monthly Maximum, Minimum and Average Temperature (oC)

	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Annual Average		
Year	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Average**	**Max**	**Min**
1992	32.0	17.4	24.7	29.5	17.6	23.6	30.1	16.7	23.4	29.9	18.1	24.0	28.8	17.1	23.0	28.8	16.6	22.7	26.5	16.1	21.3	28.3	16.7	22.5	27.3	16.3	21.8	29.0	17.0	23.0	28.8	15.3	22.1	29.8	15.7	22.8	**22.9**	**32.0**	**15.3**
1993	29.2	19.7	24.5	30.7	16.8	23.8	30.8	16.0	23.4	30.7	17.9	24.3	31.2	17.1	24.2	28.2	17.3	22.8	28.6	16.2	22.4	29.7	15.7	22.7	30.1	16.2	23.2	31.2	17.1	24.2	31.3	17.3	24.3	32.2	17.7	25.0	**23.7**	**32.2**	**15.7**
1994	32.0	17.4	24.7	32.4	17.5	25.0	30.7	18.1	24.4	29.9	18.0	24.0	28.4	18.2	23.3	28.1	16.8	22.5	26.7	15.3	21.0	27.1	15.1	21.1	28.1	15.0	21.5	29.3	16.5	22.9	28.0	17.2	22.6	30.2	16.5	23.4	**23.0**	**32.4**	**15.0**
1995	32.3	16.6	24.4	30.8	17.3	24.1	30.3	17.4	23.9	30.1	18.3	24.2	29.2	16.5	22.8	28.9	17.5	23.2	28.0	16.3	22.2	29.2	16.1	22.7	29.7	17.1	23.4	29.6	17.3	23.5	29.9	17.3	23.6	30.3	16.9	23.6	**23.5**	**32.3**	**16.1**
1996	30.8	16.7	23.7	30.4	17.9	24.1	31.0	17.7	24.4	29.7	17.6	23.6	29.3	17.7	23.5	27.9	16.7	22.3	28.4	16.9	22.7	29.4	16.2	22.8	29.3	16.0	22.7	29.6	16.8	23.2	29.3	16.8	23.1	29.7	16.6	23.2	**23.3**	**31.0**	**16.0**
1997	30.9	16.6	23.8	31.6	16.9	24.3	31.2	17.7	24.5	29.9	17.4	23.7	29.5	17.5	23.5	26.7	16.3	21.5	27.9	16.7	22.3	29.5	16.0	22.8	29.0	16.2	22.6	29.6	16.6	23.1	27.8	16.8	22.3	27.7	16.4	22.1	**23.0**	**31.6**	**16.0**
1998	28.8	17.1	23.0	29.0	17.0	23.0	28.9	16.8	22.9	28.8	16.8	22.8	28.4	16.9	22.7	28.8	16.5	22.7	29.1	16.3	22.7	29.4	16.2	22.8	29.3	16.5	22.9	29.5	16.4	23.0	29.2	16.8	23.0	29.6	16.3	23.0	**22.9**	**29.6**	**16.2**
1999	31.6	17.1	24.4	35.0	16.7	25.9	30.6	18.5	24.6	29.6	18.4	24.0	28.9	17.7	23.3	28.9	17.4	23.2	28.5	17.0	22.8	28.7	16.9	22.8	29.4	16.5	23.0	28.8	17.6	23.2	29.6	17.5	23.6	30.0	17.3	23.7	**23.7**	**35.0**	**16.5**
2000	32.0	16.3	24.2	31.1	15.5	23.3	32.2	18.2	25.2	28.1	17.9	23.0	29.3	18.2	23.8	28.1	16.6	22.4	28.7	17.5	23.1	28.6	16.6	22.6	29.0	20.4	24.7	29.2	17.7	23.5	26.9	18.1	22.5	29.3	18.4	23.9	**23.5**	**32.2**	**15.5**
2001	29.2	16.6	22.9	31.9	17.2	24.6	31.7	17.7	24.7	29.8	17.9	23.9	29.0	17.7	23.4	28.3	15.9	22.1	28.1	15.8	22.0	29.1	16.4	22.8	29.4	16.4	22.9	29.4	16.5	23.0	29.1	16.8	23.0	31.9	16.5	24.2	**23.3**	**31.9**	**15.8**
2002	29.9	16.7	23.3	33.6	18.4	26.0	30.6	18.0	24.3	29.9	17.9	23.9	28.7	17.3	23.0	28.6	16.8	22.7	29.7	17.1	23.4	29.5	16.3	22.9	30.8	16.4	23.6	30.0	17.0	23.5	29.0	16.7	22.9	29.0	16.0	22.5	**23.5**	**33.6**	**16.0**
2003	30.7	17.0	23.8	32.8	17.7	25.3	31.9	17.8	24.9	30.3	17.8	24.0	28.9	17.2	23.1	28.6	16.4	22.5	28.1	16.0	22.0	29.1	16.4	22.7	29.9	16.1	23.0	30.4	16.6	23.5	29.6	16.7	23.2	30.1	15.9	23.0	**23.4**	**32.8**	**15.9**
2004	31.4	16.5	24.0	31.6	16.9	24.2	32.2	18.0	25.1	29.3	17.1	23.2	29.9	16.7	23.3	28.7	16.2	22.4	29.3	15.5	22.4	28.8	15.9	22.3	29.3	15.7	22.5	29.9	17.1	23.5	29.1	17.8	23.4	30.3	17.5	23.9	**23.4**	**32.2**	**15.5**
2005	31.6	17.2	24.4	34.9	19.5	27.2	31.7	19.2	25.5	30.2	19.2	24.7	28.6	18.7	23.6	28.8	18.0	23.4	28.6	17.2	22.9	28.8	17.1	22.9	29.3	17.7	23.5	29.9	17.5	23.7	30.8	17.7	24.2	32.9	16.8	24.9	**24.2**	**34.9**	**16.8**
2006	33.0	18.1	25.5	32.8	19.1	26.0	29.8	18.6	24.2	28.8	18.6	23.7	29.1	18.0	23.6	28.7	17.3	23.0	28.8	17.3	23.0	29.4	17.0	23.2	29.6	17.3	23.4	29.9	17.8	23.8	27.8	17.2	22.5	28.1	16.6	22.4	**23.7**	**33.0**	**16.6**
2007	29.8	16.9	23.3	29.9	18.4	24.2	31.8	18.3	25.0	30.9	19.0	24.9	29.6	18.5	24.0	27.8	17.6	22.7	27.4	17.1	22.3	28.0	16.8	22.4	28.4	17.0	22.7	29.5	16.9	23.2	29.6	17.0	23.3	30.9	16.5	23.7	**23.5**	**31.8**	**16.5**
2008	31.4	17.3	24.4	30.7	17.5	24.1	30.1	18.2	24.2	30.0	17.8	23.9	29.3	18.2	23.8	28.4	17.2	22.8	27.5	16.3	21.9	28.4	16.7	22.5	29.7	16.9	23.3	28.6	17.3	22.9	29.8	16.6	23.2	32.2	16.8	24.5	**23.5**	**32.2**	**16.3**
2009	31.9	17.5	24.7	31.6	17.9	24.7	32.9	18.2	25.6	29.0	17.9	23.4	29.0	17.9	23.5	30.2	17.5	23.8	29.3	17.2	23.2	29.8	17.4	23.6	29.8	17.6	23.7	29.9	17.9	23.9	29.8	17.7	23.7	29.6	17.5	23.6	**24.0**	**32.9**	**17.2**
2010	31.0	16.6	23.8	30.6	17.2	23.9	30.0	17.5	23.7	30.3	17.7	24.0	29.2	17.2	23.2	28.8	16.6	22.7	28.7	16.2	22.5	29.0	16.7	22.9	29.1	16.3	22.7	29.4	17.0	23.2	30.1	15.3	22.7	30.1	15.7	22.9	**23.2**	**31.0**	**15.3**
2011	31.5	15.1	23.3	33.6	15.4	24.5	31.4	16.2	23.8	31.0	16.7	23.9	29.2	16.5	22.8	29.0	15.5	22.3	29.5	14.9	22.2	28.5	15.3	21.9	29.2	17.3	23.3	28.9	17.8	23.3	28.0	17.7	22.9	29.9	17.6	23.7	**23.2**	**33.6**	**14.9**
2012	33.0	16.6	24.8	34.0	17.1	25.6	33.4	18.1	25.8	29.2	17.5	23.4	28.8	17.4	23.1	28.3	17.2	22.8	28.0	16.6	22.3	28.6	16.9	22.7	28.5	17.2	22.9	29.7	17.7	23.7	29.3	17.6	23.4	29.3	17.6	23.4	**23.7**	**34.0**	**16.6**
2013	31.0	17.9	24.5	33.0	17.7	25.3	31.2	18.0	24.6	29.1	17.9	23.5	38.1	18.1	28.1	29.1	17.7	23.4	29.5	16.6	23.0	28.4	16.9	22.7	29.2	16.9	23.1	29.4	17.4	23.4	29.3	18.2	23.8	30.1	17.5	23.8	**24.1**	**38.1**	**16.6**
Average	**31.1**	**17.0**	**24.1**	**31.9**	**17.4**	**24.7**	**31.1**	**17.8**	**24.5**	**29.7**	**17.9**	**23.8**	**29.6**	**17.6**	**23.6**	**28.5**	**16.9**	**22.7**	**28.4**	**16.5**	**22.4**	**28.9**	**16.4**	**22.6**	**29.2**	**16.8**	**23.0**	**29.6**	**17.2**	**23.4**	**29.2**	**17.1**	**23.1**	**30.1**	**16.8**	**23.5**	**23.4**	**32.7**	**16.0**

Tororo Monthly Rainfall Totals (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	32.4	83.4	63.4	226.6	171.1	118.4	52.9	147.5	118.3	102.5	178.4	107.0	**1401.9**
1993	38.7	24.7	127.5	136.2	268.3	79.4	30.9	30.5	137.3	59.1	62.4	53.4	**1048.4**
1994	73.8	29.7	175.9	175.9	208.9	164.8	156.2	63.2	114.8	109.6	283.0	41.3	**1597.1**
1995	71.7	82.0	171.5	262.3	177.3	108.7	96.2	93.2	87.8	233.6	160.3	43.8	**1588.4**
1996	97.6	118.8	162.9	306.6	199.5	59.4	52.9	185.0	167.3	231.8	174.0	20.1	**1775.9**
1997	54.8	0.7	95.1	166.2	139.6	102.5	77.7	96.1	29.4	239.2	333.4	215.8	**1550.5**
1998	302.0	118.9	130.5	266.3	348.3	94.6	69.9	111.9	84.6	188.5	99.4	24.8	**1839.7**
1999	110.5	0.0	272.5	136.5	106.7	75.4	66.2	169.7	141.8	154.2	140.8	101.2	**1475.5**
2000	61.9	16.7	79.5	177.5	181.4	86.1	99.1	100.4	103.5	237.5	170.3	106.2	**1420.1**
2001	102.9	39.1	186.4	162.8	135.2	128.0	62.0	87.7	150.2	184.3	126.0	69.0	**1433.6**
2002	96.7	54.0	107.0	279.2	145.5	63.8	49.3	81.6	73.9	103.8	206.5	231.2	**1492.5**
2003	141.0	159.6	77.9	169.8	182.3	123.4	66.8	93.4	92.6	99.0	206.5	89.4	**1501.7**
2004	33.3	48.7	76.8	162.5	136.5	69.6	64.7	188.9	203.9	126.9	89.5	62.2	**1263.5**
2005	32.2	17.4	217.8	223.5	306.5	139.6	177.3	82.6	73.0	140.1	97.1	109.6	**1616.7**
2006	46.6	98.7	238.1	235.6	222.8	239.5	89.6	173.7	127.6	279.9	178.6	61.6	**1992.3**
2007	100.8	114.5	77.3	167.7	203.3	111.2	174.8	142.5	122.8	140.9	103.7	49.0	**1508.5**
2008	67.7	114.2	161.8	170.9	237.0	109.5	183.9	131.3	131.9	298.7	234.3	19.9	**1861.1**
2009	109.2	76.1	99.0	318.8	195.5	40.9	72.3	112.0	109.7	156.6	111.6	154.9	**1556.6**
2010	92.4	293.3	163.1	265.3	215.6	52.8	86.6	127.2	82.1	113.8	84.8	101.6	**1678.6**
2011	44.7	15.2	148.5	193.6	338.0	98.9	62.2	181.1	105.2	295.3	98.2	44.6	**1625.5**
2012	0.0	11.2	109.7	226.4	366.2	156.3	77.1	108.0	103.3	201.6	159.6	111.8	**1631.2**
2013	70.9	9.8	236.3	228.1	232.7	43.3	37.8	187.5	229.2	93.1	169.6	53.8	**1592.1**
Average	**81.0**	**69.4**	**144.5**	**211.7**	**214.5**	**103.0**	**86.7**	**122.5**	**117.7**	**172.3**	**157.6**	**85.1**	**1566.0**
Min	**0.0**	**0.0**	**63.4**	**136.2**	**106.7**	**40.9**	**30.9**	**30.5**	**29.4**	**59.1**	**62.4**	**19.9**	**1048.4**
Max	**302.0**	**293.3**	**272.5**	**318.8**	**366.2**	**239.5**	**183.9**	**188.9**	**229.2**	**298.7**	**333.4**	**231.2**	**1992.3**

Tororo Average Monthly Relative Humidty (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	62.5	52.5	68.5	71.5	78.0	73.5	73.5	74.5	72.5	71.5	66.0	53.0	68.1
1993	53.5	58.0	74.0	77.5	76.5	73.5	75.0	72.0	73.0	72.5	76.0	77.5	71.6
1994	73.0	71.0	65.0	69.0	74.0	75.5	78.5	77.0	77.0	70.0	71.0	60.0	71.8
1995	61.0	64.5	68.5	72.5	73.5	72.5	74.5	72.5	67.5	72.0	64.5	48.0	67.6
1996	53.5	55.0	54.0	70.0	66.0	59.5	62.5	64.0	66.5	67.5	66.5	65.0	62.5
1997	59.5	65.0	66.5	68.5	73.0	68.0	67.5	67.5	66.0	67.5	63.0	58.5	65.9
1998	50.5	42.0	57.5	61.0	69.5	69.0	65.5	70.0	71.0	69.5	63.5	59.5	62.4
1999	44.0	38.3	45.4	68.9	70.4	70.5	70.0	68.1	69.7	66.1	67.3	66.5	62.1
2000	51.0	49.0	65.0	69.5	72.5	73.5	71.0	75.0	70.5	72.5	74.5	71.0	67.9
2001	71.5	68.0	68.0	76.0	77.5	76.5	74.5	73.5	74.5	75.0	75.5	62.0	72.7
2002	71.0	57.5	74.0	74.0	76.0	74.0	70.0	70.0	68.0	72.5	75.5	75.0	71.5
2003	69.0	66.5	57.5	70.5	75.0	75.5	76.5	74.0	72.5	70.0	72.0	64.5	70.3
2004	65.5	63.5	65.5	74.0	71.0	74.5	68.5	73.5	74.5	72.0	73.0	70.0	70.5
2005	66.5	60.0	60.0	68.0	70.5	60.5	60.0	65.5	66.0	72.0	75.0	71.5	66.3
2006	65.5	55.0	68.5	70.0	72.0	71.5	71.5	70.5	66.0	73.0	72.0	69.0	68.7
2007	66.0	58.0	72.5	71.5	72.0	62.5	61.5	69.5	67.0	73.0	75.0	74.0	68.5
2008	63.5	57.0	60.0	67.5	73.5	71.0	66.5	67.0	66.0	66.5	70.0	65.0	66.1
2009	72.0	60.5	68.0	74.0	66.0	62.0	55.5	65.0	62.0	71.5	72.5	68.0	66.4
2010	60.5	53.0	69.0	68.5	70.5	67.0	64.5	70.0	68.5	68.0	68.5	57.0	65.4
2011	60.0	58.0	68.0	69.0	70.5	60.5	59.5	63.5	64.0	65.5	77.0	74.0	65.8
2012	69.0	64.5	60.0	62.5	68.0	71.5	71.0	71.0	70.5	71.0	73.5	63.5	68.0
2013	58.3	50.9	62.7	70.6	67.3	63.5	58.4	67.9	67.8	66.4	65.0	60.7	63.3
Average	**62.1**	**57.6**	**64.5**	**70.2**	**72.0**	**69.4**	**68.0**	**70.1**	**69.1**	**70.3**	**70.8**	**65.1**	**67.4**

Tororo Average Monthly Wind Speed (m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	4.1	4.6	4.3	3.7	3.4	3.3	3.8	3.4	4.0	3.3	3.6	3.9	**3.8**
1993	3.6	4.3	4.1	3.9	3.6	3.8	3.1	3.2	3.8	4.0	4.2	4.0	**3.8**
1994	3.8	4.6	4.3	4.3	3.4	4.1	3.3	4.0	4.1	3.9	4.4	4.1	**4.0**
1995	4.8	4.6	5.1	5.1	5.0	4.3	4.7	4.3	5.2	4.5	4.9	5.4	**4.8**
1996	5.0	5.3	5.9	4.8	4.9	4.6	4.6	4.4	5.4	4.8	5.3	5.8	**5.1**
1997	4.8	4.6	22.9	5.5	4.6	4.6	4.4	4.2	4.9	4.0	5.0	5.3	**6.2**
1998	4.4	4.9	4.9	4.8	4.5	4.7	4.3	3.9	4.2	4.5	5.5	4.9	**4.6**
1999	5.0	5.9	6.1	5.7	3.4	3.7	4.3	5.7	3.6	5.4	4.3	4.4	**4.8**
2000	5.1	5.6	5.4	4.9	4.1	3.7	4.9	5.0	4.1	5.3	5.1	4.9	**4.8**
2001	4.9	4.6	4.6	4.6	4.7	4.1	4.2	4.5	5.0	4.3	4.7	4.1	**4.5**
2002	4.0	4.9	5.0	4.6	4.1	3.8	4.3	4.2	4.5	4.3	4.7	4.3	**4.4**
2003	3.3	5.8	4.6	5.0	4.2	3.9	3.5	3.7	3.4	4.4	2.9	3.1	**4.0**
2004	4.3	2.8	2.2	3.2	3.3	4.1	4.3	3.9	3.5	5.0	4.4	4.1	**3.8**
2005	3.8	4.9	2.3	4.3	3.5	3.4	3.2	4.0	2.9	3.8	3.9	3.9	**3.6**
2006	4.9	4.6	4.3	3.5	3.8	3.5	3.2	4.3	4.1	3.4	4.1	4.6	**4.0**
2007	4.9	4.9	4.4	3.8	3.9	3.2	3.8	4.1	3.8	4.3	3.8	3.5	**4.0**
2008	3.9	4.1	3.9	4.2	3.4	3.0	3.0	3.1	3.0	2.0	2.9	3.3	**3.3**
2009	3.9	3.7	2.7	2.3	2.9	3.3	3.2	3.3	2.9	4.0	3.6	3.8	**3.3**
2010	2.6	2.8	2.7	2.3	2.3	1.9	2.1	2.0	2.2	2.3	2.4	2.7	**2.4**
2011	3.3	3.8	3.4	3.1	2.7	2.6	2.6	2.8	2.6	2.9	2.9	2.7	**2.9**
2012	2.7	3.1	3.3	3.3	2.6	2.4	2.3	2.8	1.8	2.8	3.0	3.2	**2.8**
2013	3.6	3.3	2.9	2.9	2.5	2.3	2.8	4.3	4.5	4.3	4.6	5.3	**3.6**
Average	**4.1**	**4.4**	**5.0**	**4.1**	**3.7**	**3.6**	**3.6**	**3.9**	**3.8**	**4.0**	**4.1**	**4.2**	**4.0**

Soroti Average Monthly Maximum, Minimum and Average Temperature (oC)

Year	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Annual Average		
	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Average	Max	Min
1992	31.8	17.5	24.7	30.9	18.9	24.9	33.0	20.4	26.7	26.7	19.7	23.2	30.6	18.6	24.6	29.5	17.0	23.3	28.4	17.2	22.8	28.5	17.8	23.2	29.9	17.5	23.7	29.1	17.5	23.3	29.1	17.4	23.3	29.2	17.1	23.2	**23.9**	**33.0**	**17.0**
1993	31.1	14.9	23.0	31.6	18.6	25.1	33.4	18.7	26.1	32.0	19.5	25.8	29.2	18.3	23.8	28.8	18.3	23.6	28.2	17.6	22.9	29.2	17.4	23.3	31.0	17.5	24.3	31.4	17.7	24.6	31.5	17.4	24.5	32.8	18.6	25.7	**24.4**	**33.4**	**14.9**
1994	33.8	18.6	26.2	33.8	19.1	26.5	32.2	19.6	25.9	30.8	19.0	24.9	29.5	18.2	23.9	28.9	18.1	23.5	28.2	17.9	23.1	27.3	17.4	22.3	28.2	17.5	22.9	30.6	17.6	24.1	29.5	17.1	23.3	31.3	17.3	24.3	**24.2**	**33.8**	**17.1**
1995	33.7	18.5	26.1	32.4	18.9	25.7	31.5	18.8	25.2	30.9	19.2	25.1	30.1	18.5	24.3	29.8	18.3	24.1	28.4	17.8	23.1	29.7	17.7	23.7	29.8	18.4	24.1	29.6	17.9	23.8	30.3	18.3	24.3	31.4	17.5	24.5	**24.5**	**33.7**	**17.5**
1996	31.2	17.8	24.5	31.3	18.5	24.9	31.9	18.8	25.4	30.4	18.6	24.5	29.8	18.6	24.2	28.3	18.0	23.2	28.3	17.8	23.0	29.5	17.6	23.5	29.8	17.7	23.8	30.8	17.7	24.3	31.0	18.0	24.5	32.2	17.7	25.0	**24.2**	**32.2**	**17.6**
1997	32.5	18.0	25.2	34.5	18.5	26.5	34.4	20.2	27.3	29.5	18.9	24.2	29.7	18.6	24.2	29.7	18.5	24.1	28.7	18.2	23.5	29.7	18.0	23.9	33.5	18.4	25.9	30.3	18.8	24.5	28.4	18.5	23.4	29.4	18.4	23.9	**24.7**	**34.5**	**18.0**
1998	30.4	18.3	24.4	32.5	19.4	26.0	34.4	20.5	27.4	32.2	20.3	26.2	29.8	19.6	24.7	29.0	18.8	23.9	28.1	18.2	23.2	29.0	18.1	23.6	30.9	18.1	24.5	29.6	18.4	24.0	30.7	18.2	24.4	33.0	17.6	25.3	**24.8**	**34.4**	**17.6**
1999	32.1	18.1	25.1	34.6	19.0	26.8	30.5	18.8	24.6	31.3	18.3	24.8	29.3	18.4	23.8	29.5	18.0	23.7	28.5	17.4	23.0	29.4	17.4	23.4	30.0	17.6	23.8	29.4	17.6	23.5	29.6	17.5	23.6	31.6	17.6	24.6	**24.2**	**34.6**	**17.4**
2000	34.0	17.9	25.9	34.3	19.0	26.7	33.3	19.7	26.5	31.4	19.3	25.3	29.9	18.8	24.3	29.7	18.6	24.1	29.0	18.1	23.6	29.0	17.6	23.3	30.7	17.9	24.3	29.8	18.2	24.0	30.2	18.2	24.2	31.2	18.4	24.8	**24.8**	**34.3**	**17.6**
2001	30.9	18.3	24.6	33.7	15.5	24.6	31.5	18.4	24.9	30.2	18.4	24.3	29.7	18.4	24.0	28.9	17.6	23.3	28.5	17.6	23.1	28.9	17.7	23.3	30.2	17.6	23.9	29.8	18.2	24.0	29.5	18.1	23.8	32.6	18.2	25.4	**24.1**	**33.7**	**15.5**
2002	31.4	18.3	24.9	34.4	19.5	27.0	31.5	19.4	25.4	31.1	19.1	25.1	29.4	19.0	24.2	29.5	18.6	24.0	30.5	18.5	24.5	30.1	18.2	24.1	31.9	18.0	24.9	30.5	18.1	24.3	30.2	18.1	24.1	30.9	18.4	24.7	**24.8**	**34.4**	**18.0**
2003	32.0	18.2	25.1	33.9	19.6	26.8	32.9	19.7	26.3	31.0	19.6	25.3	29.2	19.0	24.1	28.7	18.5	23.6	28.1	18.4	23.3	28.1	18.3	23.2	30.0	18.5	24.2	31.0	18.9	25.0	30.7	18.9	24.8	31.0	18.4	24.7	**24.7**	**33.9**	**18.2**
2004	31.9	19.4	25.6	32.2	19.6	25.9	33.4	20.5	26.9	29.7	19.3	24.5	29.9	19.1	24.5	29.2	18.7	24.0	29.4	18.2	23.8	29.2	18.4	23.8	30.0	18.3	24.2	30.9	18.9	24.9	30.2	18.7	24.4	31.2	19.2	25.2	**24.8**	**33.4**	**18.2**
2005	32.9	18.2	25.6	35.3	19.6	27.5	32.3	19.7	26.0	29.4	19.6	24.5	28.7	19.0	23.9	29.1	18.5	23.8	28.5	18.4	23.4	29.5	18.3	23.9	29.9	18.5	24.2	30.3	18.9	24.6	31.4	18.9	25.1	33.8	18.4	26.1	**24.9**	**35.3**	**18.2**
2006	29.6	20.3	24.9	31.8	20.6	26.2	29.4	19.2	24.3	28.7	18.7	23.7	27.4	19.3	23.4	27.3	18.7	23.0	27.0	18.8	22.9	27.7	18.6	23.2	28.3	18.2	23.2	28.7	18.9	23.8	30.0	18.7	24.3	31.3	18.6	25.0	**24.0**	**31.8**	**18.2**
2007	31.0	19.1	25.1	31.0	19.2	25.1	32.8	17.8	25.3	31.7	19.6	25.6	29.9	19.3	24.6	27.8	18.7	23.2	27.8	18.6	23.2	28.2	18.5	23.4	28.5	18.4	23.4	30.2	18.7	24.5	30.6	18.6	24.6	32.1	18.6	25.3	**24.4**	**32.8**	**17.8**
2008	32.8	19.4	26.1	32.8	19.8	26.3	31.0	19.3	25.1	29.7	19.2	24.4	29.5	19.0	24.3	28.7	19.0	23.9	28.6	18.4	23.5	28.8	18.3	23.5	29.9	18.6	24.2	29.2	18.8	24.0	30.1	18.7	24.4	32.9	19.0	25.9	**24.6**	**32.9**	**18.3**
2009	32.9	19.6	26.3	32.6	19.9	26.2	33.1	20.4	26.8	29.6	19.2	24.4	28.9	19.1	24.0	29.7	18.8	24.2	29.0	18.7	23.8	30.2	19.2	24.7	30.2	18.7	24.5	29.4	19.0	24.2	29.8	19.2	24.5	29.8	18.8	24.3	**24.8**	**33.1**	**18.7**
2010	31.2	19.4	25.3	31.2	20.4	25.8	30.1	19.5	24.8	29.9	20.0	24.9	30.0	19.8	24.9	29.0	19.2	24.1	28.2	18.9	23.6	28.6	18.9	23.8	29.0	18.6	23.8	29.2	18.6	23.9	30.7	19.2	25.0	30.9	19.9	25.4	**24.6**	**31.2**	**18.6**
2011	32.5	19.0	25.7	33.9	19.6	26.8	32.2	19.9	26.1	31.8	19.4	25.6	29.4	19.3	24.3	28.7	19.2	24.0	29.1	18.5	23.8	28.0	18.3	23.2	28.3	18.5	23.4	28.9	18.8	23.8	28.4	18.7	23.6	30.3	18.9	24.6	**24.6**	**33.9**	**18.3**
2012	33.3	18.8	26.0	34.0	19.9	27.0	34.1	20.9	27.5	29.5	19.5	24.5	28.8	18.8	23.8	28.5	18.9	23.7	27.6	18.5	23.1	28.2	18.4	23.3	29.1	18.3	23.7	30.1	19.0	24.6	29.7	18.6	24.1	29.5	18.7	24.1	**24.6**	**34.1**	**18.3**
2013	33.7	18.7	26.2	34.3	19.4	26.8	33.5	19.7	26.6	29.9	19.6	24.7	29.5	18.8	24.2	32.1	19.3	25.7	30.6	18.1	24.4	29.6	18.5	24.1	29.8	18.5	24.2	29.6	18.5	24.0	30.4	18.8	24.6	31.6	18.7	25.2	**25.1**	**34.3**	**18.1**
Average	**32.1**	**18.5**	**25.3**	**33.0**	**19.2**	**26.1**	**32.4**	**19.5**	**26.0**	**30.3**	**19.3**	**24.8**	**29.5**	**18.9**	**24.2**	**29.1**	**18.5**	**23.8**	**28.6**	**18.2**	**23.4**	**28.9**	**18.1**	**23.5**	**30.0**	**18.2**	**24.1**	**29.9**	**18.4**	**24.2**	**30.1**	**18.3**	**24.2**	**31.4**	**18.4**	**24.9**	**24.5**	**33.6**	**17.7**

Soroti Monthly Rainfall Totals (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	5.9	7.9	40.1	169.6	142.2	186.7	77.4	117.0	90.3	201.1	121.5	86.1	**1245.8**
1993	25.9	29.1	12.7	153.3	159.2	198.3	43.2	110.9	83.4	140.9	126.8	28.6	**1112.3**
1994	6.1	0.0	126.4	147.5	139.9	176.9	123.3	206.6	130.3	113.4	181.9	19.9	**1372.2**
1995	0.0	36.8	139.2	253.9	109.6	74.4	182.3	87.8	116.6	257.9	89.3	52.8	**1400.6**
1996	76.0	82.7	171.4	211.5	349.0	136.0	101.7	243.7	270.1	32.2	79.3	16.7	**1770.3**
1997	23.0	0.0	42.8	251.8	23.0	65.3	112.3	172.2	7.8	200.6	230.5	104.3	**1233.6**
1998	48.3	56.3	19.7	107.7	259.3	86.9	284.7	132.0	55.1	130.3	167.8	2.3	**1350.4**
1999	88.7	0.1	176.6	113.3	159.8	44.4	146.9	169.2	169.2	138.2	35.8	37.3	**1279.5**
2000	0.2	12.6	49.2	118.2	151.2	102.6	104.3	235.1	169.9	137.6	57.9	26.0	**1164.8**
2001	56.7	3.9	188.2	180.2	237.6	171.4	185.8	165.4	91.7	350.5	89.9	66.5	**1787.8**
2002	16.1	4.6	58.1	137.6	195.2	66.1	34.2	104.2	171.4	212.0	117.7	122.3	**1239.5**
2003	52.5	48.0	31.3	219.2	188.4	301.8	83.7	183.9	171.0	73.8	106.6	19.0	**1479.2**
2004	78.9	50.0	44.5	137.6	119.9	98.6	51.4	129.1	121.1	50.7	137.9	35.0	**1054.7**
2005	14.5	17.1	90.1	178.8	217.1	78.9	208.8	147.1	174.0	88.1	32.5	0.0	**1247.0**
2006	11.3	28.9	154.0	165.5	111.1	34.9	199.6	100.9	161.6	163.1	121.4	64.9	**1317.2**
2007	64.1	59.2	20.1	181.4	136.7	79.4	144.0	223.1	144.9	61.6	77.3	3.6	**1195.4**
2008	8.7	31.1	158.5	163.7	63.6	76.1	157.0	182.1	121.3	124.3	187.6	0.0	**1274.0**
2009	96.9	5.1	38.2	123.5	108.3	35.7	83.5	188.9	190.9	177.8	92.3	157.7	**1298.8**
2010	57.0	94.0	233.6	96.3	227.8	192.1	212.2	121.7	117.0	203.8	42.5	18.5	**1616.5**
2011	19.5	9.7	99.2	96.3	151.7	84	116.3	311.3	167.4	173.7	117.2	40.2	**1386.5**
2012	0.0	3.3	9.8	304.8	130.2	105.4	141.4	207.0	209.2	62.7	119.5	107.4	**1400.7**
2013	67.4	24.0	179.3	139.0	140.2	97.7	83.7	134.7	122.6	119.8	109.3	33.8	**1251.5**
Average	**37.2**	**27.5**	**94.7**	**165.9**	**160.0**	**113.3**	**130.8**	**167.0**	**138.9**	**146.1**	**111.0**	**47.4**	1339.9
Min	**0.0**	**0.0**	**9.8**	**96.3**	**23.0**	**34.9**	**34.2**	**87.8**	**7.8**	**32.2**	**32.5**	**0.0**	1054.7
Max	**96.9**	**94.0**	**233.6**	**304.8**	**349.0**	**301.8**	**284.7**	**311.3**	**270.1**	**350.5**	**230.5**	**157.7**	1787.8

Soroti Average Monthly Relative Humidity (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	47.5	43.0	59.5	63.0	68.0	66.5	66.5	64.5	60.5	61.5	53.0	40.0	**57.8**
1993	44.5	50.0	66.5	68.0	70.5	70.0	66.0	66.0	63.0	60.5	70.0	63.5	**63.2**
1994	56.0	63.0	56.5	60.5	67.5	73.0	71.5	71.0	70.0	60.0	57.0	49.0	**62.9**
1995	53.0	53.0	64.5	62.0	68.5	66.0	66.5	70.0	65.5	70.5	58.5	52.5	**62.5**
1996	57.0	58.0	56.0	70.0	67.5	63.0	65.5	62.0	64.5	66.0	69.0	65.5	**63.7**
1997	57.5	57.0	61.0	61.0	68.5	71.5	70.0	68.5	62.5	63.0	60.0	56.0	**63.0**
1998	49.0	49.0	55.5	62.0	71.5	69.5	67.5	71.0	71.0	67.5	71.0	57.5	**63.5**
1999	38.9	45.9	49.7	71.1	70.5	68.2	72.4	71.7	67.3	60.6	62.5	65.0	**62.0**
2000	42.5	49.5	51.0	61.0	66.0	64.5	68.0	69.0	62.0	62.5	60.0	57.5	**59.5**
2001	58.0	48.5	59.5	69.0	69.0	70.5	70.5	70.0	64.5	65.5	64.5	49.5	**63.3**
2002	54.0	45.0	62.0	64.5	68.5	66.0	59.5	63.0	58.5	65.0	66.0	59.5	**61.0**
2003	53.5	46.5	55.0	61.5	69.5	69.0	71.5	70.0	65.0	59.5	61.5	55.5	**61.5**
2004	58.0	53.0	59.0	72.5	67.5	66.5	65.0	68.5	67.5	58.5	61.0	54.0	**62.6**
2005	42.0	41.5	39.5	58.5	61.0	62.5	70.0	73.0	67.0	68.5	61.0	49.0	**57.8**
2006	42.5	36.5	60.0	58.5	64.5	69.5	66.5	73.5	65.5	66.0	64.0	52.0	**59.9**
2007	42.5	37.5	55.0	61.0	67.0	70.5	74.5	75.5	66.0	65.0	64.5	47.0	**60.5**
2008	50.0	33.0	49.5	68.5	62.0	64.5	65.5	72.0	66.5	65.5	63.0	49.5	**59.1**
2009	55.0	52.5	56.0	58.0	70.5	69.0	70.0	71.0	69.5	67.5	57.0	42.5	**61.5**
2010	56.5	44.5	60.0	64.0	71.0	67.5	74.5	72.5	72.0	66.0	67.5	57.5	**64.5**
2011	45.5	48.0	51.0	62.0	62.0	75.0	74.0	74.5	74.0	69.0	65.0	53.5	**62.8**
2012	52.5	42.5	56.0	64.5	61.5	69.5	74.5	73.0	70.0	68.5	61.0	49.5	**61.9**
2013	45.0	47.0	63.0	67.5	67.0	69.0	73.5	67.5	68.0	69.0	63.5	59.0	**63.3**
Average	**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**

Soroti Average Monthly Wind Speed (m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	3.9	3.8	2.9	2.5	1.7	2.0	2.0	2.0	2.4	2.1	3.0	2.9	**2.6**
1993	3.0	3.1	2.5	2.5	2.8	2.7	2.0	2.3	2.3	2.2	2.2	2.7	**2.5**
1994	2.6	2.7	2.1	2.6	2.4	2.3	2.4	1.9	2.3	2.5	2.8	2.9	**2.4**
1995	2.9	2.8	2.8	2.2	2.5	2.4	2.4	2.4	2.2	2.7	2.8	2.8	**2.6**
1996	3.0	2.9	3.2	2.7	2.6	2.5	2.6	3.0	2.7	2.5	2.5	2.9	**2.8**
1997	3.6	3.6	2.7	2.4	2.2	1.9	2.2	2.3	2.3	2.2	2.5	2.5	**2.5**
1998	3.2	3.8	2.6	2.4	2.2	2.0	2.1	2.4	2.2	2.3	2.3	2.5	**2.5**
1999	3.0	3.4	2.5	2.7	2.3	2.4	2.5	2.9	2.9	2.9	3.4	3.4	**2.8**
2000	3.2	3.2	3.4	2.4	2.6	2.2	2.3	2.5	2.6	3.0	3.6	3.4	**2.9**
2001	2.9	2.9	3.8	3.3	3.1	2.8	3.0	2.7	2.5	3.1	2.5	3.0	**3.0**
2002	2.6	3.1	2.8	3.5	2.3	2.7	2.7	2.4	2.1	2.3	2.8	2.7	**2.7**
2003	3.3	2.7	2.6	2.6	2.3	2.6	2.7	2.0	2.5	2.3	3.1	2.5	**2.6**
2004	2.4	3.0	2.6	2.8	2.5	2.2	2.1	2.2	2.0	3.3	4.1	3.7	**2.8**
2005	3.1	3.6	3.3	2.6	2.2	1.9	2.0	1.8	2.2	2.2	2.4	2.9	**2.5**
2006	2.4	2.4	2.2	3.0	2.2	1.6	2.2	2.2	2.2	2.5	2.2	2.2	**2.3**
2007	2.7	2.7	2.4	3.0	2.4	1.9	2.4	2.2	2.2	2.4	2.2	2.7	**2.4**
2008	3.0	2.7	2.4	2.7	2.2	1.9	2.4	2.2	2.2	2.5	2.3	2.4	**2.4**
2009	3.0	2.7	2.4	2.7	2.4	2.4	1.9	1.9	1.9	1.8	2.2	1.9	**2.3**
2010	2.7	2.4	2.2	2.7	2.2	2.2	1.9	2.2	1.9	1.9	2.2	2.5	**2.2**
2011	2.4	2.4	2.3	2.7	2.2	2.2	2.2	2.2	2.2	2.2	2.2	1.9	**2.2**
2012	2.7	2.7	2.8	2.7	1.9	2.2	2.2	2.2	2.4	2.4	2.2	2.4	**2.4**
2013	2.7	2.7	2.2	2.3	2.1	2.3	2.5	2.5	2.4	2.6	2.9	2.5	**2.5**
Average	**2.9**	**3.0**	**2.7**	**2.7**	**2.3**	**2.2**	**2.3**	**2.3**	**2.3**	**2.5**	**2.6**	**2.7**	**2.5**

Jinja Average Monthly Maximum, Minimum and Average Temperature (oC)

	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Annual Average		
Year	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Max	Min	Ave	Average	Max	Min
1992	29.8	16.3	23.1	30.3	18.3	24.3	31.7	17.5	24.6	28.3	17.7	23.0	27.8	17.4	22.6	27.2	16.2	21.7	26.9	15.3	21.1	27.2	15.0	21.1	28.3	15.8	22.1	28.2	16.2	22.2	28.2	16.0	22.1	27.8	15.7	21.7	**22.5**	**31.7**	**15.0**
1993	28.3	16.5	22.4	28.9	16.0	22.4	28.9	17.2	23.1	28.6	17.8	23.2	27.0	17.0	22.0	26.6	17.6	22.1	27.2	16.3	21.7	28.1	16.5	22.3	28.9	16.6	22.8	29.3	17.5	23.4	28.9	17.5	23.2	29.5	17.5	23.5	**22.7**	**29.5**	**16.0**
1994	30.0	17.1	23.6	30.4	17.7	24.0	28.3	17.6	22.9	27.8	17.6	22.7	26.6	16.8	21.7	26.5	16.7	21.6	26.1	16.2	21.2	27.2	16.0	21.6	28.4	18.0	23.2	28.3	16.8	22.6	27.1	17.3	22.2	28.1	16.8	22.5	**22.5**	**30.4**	**16.0**
1995	29.8	16.3	23.1	29.3	17.5	23.4	28.8	18.1	23.4	28.0	18.6	23.3	27.0	18.2	22.6	27.1	16.9	22.0	26.3	16.0	21.2	27.5	15.8	21.7	28.2	17.2	22.7	27.9	16.4	22.1	28.2	17.5	22.9	28.7	16.7	22.7	**22.6**	**29.8**	**15.8**
1996	28.4	17.1	22.8	27.9	17.3	22.6	28.2	17.8	23.0	27.5	17.7	22.6	27.1	17.8	22.4	26.0	15.8	20.9	26.1	16.2	21.1	27.6	15.5	21.6	27.8	16.4	22.1	28.4	17.0	22.7	27.8	16.8	22.3	28.7	17.0	22.8	**22.2**	**28.7**	**15.5**
1997	28.7	16.8	22.8	30.6	16.8	23.7	31.0	18.0	24.5	26.6	17.6	22.1	26.5	17.8	22.2	27.4	17.8	22.6	27.0	17.0	22.0	28.4	17.0	22.7	31.3	17.6	24.5	28.4	17.5	22.9	26.7	17.1	21.9	26.6	17.5	22.0	**22.8**	**31.3**	**16.8**
1998	27.6	16.5	22.0	29.1	18.0	23.6	29.6	18.6	24.1	27.9	16.8	22.3	27.3	17.5	22.4	27.0	17.1	22.0	26.8	17.1	21.9	27.1	17.1	22.1	28.5	17.7	23.1	27.9	17.2	22.5	29.3	17.7	23.5	30.6	16.9	23.8	**22.8**	**30.6**	**16.5**
1999	29.0	17.1	23.0	31.9	17.2	24.5	28.0	17.9	22.9	27.2	18.5	22.8	27.0	17.5	22.2	27.4	17.0	22.2	27.6	16.2	21.9	27.6	17.1	22.4	27.9	17.0	22.5	27.3	17.5	22.4	28.0	17.5	22.7	28.2	17.3	22.7	**22.7**	**31.9**	**16.2**
2000	29.6	16.5	23.0	29.4	16.6	23.0	29.4	18.2	23.8	28.1	18.3	23.2	27.9	18.0	22.9	27.9	17.4	22.6	28.0	17.0	22.5	28.0	16.5	22.2	28.6	17.1	22.9	28.3	17.6	22.9	27.6	17.8	22.7	27.5	17.6	22.6	**22.9**	**29.6**	**16.5**
2001	27.8	16.5	22.1	29.4	17.9	23.7	29.0	17.8	23.4	27.7	17.9	22.8	27.0	17.8	22.4	26.7	16.6	21.7	26.5	16.4	21.5	27.4	16.5	21.9	27.9	16.7	22.3	27.9	17.2	22.6	27.9	17.1	22.5	29.2	17.1	23.1	**22.5**	**29.4**	**16.4**
2002	27.5	17.1	22.3	30.7	17.2	24.0	28.4	17.8	23.1	28.0	17.4	22.7	27.5	17.3	22.4	27.7	16.2	22.0	28.6	15.8	22.2	28.5	16.0	22.2	29.2	16.3	22.8	29.2	16.6	22.9	27.9	16.5	22.2	28.3	16.9	22.6	**22.6**	**30.7**	**15.8**
2003	29.2	16.9	23.1	31.7	17.6	24.7	30.3	18.3	24.3	28.4	18.3	23.4	27.7	18.6	23.1	27.0	17.3	22.2	26.9	16.7	21.8	28.0	17.0	22.5	28.9	17.2	23.1	29.1	18.0	23.6	28.8	17.5	23.2	28.5	16.3	22.4	**23.1**	**31.7**	**16.3**
2004	29.2	17.3	23.2	29.4	17.2	23.3	29.6	18.6	24.1	27.6	18.0	22.8	28.2	17.5	22.9	27.6	18.0	22.8	28.4	16.4	22.4	28.4	17.0	22.7	28.3	17.0	22.7	28.9	17.5	23.2	28.2	16.8	22.5	28.7	16.9	22.8	**23.0**	**29.6**	**16.4**
2005	29.5	17.0	23.3	31.8	17.2	24.5	29.4	18.2	23.8	28.7	18.3	23.5	27.4	17.7	22.6	27.0	17.7	22.4	27.7	16.2	22.0	28.4	16.4	22.4	27.8	16.6	22.2	29.0	17.1	23.1	30.0	17.0	23.5	27.0	16.0	21.5	**22.9**	**31.8**	**16.0**
2006	31.3	17.3	24.3	30.3	17.5	23.9	28.0	18.7	23.4	27.5	17.8	22.7	27.0	17.3	22.2	28.0	17.1	22.6	27.2	16.7	22.0	27.9	15.9	21.9	28.5	16.9	22.7	29.0	17.7	23.4	27.0	17.3	22.2	27.1	17.0	22.1	**22.8**	**31.3**	**15.9**
2007	28.3	17.1	22.7	28.7	17.5	23.1	29.8	17.4	23.6	28.7	18.0	23.4	27.8	17.9	22.9	26.5	16.8	21.7	26.7	16.3	21.5	27.1	16.5	21.8	27.7	16.7	22.2	28.2	16.7	22.5	28.3	16.6	22.5	29.1	16.2	22.7	**22.5**	**29.8**	**16.2**
2008	29.8	17.2	23.5	29.1	17.0	23.1	27.8	17.0	22.4	27.8	17.0	22.4	27.7	17.5	22.6	26.8	16.4	21.6	26.7	15.7	21.2	27.4	16.3	21.9	28.8	16.6	22.7	28.2	16.9	22.6	28.7	16.4	22.6	30.0	16.1	23.1	**22.5**	**30.0**	**15.7**
2009	29.5	16.9	23.2	29.0	17.1	23.1	29.9	17.7	23.8	27.6	17.8	22.7	27.5	17.2	22.4	28.1	16.5	22.3	27.8	16.0	21.9	28.9	17.8	23.4	28.9	18.0	23.5	28.0	18.0	23.0	28.0	17.8	22.9	27.8	17.7	22.8	**22.9**	**29.9**	**16.0**
2010	29.5	17.5	23.5	28.8	18.2	23.5	28.4	17.9	23.2	28.3	18.4	23.4	27.8	17.9	22.9	27.6	17.1	22.4	27.4	16.6	22.0	27.7	16.3	22.0	28.2	16.7	22.5	29.2	16.5	22.9	29.4	16.4	22.9	28.4	15.1	21.8	**22.7**	**29.5**	**15.1**
2011	30.0	15.1	22.6	29.9	15.4	22.7	28.7	16.3	22.5	28.3	16.7	22.5	27.3	16.4	21.9	27.7	15.5	21.6	27.9	15.0	21.5	26.8	15.3	21.1	27.2	16.2	21.7	27.6	17.8	22.7	27.4	17.7	22.6	27.6	17.6	22.6	**22.1**	**30.0**	**15.0**
2012	31.5	16.0	23.7	31.4	17.0	24.2	29.2	17.9	23.5	27.4	17.8	22.6	27.6	17.9	22.8	27.4	17.9	22.6	26.7	16.3	21.5	27.4	16.6	22.0	28.4	17.1	22.7	28.5	17.9	23.2	27.9	17.3	22.6	27.7	17.5	22.6	**22.8**	**31.5**	**16.0**
2013	29.1	22.3	25.7	29.7	16.8	23.3	28.9	18.2	23.5	27.5	18.0	22.8	27.8	17.8	22.8	27.6	17.1	22.3	27.8	15.5	21.6	27.4	16.6	22.0	28.2	16.6	22.4	28.3	17.2	22.7	28.2	16.9	22.5	28.2	16.8	22.5	**22.8**	**29.7**	**15.5**
Average	**29.2**	**17.0**	**23.1**	**29.9**	**17.2**	**23.6**	**29.1**	**17.9**	**23.5**	**27.9**	**17.8**	**22.8**	**27.4**	**17.6**	**22.5**	**27.2**	**16.9**	**22.1**	**27.2**	**16.2**	**21.7**	**27.7**	**16.4**	**22.1**	**28.5**	**16.9**	**22.7**	**28.4**	**17.2**	**22.8**	**28.2**	**17.1**	**22.6**	**28.3**	**16.8**	**22.6**	**22.7**	**30.4**	**15.9**

Jinja Monthly Rainfall Totals (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	0.0	7.2	34.2	100.7	109.8	128.3	66.8	31.5	128.1	281.9	152.8	79.4	**1120.7**
1993	34.3	28.3	98.4	98.1	120.9	94.9	17.5	91.0	124.5	98.1	87.8	129.2	**1023.0**
1994	45.0	22.5	84.0	180.0	165.0	77.5	25.5	45.1	61.5	94.2	147.2	39.5	**987.0**
1995	9.5	27.5	100.2	97.6	86.0	45.1	97.0	82.8	233.0	209.6	112.4	82.7	**1183.4**
1996	185.8	70.8	114.3	125.3	101.6	127.0	52.1	56.1	91.3	95.3	71.9	34.2	**1125.7**
1997	46.7	0.0	138.0	234.5	0.0	79.9	79.0	106.5	56.5	227.0	262.0	292.0	**1522.1**
1998	186.0	117.0	177.0	129.0	126.0	128.0	37.0	137.0	109.0	236.9	62.0	17.0	**1461.9**
1999	192.3	27.2	246.3	252.7	199.2	49.9	49.3	65.6	117.5	133.5	139.6	144.5	**1617.6**
2000	31.4	37.0	76.3	133.7	108.7	32.3	28.3	117.7	117.1	129.6	113.6	121.8	**1047.5**
2001	90.9	58.3	115.3	165.2	207.7	139.3	48.5	149.6	160.7	218.7	243.9	51.8	**1649.9**
2002	89.5	26.7	178.7	419.0	133.3	5.2	16.4	72.3	54.8	83.3	221.6	148.3	**1449.1**
2003	129.1	20.2	118.4	108.9	149.4	163.5	9.8	69.0	70.8	210.8	110.8	144.0	**1304.7**
2004	89.8	55.9	91.0	281.4	44.0	12.4	47.1	132.1	175.5	117.8	245.7	126.8	**1419.5**
2005	35.5	35.2	112.0	202.2	182.4	31.6	150.8	210.4	100.1	118.7	71.0	9.8	**1259.7**
2006	141.7	111.8	102.3	144.1	137.3	49.0	110.1	100.0	82.4	118.7	397.6	170.6	**1665.6**
2007	75.7	54.2	85.7	159.8	158.5	140.9	94.3	76.6	76.4	146.3	75.8	34.3	**1178.5**
2008	112.7	112.7	48.6	153.1	240.2	96.5	25.5	82.6	67.9	134.0	154.1	91.8	**1319.7**
2009	73.4	104.4	68.6	166.4	216.4	25.6	56.3	58.2	99.8	147.4	197.9	97.9	**1312.3**
2010	20.2	68.8	177.6	251.7	74.5	85.3	87.5	52.5	74.3	87.6	97.4	102.4	**1179.9**
2011	60.0	27.2	201.2	132.8	130.6	92.5	59.8	159.6	191.6	331.4	177.3	55.3	**1619.3**
2012	6.4	71.9	138.5	107.9	81.0	155.4	98.2	170.7	71.0	142.2	142.8	140.7	**1326.7**
2013	77.5	48.1	191.8	118.8	123.6	72.4	25.1	164.5	219.8	130.1	111.0	74.8	**1357.5**
Average	**73.8**	**59.5**	**121.9**	**181.8**	**142.0**	**78.7**	**61.3**	**115.4**	**111.6**	**151.2**	**168.6**	**97.9**	**1363.6**
Min	**6.4**	**20.2**	**48.6**	**107.9**	**44**	**5.2**	**9.8**	**52.53**	**54.8**	**83.3**	**71**	**9.8**	**1047.5**
Max	**141.7**	**112.7**	**201.2**	**419**	**240.2**	**163.5**	**150.8**	**210.4**	**219.8**	**331.4**	**397.6**	**170.6**	**1665.6**

Jinja Average Monthly Relative Humidity (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	59.7	56.6	53.4	70.3	70.6	72.5	72.7	73.3	68.0	69.4	66.5	71.1	67.0
1993	61.7	64.3	62.9	63.6	74.8	73.0	68.4	65.6	61.2	59.4	61.5	57.9	64.5
1994	60.2	61.6	65.9	68.4	74.7	75.7	75.8	69.6	66.2	65.9	74.1	65.9	68.7
1995	61.1	63.8	64.8	71.6	75.1	74.3	76.9	67.3	69.7	71.9	68.1	63.5	69.0
1996	67.4	72.0	70.3	71.9	75.0	78.2	76.4	71.0	73.0	65.3	71.3	64.0	71.3
1997	65.5	60.3	58.1	73.9	74.1	69.2	67.1	63.4	55.3	66.8	76.4	75.2	67.1
1998	72.2	68.1	68.7	74.2	74.2	71.6	68.7	68.7	69.0	68.9	63.3	55.6	68.6
1999	65.8	48.2	70.4	73.1	75.4	67.3	66.4	66.7	65.4	74.8	66.5	67.7	67.3
2000	60.0	57.0	63.0	70.5	73.0	66.5	67.5	67.5	66.5	66.5	69.5	72.0	66.6
2001	67.5	65.0	65.0	72.5	73.0	71.5	74.0	72.5	71.0	73.0	68.5	66.0	70.0
2002	71.0	58.0	70.0	70.5	72.5	68.5	67.0	69.5	67.5	67.5	73.5	69.0	68.7
2003	68.0	61.0	66.0	73.0	74.5	74.5	73.5	75.5	69.5	68.5	69.0	67.0	70.0
2004	65.0	61.0	65.5	72.0	71.5	65.5	63.5	69.0	68.0	66.0	66.0	65.0	66.5
2005	60.5	50.0	67.5	68.0	73.5	72.0	68.0	68.5	69.5	67.5	64.0	52.0	65.1
2006	52.0	59.0	71.0	72.0	76.0	71.5	68.5	68.5	66.5	65.5	76.0	73.0	68.3
2007	71.5	68.5	62.5	67.5	72.5	74.5	74.5	74.5	73.0	66.5	65.5	50.0	68.4
2008	62.0	66.5	67.0	70.5	72.0	73.0	76.0	73.0	68.5	71.0	68.5	62.0	69.2
2009	64.0	68.0	64.0	71.5	73.5	67.5	68.5	67.5	67.5	70.0	73.5	73.0	69.0
2010	67.0	70.5	69.0	74.5	74.0	75.0	72.5	74.0	76.0	69.5	66.5	69.0	71.5
2011	61.5	63.0	67.5	69.5	76.0	74.5	71.0	76.0	77.0	70.5	75.0	71.5	71.1
2012	65.8	48.2	70.4	73.1	75.4	67.3	66.4	66.7	65.4	74.8	66.5	67.7	67.3
2013	67.9	61.5	69.3	71.1	72.7	68.4	67.5	71.3	71.1	70.6	67.6	68.0	68.9
Average	**64.4**	**61.5**	**66.0**	**71.1**	**73.8**	**71.4**	**70.5**	**70.0**	**68.4**	**68.6**	**69.0**	**65.7**	**68.4**

Jinja Average Monthly Wind Speed (m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	4.1	4.1	3.8	3.5	3.5	3.5	3.5	3.2	3.5	3.8	3.0	3.0	**3.5**
1993	4.3	3.8	3.2	3.5	3.0	3.5	2.7	3.2	3.5	3.8	3.2	3.2	**3.4**
1994	4.6	3.8	3.0	3.2	3.2	3.2	2.7	3.0	3.2	3.2	3.5	2.4	**3.3**
1995	3.5	3.8	3.8	3.2	3.0	3.2	3.2	3.2	3.2	3.2	2.7	3.5	**3.3**
1996	3.5	4.6	4.9	4.3	4.6	3.5	3.5	3.5	3.5	3.2	3.5	3.2	**3.8**
1997	2.8	2.6	2.9	2.8	2.7	2.6	2.8	2.6	2.7	2.7	2.7	2.2	**2.7**
1998	3.0	3.1	3.0	2.9	2.9	2.1	2.4	2.6	2.5	2.6	2.6	2.1	**2.6**
1999	2.3	3.1	2.9	2.6	2.6	2.6	2.3	2.7	2.5	2.4	2.3	2.7	**2.6**
2000	2.8	3.8	3.6	3.2	3.3	3.3	3.5	3.9	3.4	3.3	3.8	3.8	**3.5**
2001	3.4	4.2	3.4	3.7	3.3	3.5	3.3	3.8	4.1	3.5	3.0	3.0	**3.5**
2002	3.8	4.9	3.8	4.3	4.1	4.1	3.5	3.8	4.1	3.8	3.2	3.0	**3.8**
2003	3.0	3.8	4.1	4.1	4.3	3.2	3.8	4.3	4.3	3.5	3.5	3.8	**3.8**
2004	3.2	4.1	3.5	4.1	4.1	4.1	3.8	3.8	3.8	3.0	3.0	2.7	**3.6**
2005	3.1	4.0	3.5	3.3	2.6	2.7	2.6	2.9	3.6	3.0	3.4	2.4	**3.1**
2006	3.2	3.5	3.2	3.0	2.5	2.2	2.3	3.1	3.4	3.0	3.5	4.1	**3.1**
2007	3.1	3.4	3.3	2.9	2.7	3.2	2.3	2.3	2.9	3.1	3.0	2.7	**2.9**
2008	3.0	3.8	3.7	3.1	2.5	1.9	2.3	2.2	2.8	2.7	2.7	2.6	**2.8**
2009	2.8	3.3	3.6	2.8	2.4	3.1	3.1	2.2	2.9	3.4	2.9	2.7	**2.9**
2010	2.9	3.8	3.7	3.3	2.2	2.2	2.3	2.5	2.8	2.7	2.5	2.6	**2.8**
2011	3.6	4.6	2.8	2.6	3.1	2.6	3.0	3.3	5.1	3.4	3.5	3.1	**3.4**
2012	2.7	3.0	2.2	1.9	2.2	1.9	2.2	2.4	2.7	2.7	2.4	2.7	**2.4**
2013	2.7	2.9	2.6	2.7	2.6	2.6	2.4	2.7	2.2	2.3	2.4	2.5	**2.5**
Average	**3.2**	**3.7**	**3.4**	**3.2**	**3.1**	**2.9**	**2.9**	**3.1**	**3.3**	**3.1**	**3.0**	**2.9**	**3.2**

Entebbe Average Monthly Maximum, Minimum and Average Temperature (oC)

	Jan			Feb			Mar			Apr			May			Jun			Jul			Aug			Sep			Oct			Nov			Dec			Annual Average		
Year	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Max**	**Min**	**Ave**	**Average**	**Max**	**Min**
1992	27.0	18.1	22.6	26.7	17.9	22.3	26.8	18.5	22.6	26.2	18.3	22.2	25.6	18.3	21.9	25.8	18.1	22.0	25.5	17.2	21.3	25.8	17.1	21.5	26.7	17.5	22.1	26.5	17.5	22.0	26.4	18.4	22.4	27.1	18.4	22.7	**22.1**	**27.1**	**17.1**
1993	26.5	18.6	22.6	26.7	18.6	22.7	26.5	18.6	22.6	26.1	18.7	22.4	25.2	18.8	22.0	24.9	18.5	21.7	25.4	17.4	21.4	25.6	17.3	21.5	26.5	17.6	22.1	27.3	18.3	22.8	26.5	18.8	22.7	27.0	19.0	23.0	**22.3**	**27.3**	**17.3**
1994	27.3	19.0	23.2	27.7	19.3	23.5	26.8	18.5	22.6	26.2	19.1	22.7	25.1	16.8	21.0	25.0	16.7	20.9	24.4	16.2	20.3	25.8	17.2	21.5	26.4	17.2	21.8	25.8	17.7	21.8	25.3	18.1	21.7	25.9	18.8	22.4	**21.9**	**27.7**	**16.2**
1995	27.3	19.3	23.3	26.5	19.4	23.0	26.4	19.3	22.9	26.2	20.1	23.2	25.4	18.9	22.2	25.6	18.5	22.1	24.5	17.6	21.1	25.5	18.8	22.2	26.0	17.5	21.8	25.6	17.6	21.6	26.1	17.5	21.8	26.8	18.6	22.7	**22.3**	**27.3**	**17.5**
1996	25.9	18.2	22.1	26.8	18.9	22.9	25.9	19.0	22.5	25.5	18.8	22.2	25.3	18.6	22.0	24.8	18.0	21.4	25.0	17.3	21.2	25.8	17.4	21.6	26.0	17.6	21.8	26.9	17.9	22.4	25.4	18.0	21.7	26.2	18.5	22.3	**22.0**	**26.9**	**17.3**
1997	26.8	18.2	22.5	29.5	18.3	23.9	27.9	19.3	23.6	27.8	17.0	22.4	25.7	18.7	22.2	25.4	18.7	22.1	26.0	18.1	22.1	27.7	18.1	22.9	30.4	18.8	24.6	26.9	18.2	22.6	25.9	18.1	22.0	26.1	18.0	22.1	**22.7**	**30.4**	**17.0**
1998	26.0	18.8	22.4	28.1	19.8	24.0	28.4	19.9	24.2	27.0	19.9	23.5	27.1	19.8	23.5	27.0	18.9	23.0	26.6	18.5	22.6	27.2	18.2	22.7	28.2	18.2	23.2	27.9	18.5	23.2	26.9	18.8	22.9	30.6	18.8	24.7	**23.3**	**30.6**	**18.2**
1999	26.9	18.5	22.7	29.0	19.3	24.2	26.2	18.8	22.5	25.8	18.8	22.3	25.6	18.7	22.1	25.9	18.6	22.2	24.9	17.5	21.2	25.8	17.9	21.8	26.3	17.8	22.0	26.1	17.6	21.9	26.5	17.8	22.2	26.4	18.3	22.4	**22.3**	**29.0**	**17.5**
2000	27.8	18.6	23.2	27.9	18.7	23.3	26.3	19.5	22.9	26.1	18.9	22.5	26.1	18.2	22.2	25.8	18.6	22.2	26.4	18.3	22.4	26.2	17.7	22.0	26.6	18.0	22.3	25.9	18.3	22.1	25.6	18.5	22.1	25.6	18.6	22.1	**22.4**	**27.9**	**17.7**
2001	26.0	18.4	22.2	27.2	19.3	23.3	26.1	18.6	22.3	25.8	18.9	22.3	25.6	18.9	22.3	25.1	18.3	21.7	25.2	18.0	21.6	26.2	18.2	22.2	26.0	17.7	21.8	26.4	18.4	22.4	26.4	18.3	22.4	26.5	18.9	22.7	**22.3**	**27.2**	**17.7**
2002	26.1	19.1	22.6	27.0	18.3	22.7	26.1	19.4	22.8	26.1	19.2	22.7	25.7	19.8	22.8	25.6	18.6	22.1	25.9	18.4	22.2	25.6	18.5	22.1	26.5	17.6	22.1	27.3	18.3	22.8	26.5	18.8	22.7	27.0	19.0	23.0	**22.5**	**27.3**	**17.6**
2003	26.7	19.2	23.0	27.8	18.6	23.2	27.5	19.4	23.5	26.2	19.1	22.7	25.9	19.4	22.7	24.7	18.6	21.7	24.8	17.9	21.4	16.0	18.2	17.1	26.4	18.0	22.2	27.1	18.8	23.0	27.0	18.7	22.9	27.1	18.3	22.7	**22.1**	**27.8**	**16.0**
2004	27.3	18.6	23.0	27.9	18.9	23.4	28.6	18.1	23.4	25.8	18.7	22.3	26.5	19.3	22.9	26.0	18.5	22.3	26.3	17.8	22.1	27.0	17.9	22.4	26.5	18.1	22.3	27.9	18.5	23.2	27.2	18.1	22.7	26.9	18.7	22.8	**22.7**	**28.6**	**17.8**
2005	27.5	18.9	23.2	29.5	19.9	24.7	27.8	19.6	23.7	27.5	19.7	23.6	25.7	18.7	22.2	26.0	19.1	22.5	25.6	17.8	21.7	25.8	18.1	22.0	26.4	18.2	22.3	26.6	18.3	22.5	27.1	18.8	23.0	28.1	18.7	23.4	**22.9**	**29.5**	**17.8**
2006	29.3	18.7	24.0	29.2	19.6	24.4	27.6	19.0	23.3	27.1	18.3	22.7	27.2	18.2	22.7	27.1	18.1	22.6	27.1	18.0	22.6	27.2	17.3	22.3	27.8	17.7	22.8	28.1	17.9	23.0	27.5	17.8	22.7	28.1	18.0	23.1	**23.0**	**29.3**	**17.3**
2007	26.7	19.1	22.9	26.8	19.3	23.1	27.9	19.8	23.9	26.3	19.4	22.9	25.6	19.4	22.5	24.9	18.4	21.7	24.7	18.3	21.5	25.1	18.2	21.7	25.7	17.7	21.7	26.6	18.3	22.5	26.9	18.6	22.8	27.4	18.5	23.0	**22.5**	**27.9**	**17.7**
2008	30.0	17.2	23.6	28.0	15.8	21.9	27.8	15.5	21.7	28.3	15.2	21.8	27.5	16.7	22.1	28.0	16.8	22.4	28.1	16.0	22.1	28.4	16.5	22.5	27.0	16.8	21.9	26.1	16.6	21.4	29.7	15.9	22.8	29.3	17.1	23.2	**22.3**	**30.0**	**15.2**
2009	26.6	18.9	22.8	26.6	19.2	22.9	27.0	19.5	23.3	26.0	18.9	22.5	25.8	19.1	22.5	26.3	19.4	22.9	26.0	18.4	22.2	26.2	18.7	22.5	25.6	18.5	22.1	26.5	18.5	22.5	26.6	19.0	22.8	25.4	18.7	22.1	**22.6**	**27.0**	**18.4**
2010	26.5	19.2	22.9	26.3	19.7	23.0	26.8	19.4	23.1	26.6	19.6	23.1	26.0	19.7	22.9	26.1	19.0	22.6	26.1	18.7	22.4	26.2	18.6	22.4	26.3	18.3	22.3	26.9	18.8	22.9	26.5	19.0	22.8	25.6	18.4	22.0	**22.7**	**26.9**	**18.3**
2011	26.6	18.7	22.7	27.1	19.3	23.2	26.4	19.1	22.8	26.5	19.7	23.1	25.8	19.4	22.6	26.2	18.9	22.6	26.7	18.3	22.5	25.1	18.1	21.6	25.9	18.1	22.0	25.6	18.1	21.9	25.7	18.5	22.1	25.4	18.9	22.2	**22.4**	**27.1**	**18.1**
2012	28.1	18.8	23.5	28.2	19.1	23.7	27.1	19.5	23.3	25.2	19.1	22.1	25.7	19.1	22.4	25.8	18.9	22.4	26.0	18.0	22.0	26.4	17.7	22.1	26.0	18.0	22.0	26.6	18.9	22.8	26.0	18.5	22.3	25.9	18.5	22.2	**22.5**	**28.2**	**17.7**
2013	26.4	19.2	22.8	26.8	19.4	23.1	26.8	19.1	22.9	26.0	18.9	22.5	27.1	19.0	23.1	26.0	19.4	22.7	26.6	18.2	22.4	25.1	18.3	21.7	26.0	18.2	22.1	26.1	18.2	22.2	26.3	18.6	22.4	26.0	18.2	22.1	**22.5**	**27.1**	**18.2**
Average	**27.1**	**18.7**	**22.9**	**27.6**	**18.9**	**23.3**	**27.0**	**19.0**	**23.0**	**26.4**	**18.8**	**22.6**	**26.0**	**18.8**	**22.4**	**25.8**	**18.5**	**22.1**	**25.8**	**17.8**	**21.8**	**25.7**	**17.9**	**21.8**	**26.6**	**17.9**	**22.2**	**26.7**	**18.1**	**22.4**	**26.5**	**18.3**	**22.4**	**26.8**	**18.5**	**22.7**	**22.5**	**28.1**	**17.4**

Entebbe Monthly Rainfall Totals (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1992	136.1	9.2	7.2	117.9	255.1	102.9	152.1	27.0	39.4	131.1	114.6	181.9	**1274.5**
1993	40.6	108.3	190.6	225.2	261.8	178.5	38.2	70.8	38.7	34.7	127.4	58.7	**1373.5**
1994	39.5	54.0	152.5	284.4	328.6	51.6	87.0	97.1	70.2	195.8	229.3	83.7	**1673.7**
1995	65.0	72.0	277.1	294.8	465.8	89.6	0.0	47.1	76.1	196.8	81.5	183.4	**1849.2**
1996	234.1	143.6	343.0	272.1	367.2	79.0	38.2	52.6	52.9	58.3	160.5	92.8	**1894.3**
1997	223.1	44.0	180.1	268.2	169.0	196.5	80.0	69.2	29.0	300.5	252.7	512.2	**2324.5**
1998	145.1	111.4	266.0	364.7	232.2	137.8	39.7	125.5	71.2	104.9	27.0	36.1	**1661.6**
1999	187.0	110.2	269.5	516.3	308.3	165.8	252.2	140.8	45.2	153.7	374.0	156.2	**2679.2**
2000	107.8	36.3	73.9	274.3	235.7	90.6	30.8	49.5	149.5	326.8	137.0	124.1	**1636.3**
2001	69.3	159.0	242.0	256.0	202.5	119.9	30.8	45.8	193.3	195.2	183.8	54.4	**1752.0**
2002	184.8	114.7	256.0	326.8	121.2	123.1	30.1	52.3	54.2	99.6	309.4	301.8	**1974.0**
2003	60.1	39.1	117.9	203.3	222.6	159.7	99.2	110.9	61.1	161.9	94.3	123.9	**1454.0**
2004	98.3	137.7	49.8	262.1	56.7	64.3	13.8	32.0	84.6	78.5	74.8	164.5	**1117.1**
2005	41.3	6.4	137.4	155.3	201.3	34.4	156.3	165.0	62.1	36.2	74.1	64.2	**1134.0**
2006	118.0	45.4	169.5	261.7	218.9	176.4	39.3	167.5	88.9	183.0	399.2	184.3	**2052.1**
2007	125.0	32.4	54.5	165.2	224.8	178.6	19.7	128.4	176.8	56.2	64.5	126.3	**1352.4**
2008	126.1	99.0	321.5	380.0	205.2	121.1	28.4	46.5	71.7	182.4	80.3	46.2	**1708.4**
2009	145.6	71.7	181.3	250.0	133.5	60.9	44.5	152.0	92.4	186.9	179.2	189.9	**1687.9**
2010	30.1	174.9	201.8	307.5	201.7	127.5	41.8	42.6	33.2	71.3	102.0	125.3	**1459.7**
2011	65.3	24.3	247	166.8	99.9	57.1	48.6	96.1	109.1	324.2	203	96.2	**1537.6**
2012	4.8	40.2	106.0	209.8	202.4	68.1	4.0	42.6	98.3	38.2	177.9	207.2	**1199.5**
2013	131.5	65.2	213.7	155.3	159.8	13.9	2.7	48.6	170.6	71.2	139.1	108.6	**1280.2**
Average	**108.1**	**77.2**	**184.5**	**259.9**	**221.6**	**109.0**	**58.1**	**82.3**	**84.9**	**144.9**	**163.0**	**146.5**	**1639.8**
Min	**4.8**	**6.4**	**7.2**	**117.9**	**56.7**	**13.9**	**0.0**	**27.0**	**29.0**	**34.7**	**27.0**	**36.1**	**1117.1**
Max	**234.1**	**174.9**	**343.0**	**516.3**	**465.8**	**196.5**	**252.2**	**167.5**	**193.3**	**326.8**	**399.2**	**512.2**	**2679.2**

Entebbe Average Monthly Relative Humidity (%)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	77.5	74.5	70.5	80.5	81.5	80.5	80.5	71.5	76.5	76.0	80.5	79.0	77.4
1993	78.0	76.0	75.0	78.5	78.5	79.0	78.5	76.0	77.0	80.0	78.5	80.0	77.9
1994	76.5	75.0	80.5	80.0	79.0	78.0	76.5	77.0	80.0	80.5	80.0	79.0	78.5
1995	78.5	70.0	73.0	79.0	76.5	82.0	77.0	79.0	78.5	76.0	76.0	76.0	76.8
1996	73.5	65.5	75.5	78.5	74.5	75.0	74.0	71.0	75.0	73.5	73.0	75.0	73.7
1997	72.5	69.5	74.0	76.0	80.5	76.0	76.5	76.5	77.5	75.0	74.0	73.0	75.1
1998	67.5	70.0	78.0	79.0	82.5	78.5	78.0	80.5	77.0	76.5	81.0	79.5	77.3
1999	75.0	77.0	72.5	79.0	79.5	79.0	80.0	81.0	78.5	74.0	74.5	71.0	76.8
2000	72.0	74.5	76.0	80.5	80.0	77.5	78.0	79.0	75.5	79.0	76.0	75.0	76.9
2001	75.0	70.0	73.0	79.0	76.5	82.0	77.0	79.0	77.0	77.0	78.5	78.5	76.9
2002	78.0	79.5	78.5	83.0	80.0	77.5	74.0	74.0	74.0	73.0	67.5	76.0	76.3
2003	72.5	72.0	75.0	75.0	81.0	75.5	76.5	79.0	79.0	84.0	78.5	79.0	77.3
2004	77.5	74.5	70.5	80.5	81.5	80.5	80.5	71.5	76.5	76.0	80.5	79.0	77.4
2005	65.5	64.5	68.0	72.5	74.0	71.5	71.0	73.5	69.0	72.0	73.5	74.0	70.8
2006	71.0	68.0	72.0	77.0	74.5	75.5	74.0	76.0	73.5	76.0	76.5	73.5	74.0
2007	74.0	69.5	75.5	75.5	74.5	73.5	69.5	71.0	71.5	71.0	76.5	70.0	72.7
2008	71.0	63.0	64.5	72.0	73.0	77.0	76.5	76.0	72.5	69.0	72.0	67.0	71.1
2009	70.0	61.5	67.0	73.0	69.0	67.0	61.5	72.0	72.5	74.5	71.0	71.0	69.2
2010	60.5	59.5	69.0	70.0	75.5	71.0	71.0	71.5	71.0	72.5	66.5	56.0	67.8
2011	59.0	68.5	76.5	77.0	84.5	75.0	70.5	70.0	72.5	74.5	80.5	78.0	73.9
2012	74.0	74.5	72.5	75.0	76.5	78.0	82.0	80.0	78.5	75.5	71.5	69.0	75.6
2013	78.0	76.0	75.0	78.5	78.5	79.0	78.5	76.0	77.0	80.0	78.5	80.0	77.9
Average	**72.6**	**70.6**	**73.3**	**77.2**	**77.8**	**76.8**	**75.5**	**75.5**	**75.5**	**75.7**	**75.7**	**74.5**	**75.0**

Entebbe Average Monthly Wind Speed (m/sec)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
1992	2.6	3.2	3.3	2.9	3.0	3.2	3.2	3.1	3.5	3.1	2.5	2.6	**3.0**
1993	3.3	3.3	3.4	3.0	3.3	2.9	3.3	3.7	3.5	3.0	3.0	2.8	**3.2**
1994	3.1	3.4	3.4	3.3	3.6	3.0	3.6	3.9	4.1	3.8	3.3	3.2	**3.5**
1995	2.9	3.7	3.7	2.9	4.6	3.3	3.5	3.8	3.4	3.3	3.4	3.2	**3.5**
1996	3.3	4.0	4.0	3.5	3.5	4.0	4.2	3.8	3.8	3.6	3.5	2.8	**3.7**
1997	3.2	3.6	3.5	3.2	2.8	3.3	3.5	3.3	3.3	2.9	3.1	3.2	**3.2**
1998	4.0	3.2	3.0	3.6	2.9	3.2	3.7	3.5	3.8	3.7	2.7	2.8	**3.3**
1999	3.0	3.5	3.6	3.6	3.2	2.9	3.0	3.4	3.1	18.8	2.8	3.1	**4.5**
2000	3.3	3.1	3.5	2.9	3.2	3.7	3.2	3.4	3.7	3.9	3.9	3.5	**3.4**
2001	2.7	2.7	2.4	3.2	2.2	2.7	2.2	1.9	1.9	2.2	3.3	2.9	**2.5**
2002	3.6	3.5	3.9	3.8	3.9	4.3	4.7	4.2	4.2	3.8	3.4	3.2	**3.9**
2003	3.5	4.4	4.4	4.1	3.8	3.6	3.8	4.1	4.1	3.5	3.3	3.0	**3.8**
2004	2.6	3.2	3.3	2.9	3.0	3.2	3.2	3.1	3.5	3.1	2.5	2.6	**3.0**
2005	1.3	1.7	1.5	1.6	1.9	1.7	1.8	2.1	2.3	2.0	1.7	1.9	**1.8**
2006	1.8	2.6	2.1	2.1	1.8	1.5	1.6	2.1	1.9	2.0	1.9	1.8	**1.9**
2007	1.9	1.6	1.9	1.9	1.9	1.9	1.6	1.9	1.9	2.1	1.6	1.6	**1.8**
2008	3.0	3.4	2.7	2.4	1.9	2.2	2.4	1.9	1.9	3.4	1.9	2.4	**2.5**
2009	2.4	2.4	1.9	2.2	3.2	2.4	2.4	3.5	2.4	3.5	1.9	1.9	**2.5**
2010	2.1	2.3	2.9	2.2	2.1	2.1	2.0	1.8	1.9	2.1	2.2	2.4	**2.2**
2011	2.1	2.3	2.4	1.9	2.2	2.1	2.1	1.7	2.4	3.6	3.9	2.5	**2.4**
2012	2.7	2.7	2.4	3.2	2.3	2.4	2.2	1.9	1.9	2.3	2.2	1.3	**2.3**
2013	3.3	3.3	3.4	3.0	3.3	2.9	3.3	3.7	3.5	3.0	3.0	2.8	**3.2**
Average	**2.8**	**3.0**	**3.0**	**2.9**	**2.9**	**2.8**	**2.9**	**3.0**	**3.0**	**3.8**	**2.8**	**2.6**	**3.0**

Average Daily Sunshine hours by Month in mm

SERERE Agric Station

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Max. Record	11.4	11.4	11.5	11.4	11.4	11.3	11.4	11.3	11.4	11.4	11.7	11.3	11.7
Mean Max. in the month	11	11.2	11.1	11	10.8	10.8	10.5	10.8	11.1	11.1	11	10.9	10.9
Mean	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
Mean Min. in the month	2.7	1.9	1.4	1.8	1.8	1.3	0.7	1	2.1	3	3.6	2.2	2
Min. Record	0	0	0.1	0	0.3	0.3	0	0	0.6	0.9	0.6	0	0

BUGUSEGE Coffee Res Stataion

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Max. Record	10.8	11.6	10.1	10.4	10.7	10.4	10.2	10.8	10.8	9.9	10.9	10.4	11.6
Mean Max. in the month	10.6	10.5	9.7	9.3	9.2	9.5	9.2	9.8	9.5	8.8	9.6	9.4	9.6
Mean	7.7	6.4	5.5	4.5	5.7	6.2	5.3	5.8	6.1	5.2	5	6.1	5.8
Mean Min. in the month	3.6	1.5	1	0.3	0.9	1.5	1.3	1.3	2.7	1.5	1.1	1.7	1.5
Min. Record	1.3	0	0	0	0	0.4	0.2	0.5	1.7	0	0.1	0	0

ENTEBBE

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Max. Record	11.8	11.7	11.2	11.5	11.7	11.6	11.5	11.7	11.4	11.9	11.9	11.8	11.9
Mean Max. in the month	11.3	11	10.8	10.5	10.8	10.5	10.8	10.9	10.7	10.9	11.1	11.2	10.9
Mean	7.5	7.1	6.6	6	6.2	6.3	6.4	6.3	6.4	6.5	6.6	6.8	6.6
Mean Min. in the month	1	0.7	0.5	0.8	0.7	0.6	0.6	0.5	0.5	1	0.7	0.7	0.7
Min. Record	0	0	0	0	0	0	0	0	0	0	0	0	0

JINJA

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Max. Record	11.7	11.5	11.1	11.5	11.7	11.4	11.4	11.6	11.3	11.9	11.7	11.7	11.9
Mean Max. in the month	11.5	11.4	10.9	11	11.6	11	10.8	10.8	10.6	10.7	11.3	11.6	11.1
Mean	9	7.6	6.7	6.9	7.6	7.6	6.4	6.7	7.1	6.8	7.1	8.2	7.3
Mean Min. in the month	2.9	1.5	0.7	1.1	2.3	1.8	0.8	0.6	2.1	2	1.1	1.9	1.6
Min. Record	1.3	0.1	0	0.3	0	0	0	0.2	0.6	1.3	0	0	0

TORORO

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Max. Record	11.5	11.7	11.5	11.6	11.5	11.7	11.3	11.7	11.2	11.3	11.8	11.6	11.8
Mean Max. in the month	11.4	11.2	11	11.3	11	10.9	10.7	11	10.6	10.9	11	11.5	11
Mean	9.2	8.1	8	6.9	7.5	7.6	6.5	6.8	7.7	7.6	7.3	8.3	7.6
Mean Min. in the month	4	2.1	2.1	1.8	2.5	2	1.6	0.5	3.2	3.1	2	2.3	2.3
Min. Record	1.2	0.5	0	0.6	0.5	0.1	0.1	0	1.5	0.8	0.9	0	0

Source: The Development Study on Water Resources Development and Management for Lake Kyoga Basin Final Report, JICA Study Team, 2011

Average Daily Evaporation by Month in mm

NAMULONGE Res/ Stn. Period:1967-1977

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Annual
Evaporation (mm)	4.5	4.9	4.9	4.6	3.9	3.8	3.7	4.0	4.3	4.3	4.1	4.1	4.3	1,546

JINJA Met Station Period:1969-1977

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Annual
Evaporation (mm)	5.5	5.4	5.6	5.0	4.3	4.3	3.9	4.2	4.6	5.3	5.1	5.1	4.9	1,772

SERERE Agric Stn Period:1971-1980

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Annual
Evaporation (mm)	5.8	6.5	6.4	5.3	4.9	4.3	4.2	4.7	5.3	5.4	5.3	6.0	5.3	1,903

NAMALU WDD Period:1970-1973, 2000-2001

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Annual
Evaporation (mm)	5.3	6.9	6.6	4.4	4.0	3.9	3.9	4.0	4.1	4.7	5.8	6.0	5.0	1,757

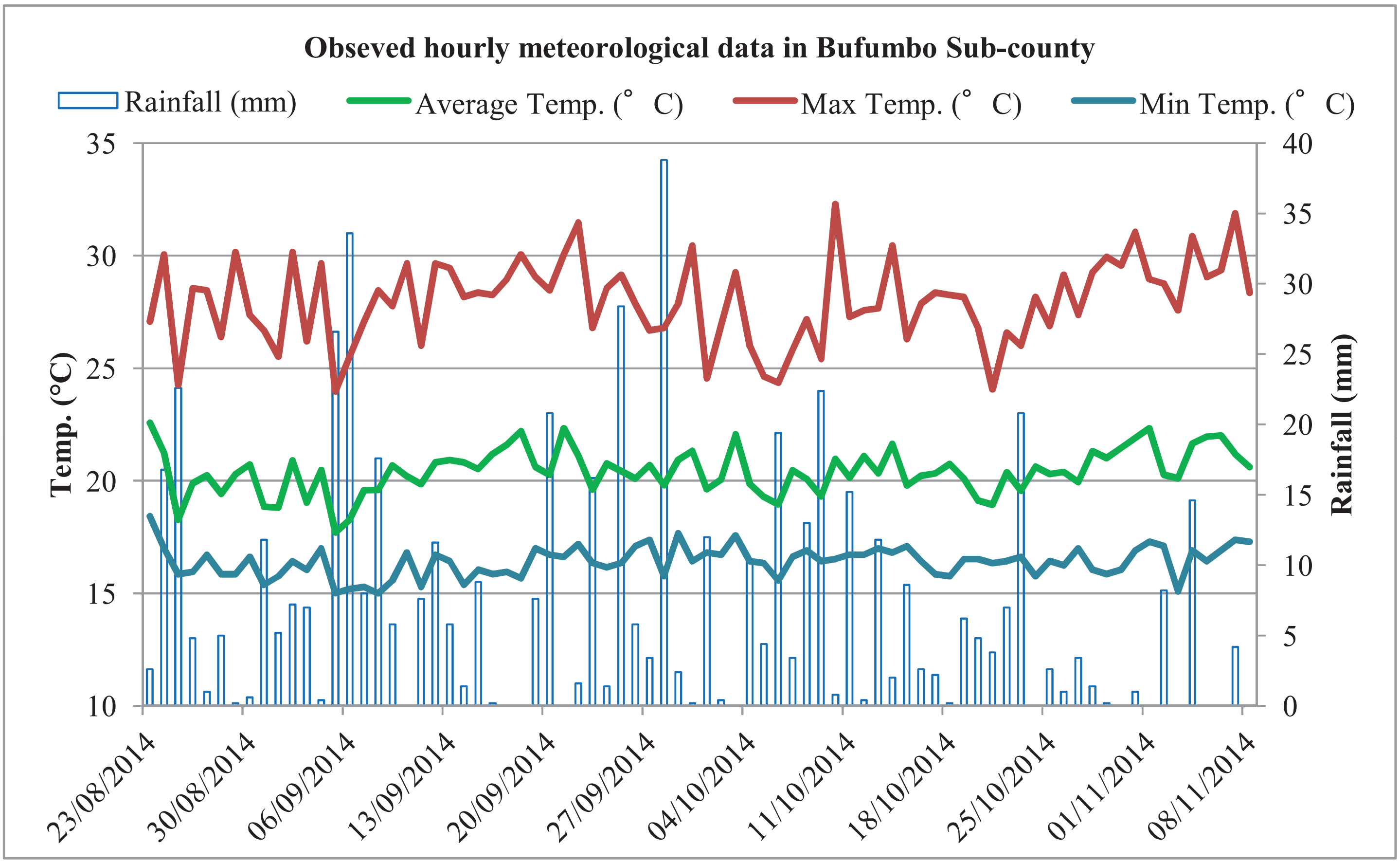
TORORO Met Stn Period:1969-1978

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Mean	Annual
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	1,853

Source: The Development Study on Water Resources Development and Management for Lake Kyoga Basin Final Report, JICA Study Team, 2011

Obseved hourly meteorological data in Bufumbo Sub-county

Date Time	Max Temp. (°C)	Average Temp. (°C)	Min Temp. (°C)	Rainfall (mm)
23/08/2014	27.1	22.6	18.4	2.6
24/08/2014	30.1	21.2	17.0	16.8
25/08/2014	24.3	18.3	15.9	22.6
26/08/2014	28.6	19.9	16.0	4.8
27/08/2014	28.5	20.2	16.7	1
28/08/2014	26.4	19.4	15.9	5
29/08/2014	30.2	20.3	15.9	0.2
30/08/2014	27.4	20.7	16.6	0.6
31/08/2014	26.7	18.8	15.4	11.8
01/09/2014	25.5	18.8	15.8	5.2
02/09/2014	30.2	20.9	16.4	7.2
03/09/2014	26.2	19.0	16.0	7
04/09/2014	29.7	20.5	17.0	0.4
05/09/2014	24.0	17.7	15.0	26.6
06/09/2014	25.5	18.3	15.2	33.6
07/09/2014	27.1	19.6	15.3	8
08/09/2014	28.5	19.6	15.0	17.6
09/09/2014	27.8	20.7	15.6	5.8
10/09/2014	29.7	20.2	16.8	0
11/09/2014	26.0	19.9	15.3	7.6
12/09/2014	29.7	20.8	16.7	11.6
13/09/2014	29.5	20.9	16.4	5.8
14/09/2014	28.2	20.8	15.4	1.4
15/09/2014	28.4	20.5	16.0	8.8
16/09/2014	28.3	21.2	15.9	0.2
17/09/2014	29.0	21.6	16.0	0
18/09/2014	30.1	22.2	15.7	0
19/09/2014	29.1	20.6	17.0	7.6
20/09/2014	28.5	20.3	16.7	20.8
21/09/2014	30.1	22.3	16.6	0
22/09/2014	31.5	21.1	17.2	1.6
23/09/2014	26.8	19.6	16.3	16.2
24/09/2014	28.6	20.8	16.1	1.4
25/09/2014	29.2	20.4	16.3	28.4
26/09/2014	27.9	20.1	17.1	5.8
27/09/2014	26.7	20.7	17.4	3.4
28/09/2014	26.8	19.8	15.8	38.8
29/09/2014	27.9	20.9	17.7	2.4
30/09/2014	30.5	21.3	16.4	0.2
01/10/2014	24.5	19.6	16.8	12
02/10/2014	26.9	20.1	16.7	0.4
03/10/2014	29.3	22.1	17.6	0
04/10/2014	26.0	19.9	16.4	10.4
05/10/2014	24.6	19.3	16.3	4.4
06/10/2014	24.4	19.0	15.6	19.4
07/10/2014	25.8	20.5	16.6	3.4
08/10/2014	27.2	20.1	16.9	13
09/10/2014	25.4	19.3	16.4	22.4
10/10/2014	32.3	21.0	16.5	0.8
11/10/2014	27.3	20.1	16.7	15.2
12/10/2014	27.6	21.1	16.7	0.4
13/10/2014	27.7	20.3	17.0	11.8
14/10/2014	30.5	21.6	16.8	2
15/10/2014	26.3	19.8	17.1	8.6
16/10/2014	27.9	20.2	16.4	2.6
17/10/2014	28.4	20.3	15.9	2.2
18/10/2014	28.3	20.8	15.8	0.2
19/10/2014	28.2	20.1	16.5	6.2
20/10/2014	26.8	19.1	16.5	4.8
21/10/2014	24.1	18.9	16.3	3.8
22/10/2014	26.6	20.4	16.4	7
23/10/2014	26.0	19.6	16.6	20.8
24/10/2014	28.2	20.6	15.8	0
25/10/2014	26.9	20.3	16.4	2.6
26/10/2014	29.2	20.4	16.2	1
27/10/2014	27.4	19.9	17.0	3.4
28/10/2014	29.3	21.3	16.0	1.4
29/10/2014	30.0	21.0	15.9	0.2
30/10/2014	29.6	21.5	16.0	0
31/10/2014	31.1	21.9	16.9	1
01/11/2014	29.0	22.3	17.3	0
02/11/2014	28.8	20.3	17.1	8.2
03/11/2014	27.6	20.1	15.1	0
04/11/2014	30.9	21.7	16.9	14.6
05/11/2014	29.1	22.0	16.4	0
06/11/2014	29.4	22.0	16.9	0
07/11/2014	31.9	21.2	17.4	4.2
08/11/2014	28.4	20.6	17.3	0


Obseved hourly meteorological data in Bufumbo Sub-county
Rainfall (mm)
Average Temp. (° C)
Max Temp. (° C)
Min Temp. (° C)
Temp. (°C)
Rainfall (mm)
35
30
25
20
15
10
40
35
30
25
20
15
10
5
0
23/08/2014
30/08/2014
06/09/2014
13/09/2014
20/09/2014
27/09/2014
04/10/2014
11/10/2014
18/10/2014
25/10/2014
01/11/2014
08/11/2014

Station & Data Source

Site	R.Sipi at Mbale -Moroto Road	Number	82243
Latitude	1°22'57.8" N	Longitude	34°18'51.8" E
Elevation	1,105 meters		
Area	92.0 sq km		
Year	January 2000 to December 2012		

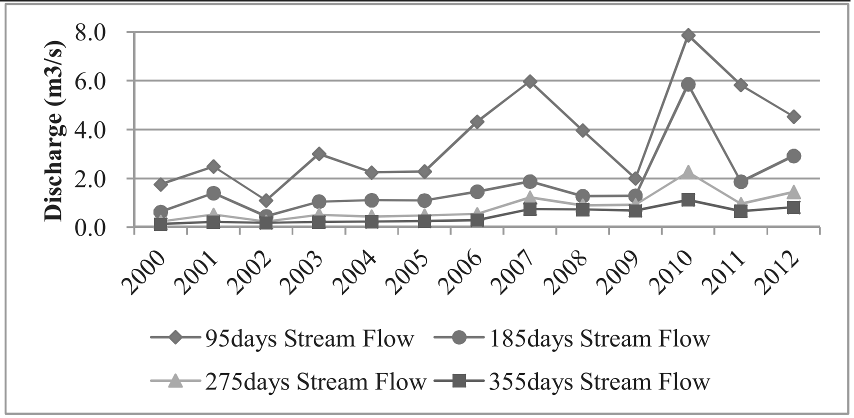
Year	Flow regime (m3/s)						Annual Discharge		Specific Discharge			Remark
	95days Stream Flow	185days Stream Flow	275days Stream Flow	355days Stream Flow	Minimum Discharge	Maximum Discharge	Average Discharge	Total Discharge	275days	355days	Average	
	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	Mm3	m3/s/100km2	m3/s/100km2	m3/s/100km2	
2000	1.754	0.626	0.230	0.129	0.112	8.921	1.45	46	0.25	0.14	1.57	
2001	2.485	1.401	0.515	0.216	0.193	8.624	1.80	57	0.56	0.23	1.96	
2002	1.096	0.448	0.227	0.181	0.150	5.110	0.74	23	0.25	0.20	0.81	
2003	3.001	1.048	0.513	0.216	0.172	6.516	1.83	58	0.56	0.23	1.99	
2004	2.242	1.110	0.438	0.226	0.182	6.938	1.55	49	0.48	0.25	1.68	
2005	2.285	1.099	0.487	0.252	0.227	9.110	1.94	61	0.53	0.27	2.10	
2006	4.324	1.460	0.540	0.292	0.266	10.214	2.72	86	0.59	0.32	2.96	
2007	5.974	1.870	1.220	0.749	0.603	9.699	3.43	108	1.33	0.81	3.73	
2008	3.967	1.271	0.890	0.727	0.685	9.112	2.54	80	0.97	0.79	2.76	
2009	2.003	1.288	0.914	0.680	0.609	6.389	1.64	52	0.99	0.74	1.78	
2010	7.858	5.852	2.262	1.126	1.047	11.411	5.38	170	2.46	1.22	5.85	
2011	5.820	1.861	0.953	0.662	0.620	10.440	3.42	108	1.04	0.72	3.71	
2012	4.529	2.920	1.447	0.818	0.727	11.088	3.33	105	1.57	0.89	3.62	
Max.	7.858	5.852	2.262	1.126	1.047	11.411	5.38	170	2.46	1.22	5.85	
Min.	1.096	0.448	0.227	0.129	0.112	5.110	0.74	18	0.25	0.14	0.81	
Aver.	3.64	1.71	0.82	0.48	0.43	8.74	2.44	73	0.89	0.52	2.66	

River Maintenance Flow

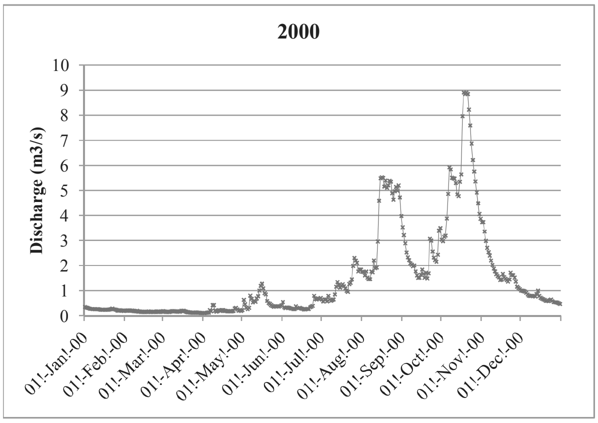
Minimum 355days Stream Flow :	0.140	m3/s/100km2
Minimum Discharge :	0.122	m3/s/100km2
Ten(10) year probability 355days Flow Stream discharge:	0.166	m3/s/100km2

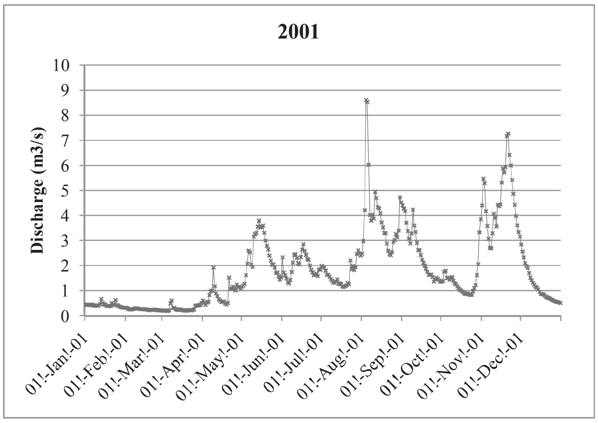
Result of Probability Analysis

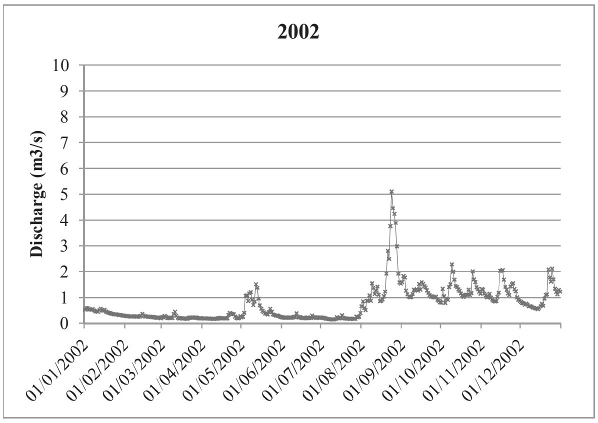
Probability	Drought (355days)	Flood(Max Discharge)
Two (2) year probability	0.387	0.0
Five (5) year probability	0.211	0.0
Ten (10) year probability	0.153	0.0
Twenty (20) year probability	0.117	0.0
One hundred (100) year probability	0.070	0.0
Two hundred (200) year probability	0.058	0.0

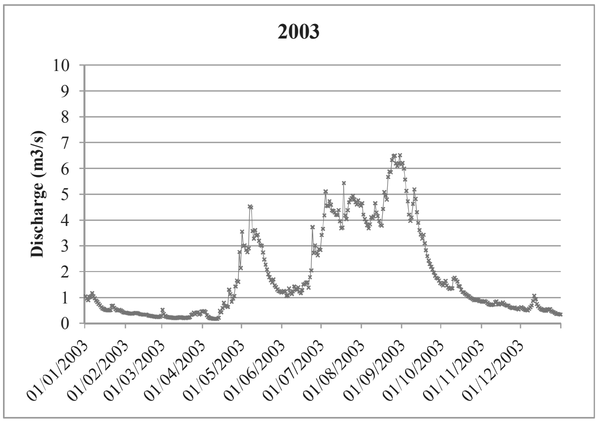


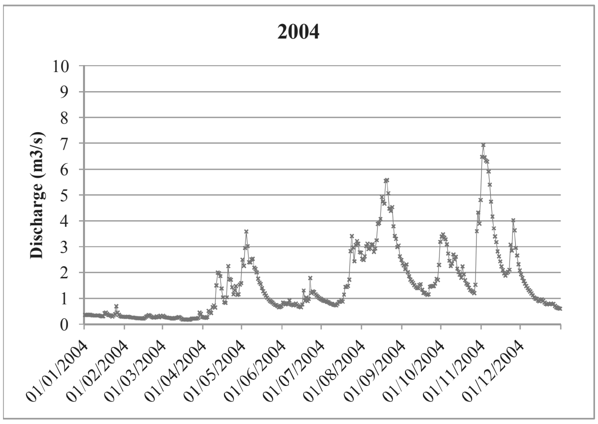
Daily discharge of Sipi river (2000-2012)

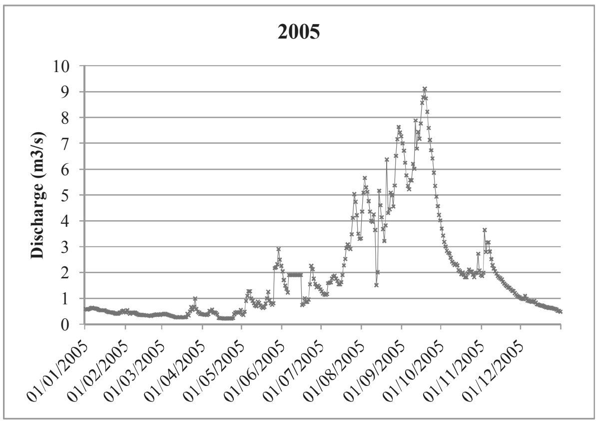


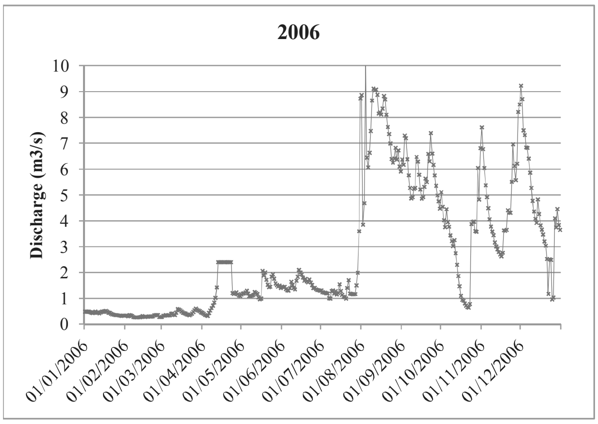


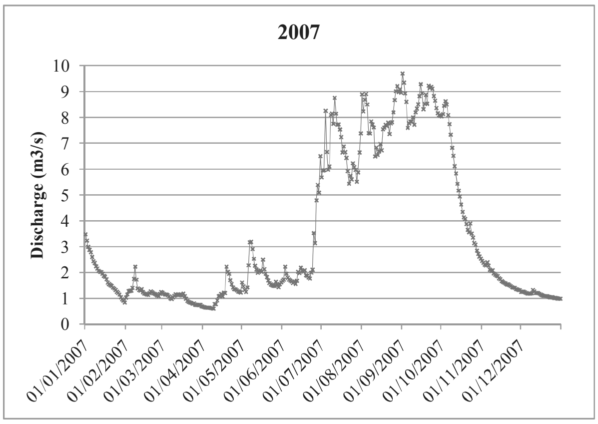




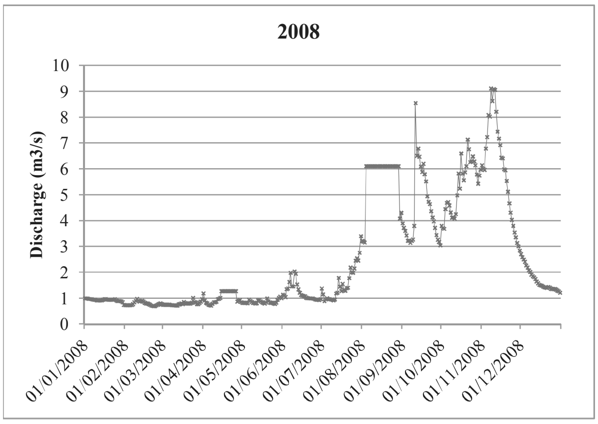


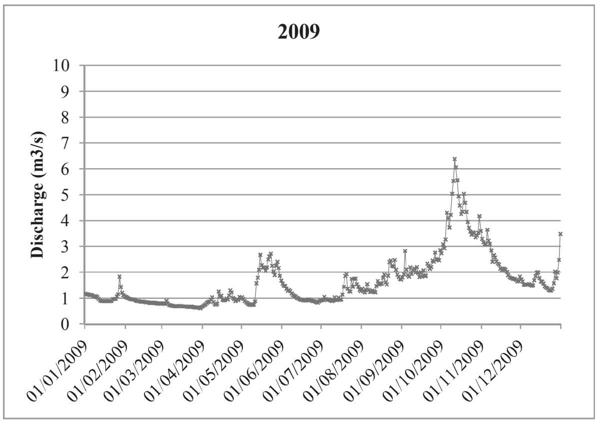


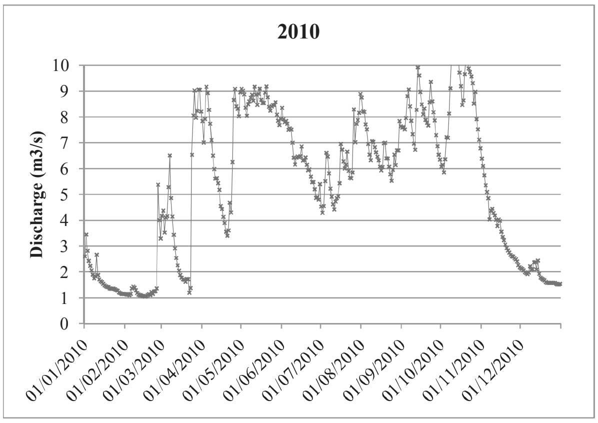


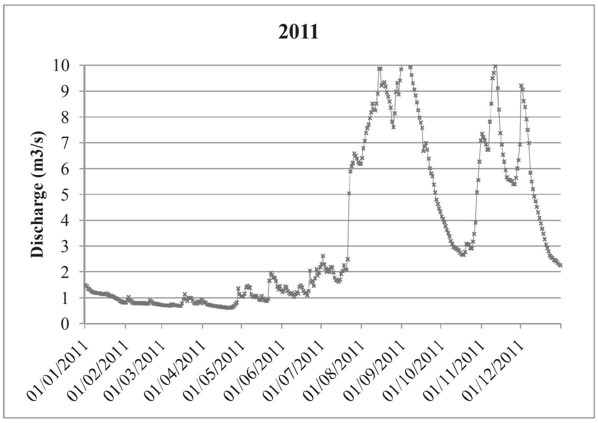


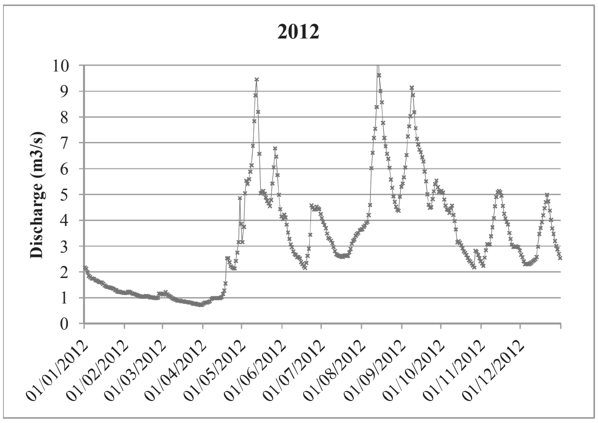
Daily discharge of Sipi river (2000-2012)











Station & Data Source

Site	R.Sironko at Mbale -Moroto Road		Number	82240
Latitude	1°14'10.2" N		Longitude	34°15'25.0" E
Elevation	1,113	meters		
Area	265.0	sq km		
Year	January 2003 to December 2012			

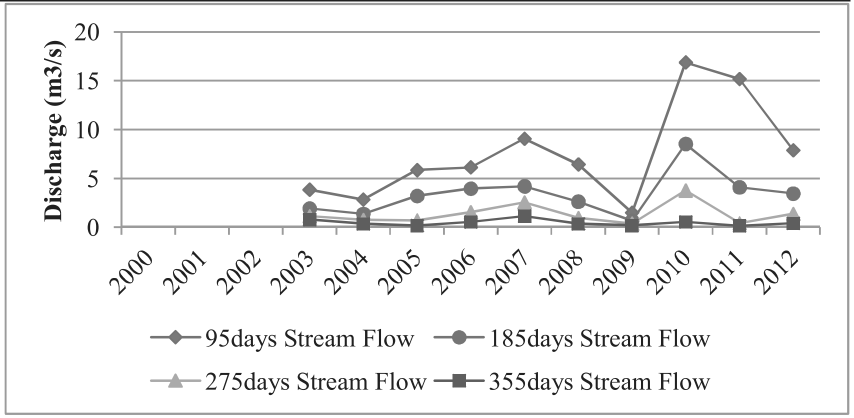
Year	Flow regime (m3/s)						Annual Discharge		Specific Discharge			Remark
	95days Stream Flow	185days Stream Flow	275days Stream Flow	355days Stream Flow	Minimum Discharge	Maximum Discharge	Average Discharge	Total Discharge	275days	355days	Average	
	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	Mm3	m3/s/100km2	m3/s/100km2	m3/s/100km2	
2000												
2001												
2002												
2003	3.838	1.911	1.128	0.784	0.559	37.317	3.41	107	0.43	0.30	1.29	
2004	2.848	1.376	0.762	0.356	0.198	31.781	2.34	74	0.29	0.13	0.88	
2005	5.860	3.201	0.707	0.177	0.115	65.337	4.97	157	0.27	0.07	1.88	
2006	6.123	3.952	1.546	0.548	0.241	40.324	5.82	184	0.58	0.21	2.20	
2007	9.048	4.186	2.542	1.155	0.780	55.794	8.05	254	0.96	0.44	3.04	
2008	6.440	2.619	0.953	0.356	0.141	43.622	4.78	151	0.36	0.13	1.80	
2009	1.494	0.682	0.361	0.189	0.145	27.207	2.03	64	0.14	0.07	0.77	
2010	16.864	8.537	3.766	0.548	0.193	63.489	12.02	379	1.42	0.21	4.54	
2011	15.183	4.087	0.412	0.145	0.100	51.340	8.53	269	0.16	0.05	3.22	
2012	7.882	3.454	1.377	0.417	0.344	28.025	5.95	188	0.52	0.16	2.25	
Max.	16.864	8.537	3.766	1.155	0.780	65.337	12.02	379	1.42	0.44	4.54	
Min.	1.494	0.682	0.361	0.145	0.100	27.207	2.03	64	0.14	0.05	0.77	
Aver.	7.56	3.40	1.36	0.47	0.28	44.42	5.79	183	0.51	0.18	2.19	

River Maintenance Flow

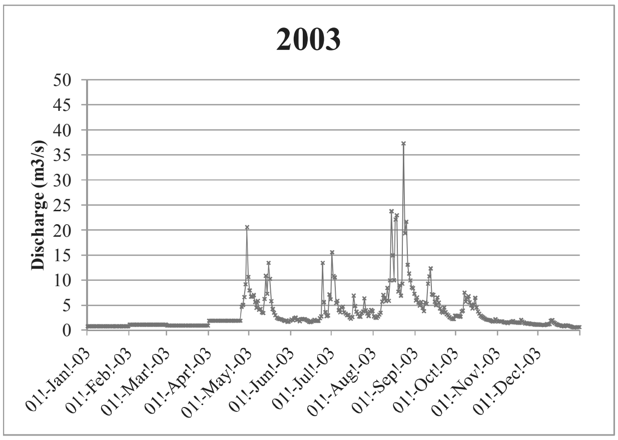
Minimum 355days Stream Flow :	0.050	m3/s/100km2
Minimum Discharge :	0.038	m3/s/100km2
Ten(10) year probability 355days Flow Stream discharge:	0.062	m3/s/100km2

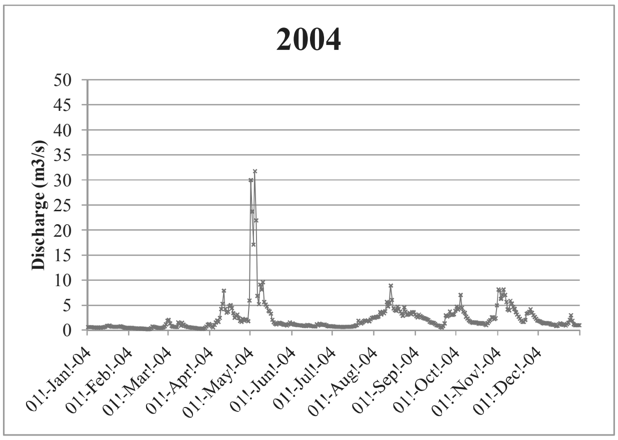
Result of Probability Analysis

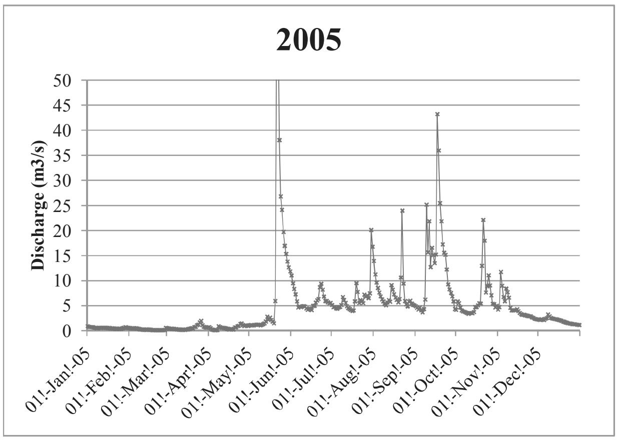
Probability	Drought (355days)	Flood(Max Discharge)
Two (2) year probability	0.375	42.6
Five (5) year probability	0.216	55.7
Ten (10) year probability	0.165	63.9
Twenty (20) year probability	0.135	71.7
One hundred (100) year probability	0.095	88.6
Two hundred (200) year probability	0.086	95.7

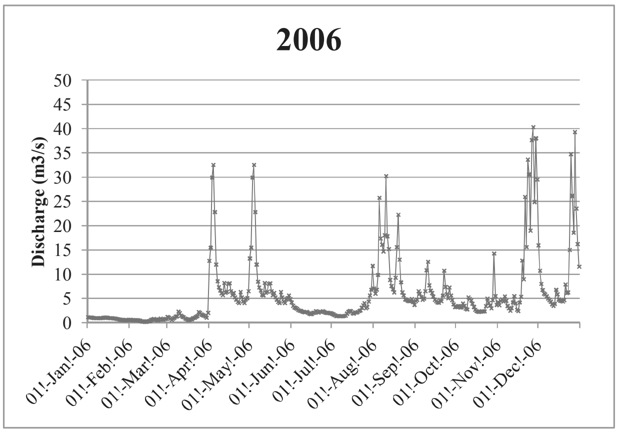


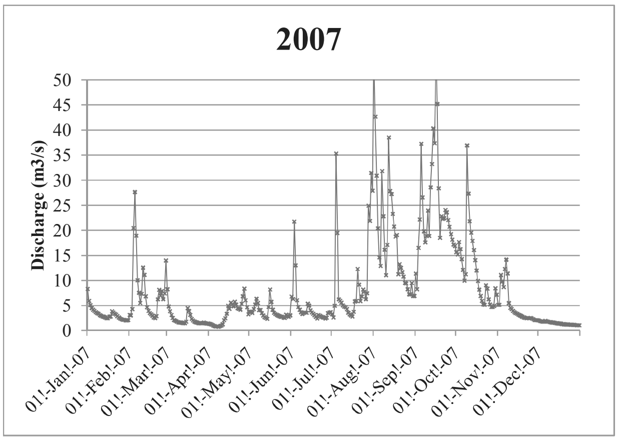
Daily discharge of Sironko river (2000-2012)

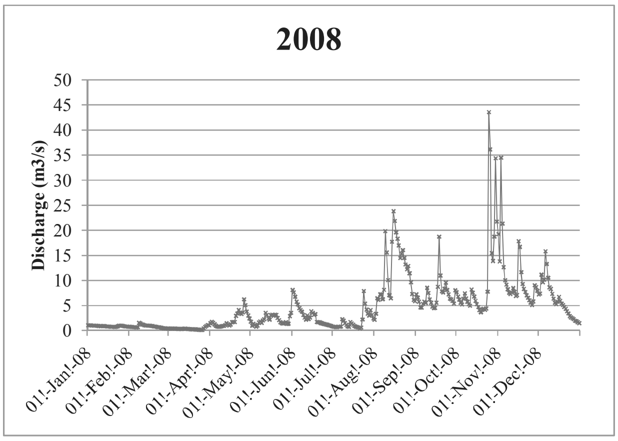




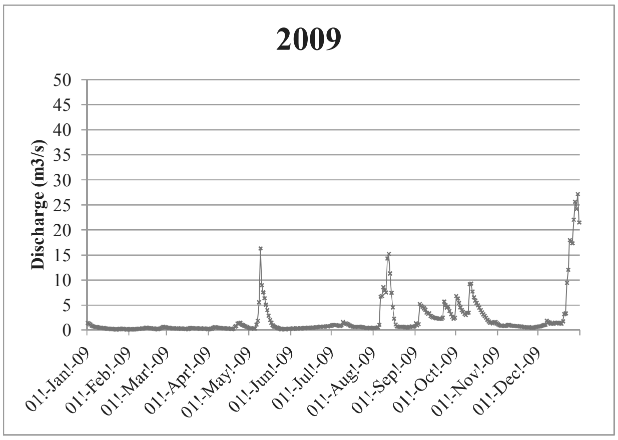


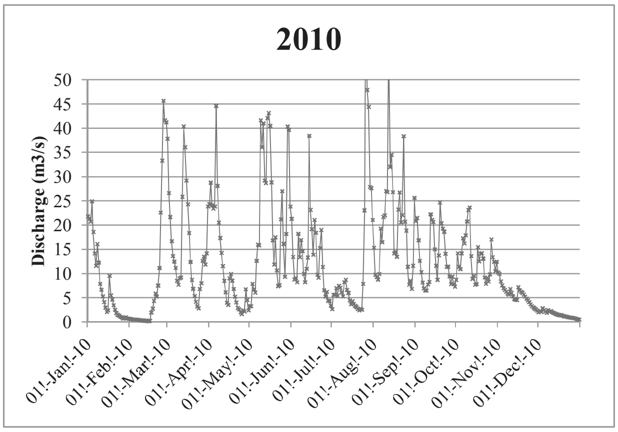


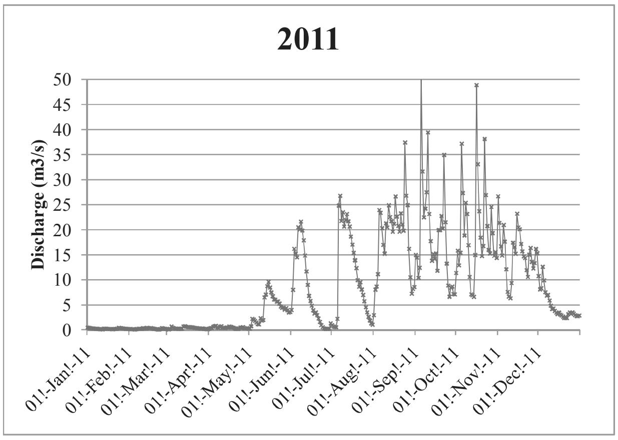


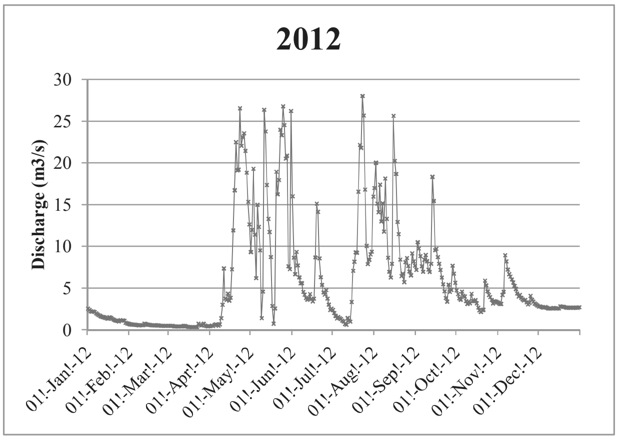


Daily discharge of Sironko river (2000-2012)









Station & Data Source

Site	R. Namatala at Mbale - Soroti Road		Number	82213
Latitude	1°06'31.1" N		Longitude	34°10'21.5" E
Elevation	1,100	meters		
Area	123.6	sq km		
Year	January 2000 to December 2012			

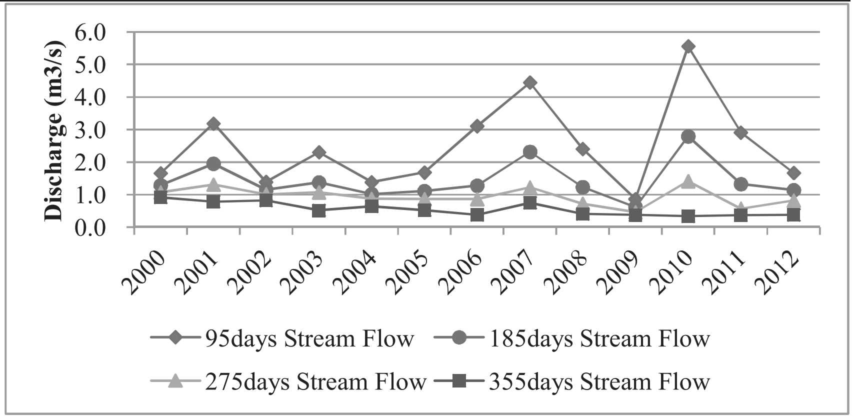
Year	Flow regime (m3/s)						Annual Discharge		Specific Discharge			Remark
	95days Stream Flow	185days Stream Flow	275days Stream Flow	355days Stream Flow	Minimum Discharge	Maximum Discharge	Average Discharge	Total Discharge	275days	355days	Average	
	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	Mm3	m3/s/100km2	m3/s/100km2	m3/s/100km2	
2000	1.658	1.291	1.079	0.918	0.865	19.995	1.64	52	0.87	0.74	1.33	
2001	3.184	1.952	1.310	0.787	0.669	12.338	2.52	79	1.06	0.64	2.04	
2002	1.385	1.154	1.011	0.826	0.706	29.048	1.59	50	0.82	0.67	1.29	
2003	2.299	1.374	1.074	0.519	0.412	9.678	1.93	61	0.87	0.42	1.56	
2004	1.381	1.017	0.875	0.645	0.555	14.074	1.41	45	0.71	0.52	1.14	
2005	1.684	1.113	0.868	0.524	0.423	12.038	1.62	51	0.70	0.42	1.31	
2006	3.104	1.279	0.865	0.384	0.326	18.813	2.54	80	0.70	0.31	2.05	
2007	4.442	2.317	1.226	0.751	0.686	27.110	3.38	107	0.99	0.61	2.73	
2008	2.405	1.231	0.723	0.409	0.328	18.703	2.01	64	0.58	0.33	1.62	
2009	0.868	0.617	0.464	0.377	0.328	8.864	0.85	27	0.38	0.31	0.69	
2010	5.558	2.793	1.412	0.339	0.326	23.483	4.02	127	1.14	0.27	3.25	
2011	2.906	1.325	0.569	0.375	0.352	31.902	2.46	78	0.46	0.30	1.99	
2012	1.668	1.139	0.826	0.382	0.379	6.053	1.34	42	0.67	0.31	1.09	
Max.	5.558	2.793	1.412	0.918	0.865	31.902	4.02	127	1.14	0.74	3.25	
Min.	0.868	0.617	0.464	0.339	0.326	6.053	0.85	15	0.38	0.27	0.69	
Aver.	2.50	1.43	0.95	0.56	0.49	17.85	2.10	63	0.77	0.45	1.70	

River Maintenance Flow

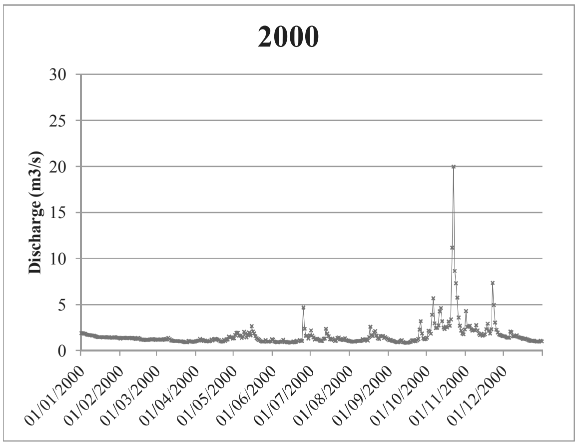
Minimum 355days Stream Flow :	0.270	m3/s/100km2
Minimum Discharge :	0.264	m3/s/100km2
Ten(10) year probability 355days Flow Stream discharge:	0.278	m3/s/100km2

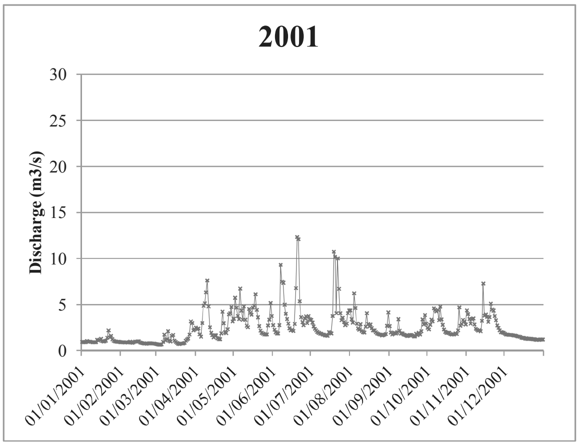
Result of Probability Analysis

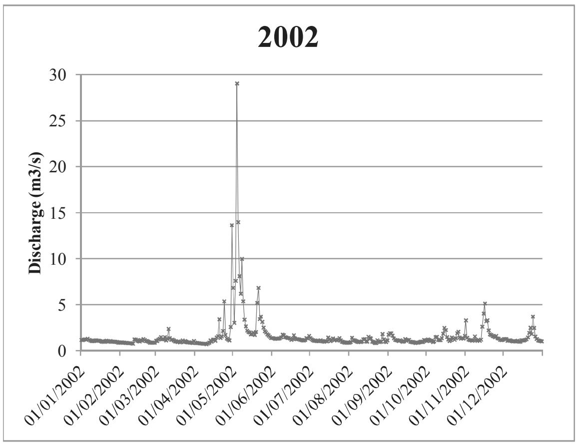
Probability	Drought (355days)	Flood(Max Discharge)
Two (2) year probability	0.509	16.8
Five (5) year probability	0.388	24.4
Ten (10) year probability	0.343	29.3
Twenty (20) year probability	0.313	33.8
One hundred (100) year probability	0.270	43.6
Two hundred (200) year probability	0.258	47.7

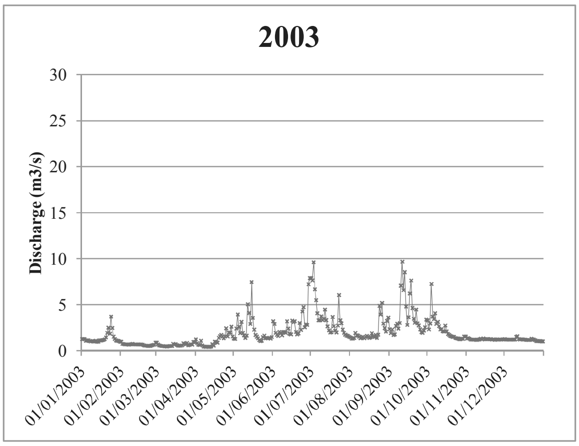


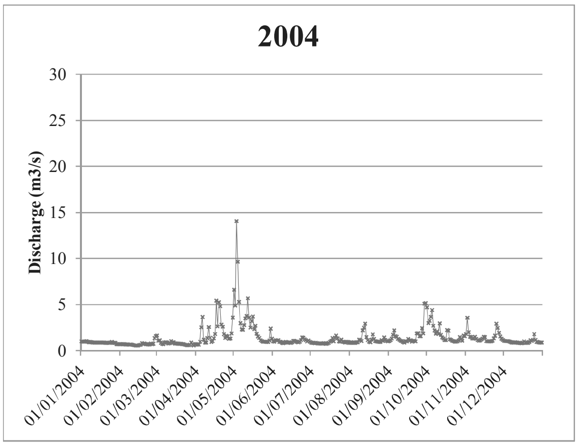
Daily discharge of Namatala river (2000-2012)

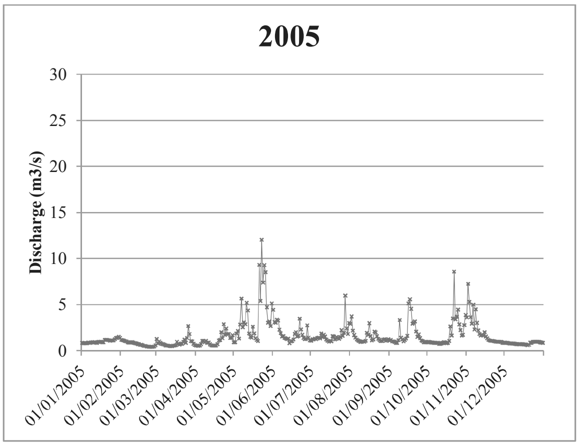


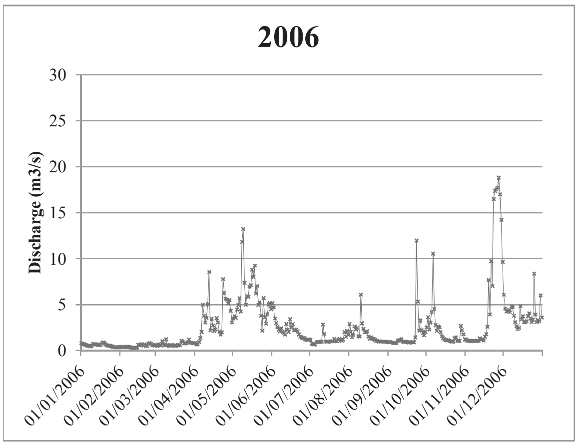


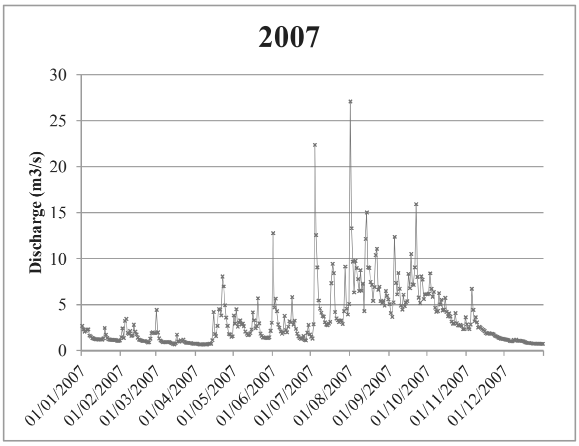




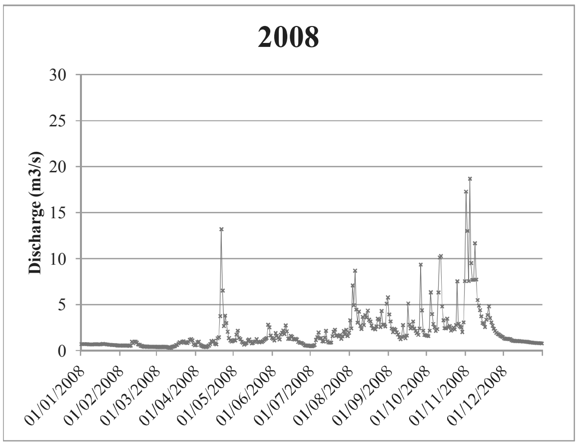


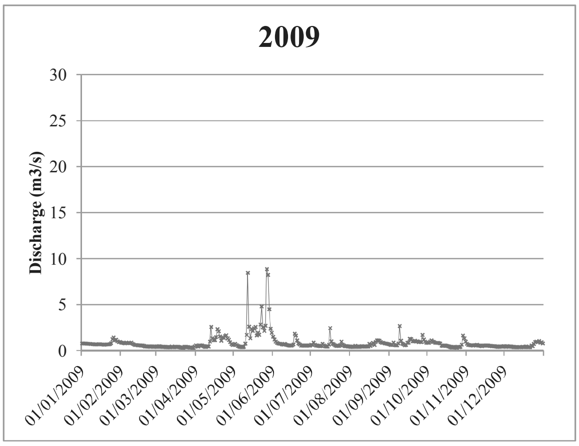


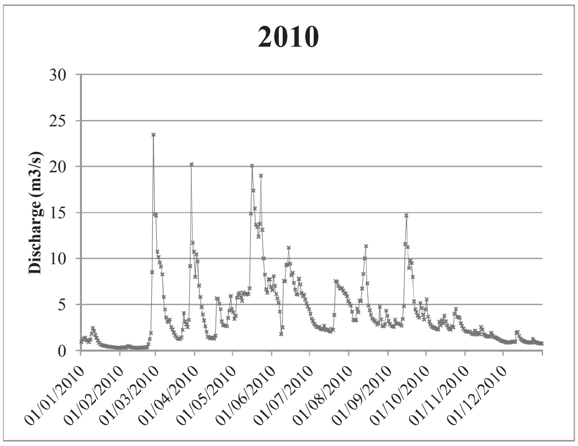


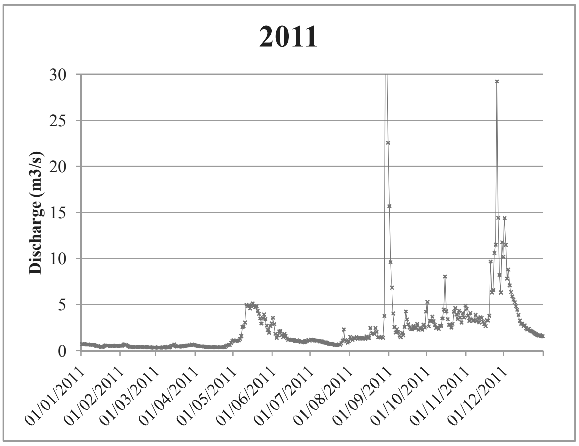


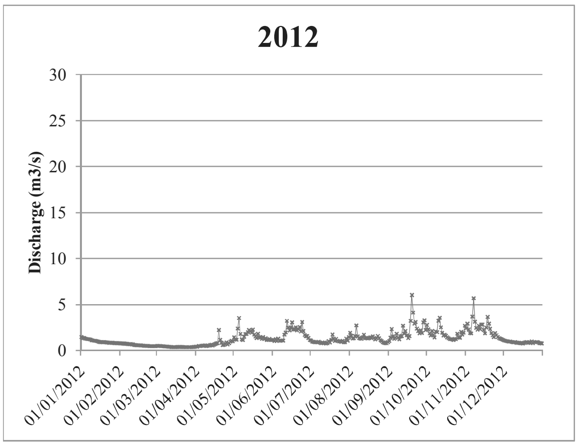
Daily discharge of Namatala river (2000-2012)











Station & Data Source

Site	R.Manafa at Mbale -Toror Road		Number	82212
Latitude	0°56'13" N		Longitude	34°09'27.6" E
Elevation	1,123	meters		
Area	494.2	sq km		
Year	January 2000 to December 2012			

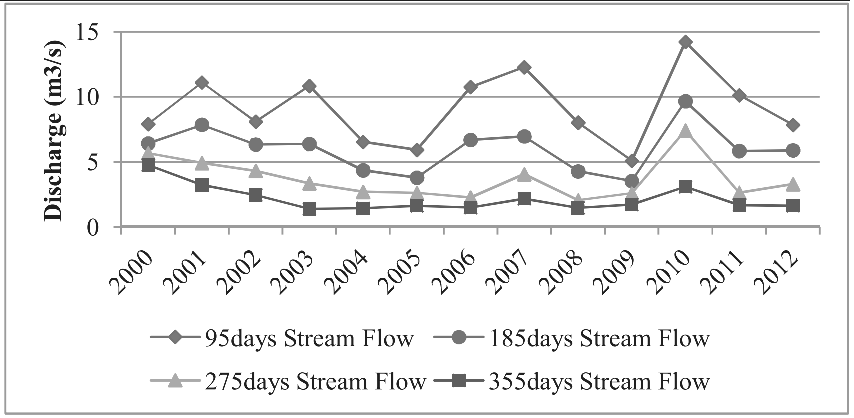
Year	Flow regime (m3/s)						Annual Discharge		Specific Discharge			Remark
	95days Stream Flow	185days Stream Flow	275days Stream Flow	355days Stream Flow	Minimum Discharge	Maximum Discharge	Average Discharge	Total Discharge	275days	355days	Average	
	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	m3/s	Mm3	m3/s/100km2	m3/s/100km2	m3/s/100km2	
2000	7.898	6.416	5.661	4.765	3.965	25.696	7.17	227	1.15	0.96	1.45	
2001	11.092	7.841	4.915	3.219	3.127	28.877	9.11	287	0.99	0.65	1.84	
2002	8.088	6.336	4.320	2.464	1.686	44.273	7.29	230	0.87	0.50	1.48	
2003	10.826	6.377	3.357	1.404	1.312	42.039	7.89	249	0.68	0.28	1.60	
2004	6.533	4.353	2.710	1.442	1.350	32.109	5.39	171	0.55	0.29	1.09	
2005	5.926	3.791	2.618	1.636	1.450	47.949	5.30	167	0.53	0.33	1.07	
2006	10.752	6.679	2.265	1.490	1.451	122.274	11.01	347	0.46	0.30	2.23	
2007	12.269	6.962	4.042	2.180	1.859	86.067	10.96	346	0.82	0.44	2.22	
2008	8.018	4.275	2.058	1.478	1.357	57.120	5.90	186	0.42	0.30	1.19	
2009	5.078	3.522	2.586	1.737	1.542	52.236	4.62	146	0.52	0.35	0.94	
2010	14.200	9.662	7.411	3.087	2.905	100.726	13.10	413	1.50	0.62	2.65	
2011	10.115	5.843	2.649	1.686	1.450	101.445	8.37	264	0.54	0.34	1.69	
2012	7.828	5.892	3.287	1.636	1.586	31.092	6.28	199	0.67	0.33	1.27	
Max.	14.200	9.662	7.411	4.765	3.965	122.274	13.10	413	1.50	0.96	2.65	
Min.	5.078	3.522	2.058	1.404	1.305	23.039	4.62	146	0.42	0.28	0.94	
Aver.	8.98	5.92	3.63	2.12	1.88	56.78	7.74	244	0.75	0.44	1.59	

River Maintenance Flow

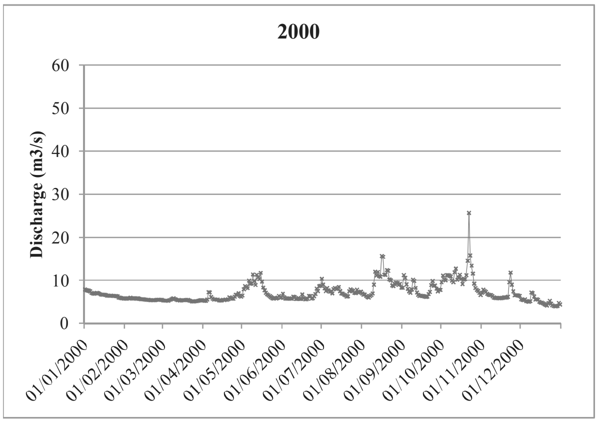
Minimum 355days Stream Flow :	0.280	m3/s/100km2
Minimum Discharge :	0.264	m3/s/100km2
Ten(10) year probability 355days Flow Stream discharge:	0.285	m3/s/100km2

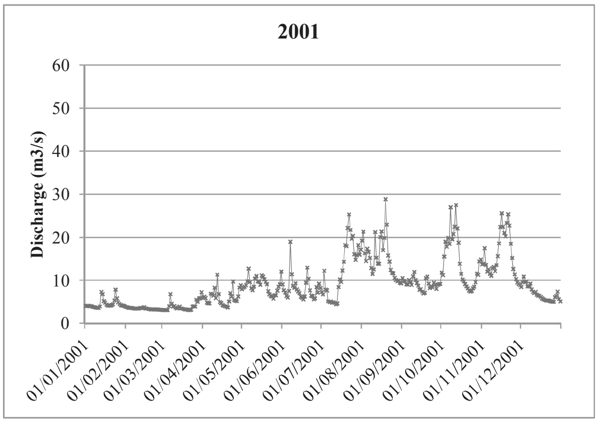
Result of Probability Analysis

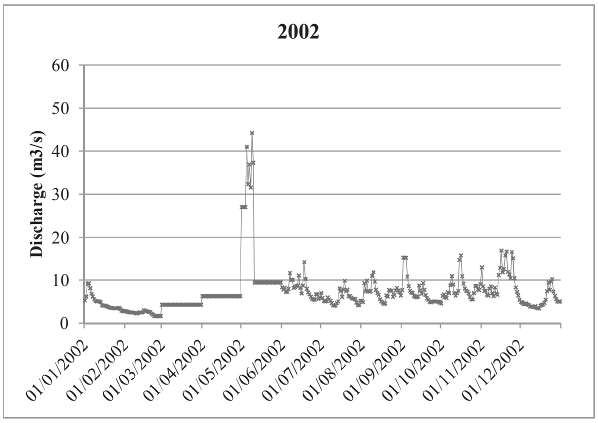
Probability	Drought (355days)	Flood(Max Discharge)
Two (2) year probability	1.832	50.7
Five (5) year probability	1.498	80.4
Ten (10) year probability	1.406	103.8
Twenty (20) year probability	1.354	128.7
One hundred (100) year probability	1.295	194.9
Two hundred (200) year probability	1.281	227.4

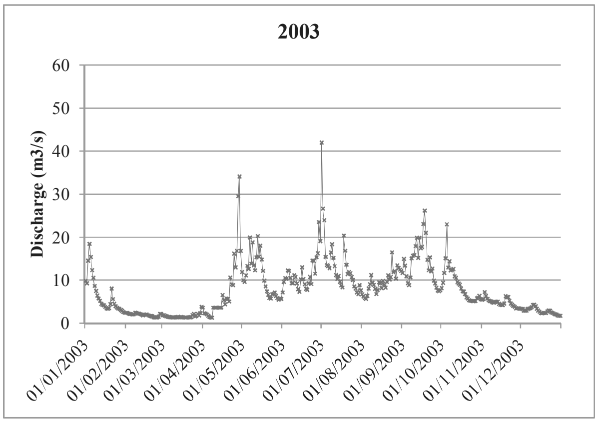


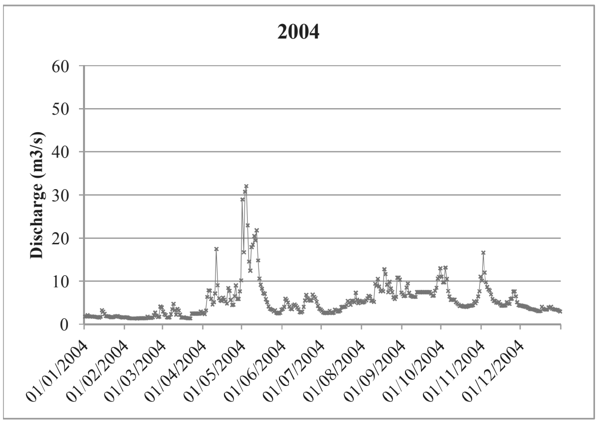
Daily discharge of Manafwa river (2000-2012)

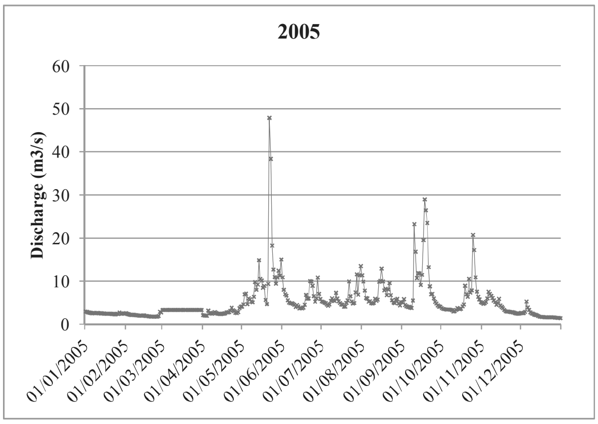


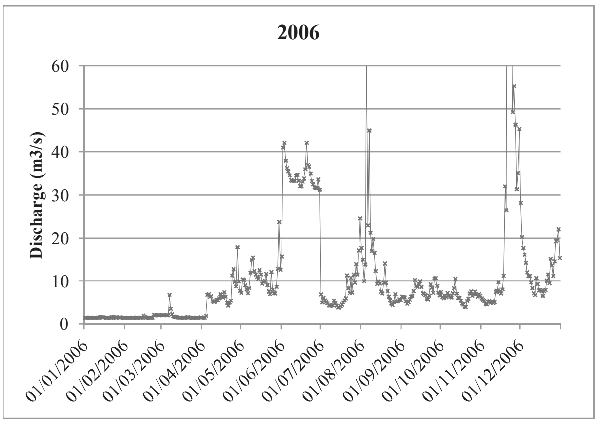


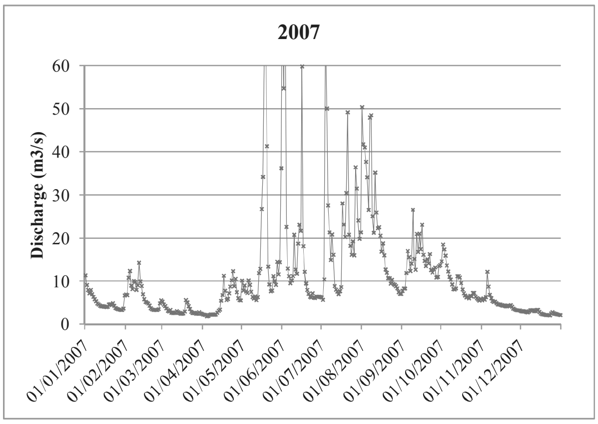




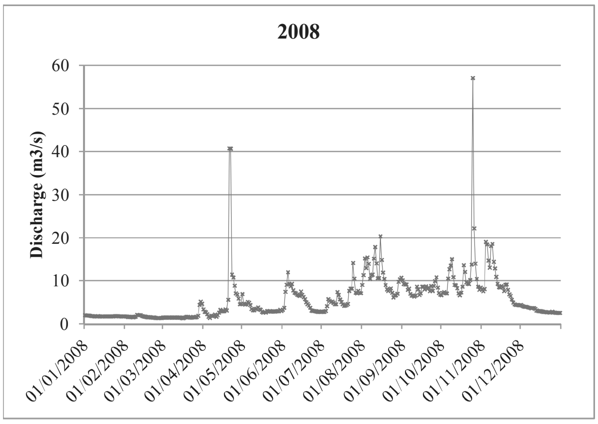


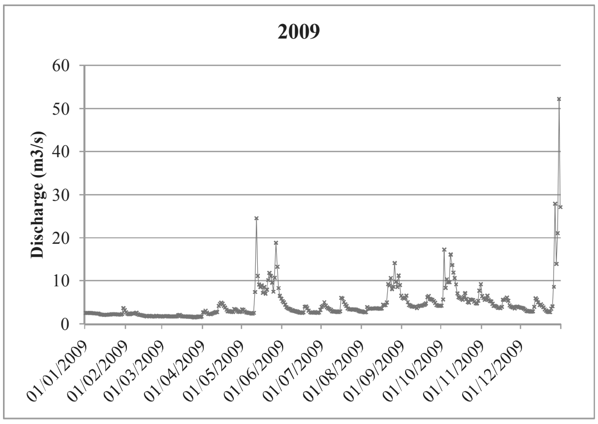


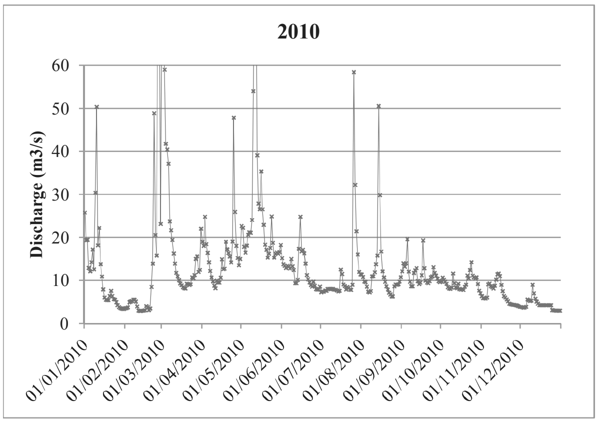


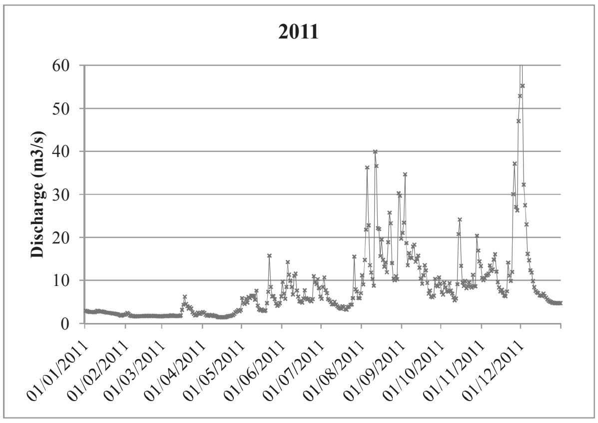


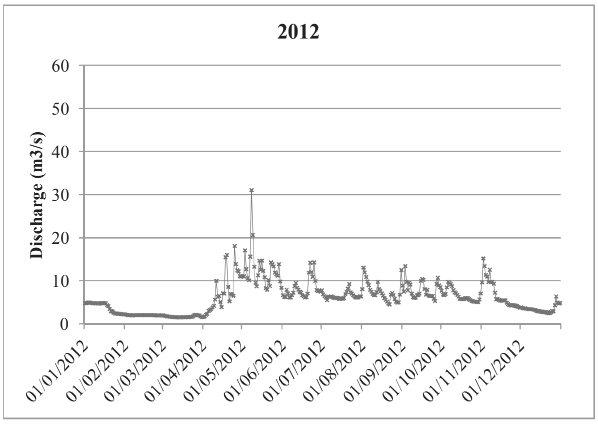
Daily discharge of Manafwa river (2000-2012)





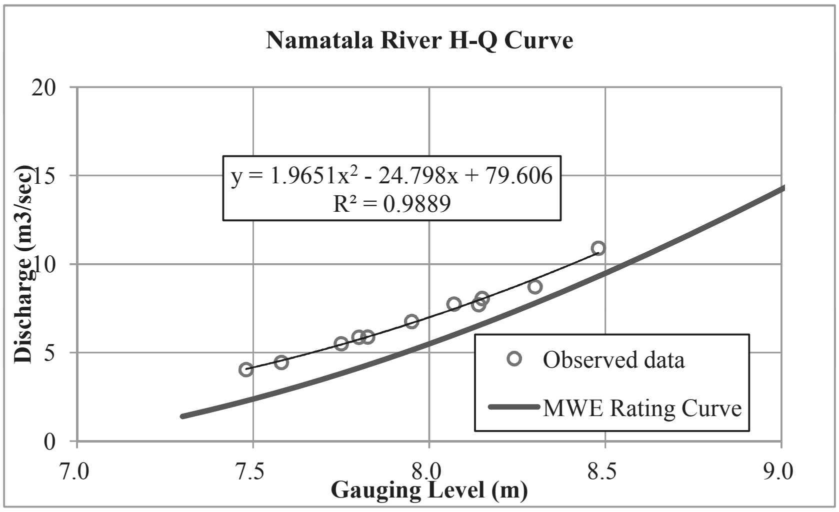






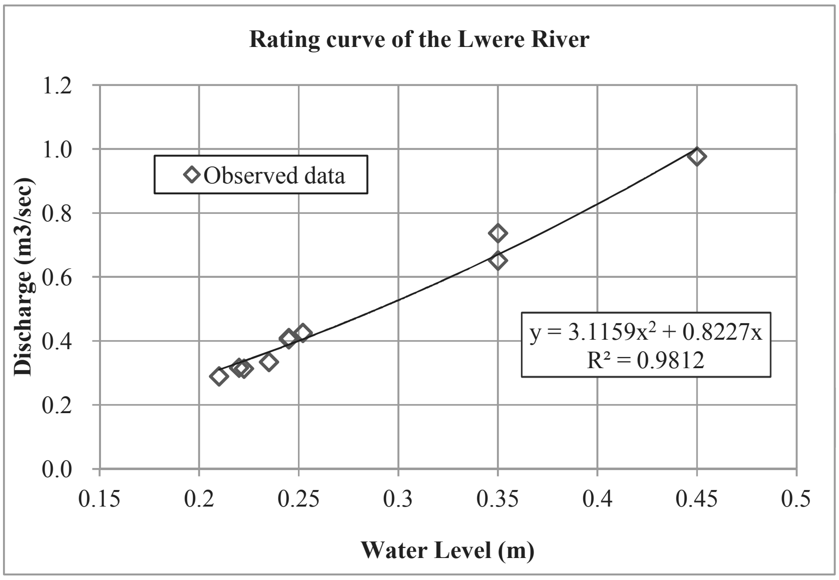
Flow measurement records of the Namatala river

No.	Date	H (m)	Q (m3/sec)
1	28/08/2014	8.3	8.72
2	05/09/2014	8.2	8.05
3	10/09/2014	7.8	5.87
4	12/09/2014	8.0	6.76
5	15/09/2014	7.6	4.44
6	18/09/2014	7.5	4.04
7	29/09/2014	8.5	10.90
8	01/10/2014	8.1	7.71
9	02/10/2014	8.1	7.74
10	14/10/2014	7.8	5.88
11	23/10/2014	7.8	5.50



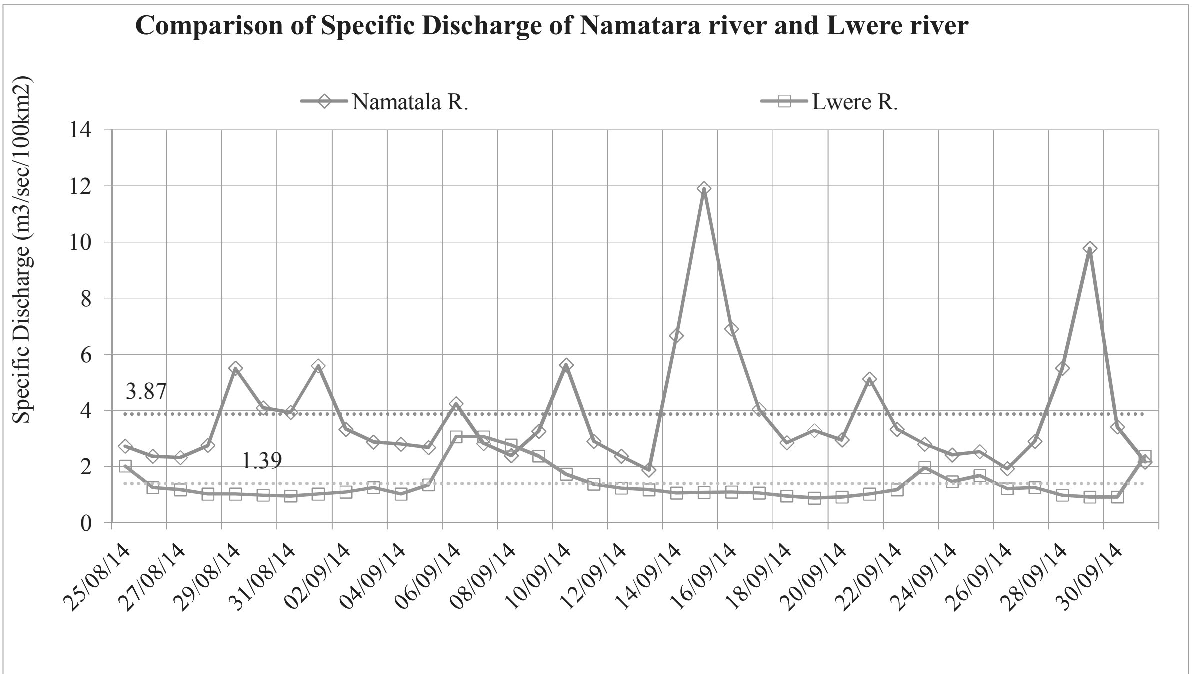
Flow measurement records of the Lwere river

No.	Date	H (m)	Q (m3/sec)
1	10/09/2014	0.25	0.43
2	12/09/2014	0.25	0.41
3	15/09/2014	0.24	0.33
4	15/09/2014	0.22	0.31
5	18/09/2014	0.21	0.29
6	29/09/2014	0.22	0.32
7	01/10/2014	0.35	0.65
8	02/10/2014	0.25	0.41
9	07/10/2014	0.45	0.98
10	23/10/2014	0.35	0.74



Obseved river discharge of Namatara and Lwere

Day	Namatala R.			Lwere R.		
	Average Gauging level	Discharge (m3/sec)	Specific Discharge (m3/sec/100km2)	Average Gauging level	Discharge (m3/sec)	Specific Discharge (m3/sec/100km2)
25/08/2014	7.68	3.72	2.73	0.32	0.56	2.02
26/08/2014	7.61	3.34	2.37	0.23	0.35	1.25
27/08/2014	7.60	3.29	2.32	0.22	0.33	1.17
28/08/2014	7.69	3.75	2.75	0.20	0.28	1.02
29/08/2014	8.18	6.67	5.50	0.20	0.28	1.02
30/08/2014	7.94	5.18	4.10	0.20	0.27	0.99
31/08/2014	7.91	5.00	3.93	0.19	0.26	0.95
01/09/2014	8.19	6.77	5.59	0.20	0.28	1.02
02/09/2014	7.80	4.37	3.33	0.21	0.30	1.10
03/09/2014	7.71	3.88	2.87	0.23	0.35	1.25
04/09/2014	7.70	3.80	2.80	0.20	0.28	1.02
05/09/2014	7.67	3.67	2.68	0.24	0.38	1.35
06/09/2014	7.97	5.33	4.24	0.41	0.85	3.06
07/09/2014	7.70	3.83	2.82	0.41	0.85	3.06
08/09/2014	7.61	3.36	2.39	0.39	0.77	2.77
09/09/2014	7.79	4.29	3.26	0.35	0.66	2.38
10/09/2014	8.20	6.81	5.62	0.29	0.48	1.73
11/09/2014	7.72	3.91	2.90	0.25	0.38	1.38
12/09/2014	7.61	3.34	2.37	0.23	0.34	1.23
13/09/2014	7.50	2.81	1.88	0.22	0.33	1.17
14/09/2014	8.36	7.93	6.67	0.21	0.29	1.06
15/09/2014	9.05	13.65	11.91	0.21	0.30	1.08
16/09/2014	8.39	8.18	6.91	0.21	0.30	1.10
17/09/2014	7.93	5.12	4.04	0.21	0.29	1.06
18/09/2014	7.71	3.85	2.85	0.19	0.26	0.95
19/09/2014	7.79	4.32	3.28	0.18	0.24	0.88
20/09/2014	7.73	3.96	2.95	0.19	0.25	0.91
21/09/2014	8.12	6.28	5.12	0.20	0.28	1.02
22/09/2014	7.80	4.37	3.33	0.22	0.33	1.17
23/09/2014	7.70	3.80	2.80	0.31	0.55	1.97
24/09/2014	7.62	3.39	2.42	0.26	0.41	1.46
25/09/2014	7.64	3.52	2.53	0.28	0.47	1.68
26/09/2014	7.51	2.85	1.92	0.23	0.34	1.21
27/09/2014	7.72	3.91	2.90	0.23	0.35	1.25
28/09/2014	8.18	6.67	5.50	0.20	0.27	0.99
29/09/2014	8.79	11.30	9.78	0.19	0.25	0.91
30/09/2014	7.82	4.46	3.41	0.19	0.25	0.92
01/10/2014	7.56	3.12	2.17	0.35	0.66	2.38



Chapter 6 EVALUATION ON POTENTIAL SOIL LOSS FROM CULTIVATED AREAS AND ITS MITIGATION UNDER LAND-USE CONVERSION TO THE RICE PADDY SYSTEM

1. Introduction

Soil erosion from cultivated topsoil is a major sediment source for rivers, wetlands and lake basins in Uganda (Wanyama *et al*., 2012) and such land degradation process involves water-enrichment with sediment load influencing on fish catch to become a severe peril for the livelihood under expansion of the population (De Meyer *et al*., 2011). Moreover high erosion rates are observed in the heavily populated and intensively cultivated plateau of the Lake Vicoria Basin while lesser or severer ranges observed in the South-western highland and Mt. Elgon in Eastern Uganda (Bamutaze, 2015) though such information/data for lowland area remains very limited. These potential erosion from cultivated land; specially for hilly area, may lead it to depletion of soil fertility to make crop production more critical. In the Project on Irrigation Scheme Development in Central and Eastern Uganda, Phase 2 (hereafter mentioned as PISD-2), it is essential to implement wise use concept in wetland development for proper agricultural production. In this context, it is important to utilize wetland from the perspectives of conservation of natural resources including cropland soil. Therefore, harmonizing the development of stable agricultural production and conservation of natural environment for sustainable utilization of wetland is an important consideration to be achieved. In the *10th Ramsar Convention*, a multi-function of paddy fields was recognized, and paddy field is considered as an artificial wetlands. The PISD 2 intend to utilize multiple functions of paddy fields for development plan of irrigation schemes, such as flood-control by storing rainwater over the field, maintaining of hydrologic circulation by return-flows, and soil erosion control (sediment reduction) in upland area. The multi-function of paddy fields includes the followings.

Flood control: paddy fields store rainwater temporarily and this function prevents a rapid rainwater flow, and can prevent or reduce the flood damage in the surrounding/downstream area.

Diversity: formed and maintained paddy field have developed ecosystem with rich biodiversity as semi natural system which provides rich habitats for diverse insects, animals and plants.

Soil erosion control: paddy fields; surrounded by levee and terraced on gentle sloping, can potentially trap most of sediments to settle down.

Return flow as for Environmental flows: Seepage from ditches and levee (bund) surrounding paddy contribute to shallow groundwater recharge and groundwater return flow to the river; while, overflows from paddy pouring into drains to joint with the river flow. Return flow can be utilized as "Environmental flows[1]".

[1] Environmental flows can be described as "the quality, quantity, and timing of water flows required to maintain the components, functions, processes, and resilience of aquatic ecosystems which provide goods and services to people" (World Bank), cited from http://water.worldbank.org/topics/environmental-services/environmental-flowss (date last verified 02/Jul/2015)

Figure: The photo (left) shows paddy plot developed under the SIAD Project (Sustainable Irrigated Agriculture Development) as JICA's Technical Cooperation, at Nakaloke area of Upstream Namatala Swamps; while the photo (right) shows bare upland soil under ploughing up and downward slope. Directions of ground slope and surface water are indicated by arrows.

2. Objective of the Quantitative Evaluation on Potential Soil Loss under Landuse Conversion

This study aims to compare and evaluate potential soil loss from cultivated areas under different landuse scenarios numerically by applying an empirical soil loss prediction model in order to indicate site-specific potential of erosion and its mitigation due to landuse conversion. The scenario involves the present condition and the future developed-condition; where organized, systematic land development with paddy systems is assumed to be introduced. The output information of the study here will therefore be useful to provide viewpoint on risk of soil loss from farming area hence related negative impact on crop production and areal environmental impact when considering alternative plans of development under the Project (PISD). It is not our intension to present and discuss land degradation (erosion) process to draw specific issues on soil and land management, precisely.

3. Study Area

The study areas are located in the two development-planning areas of Atari (N 1°30'14.32" E 34°26'43.35") and Sironko (N 1°20'50.84" E 34°14'32.15"); where the PISD conducted the Feasibility Study from June 2014 to July 2016, and each site share boarders of 2 or 3 districts of Bulambuli, Bukedea and/or Kween district, the lower-belt of Mt. Elgon region, Eastern Uganda. The landscape is characterized by flood plain area with streams flowing into wetland body with an elevation about 1070 meters above sea level for both sites. In addition, the entire part of each studying site is restricted to the gently undulating topography with intermittent isolated patch of rangeland like landuse (bush, grass and grazing land). Mean annual rainfall is 901-1100 mm (NEMA, 2009). The most extensive area is engaged in rain-fed agricultures except the lowest position in topography where the farmers are enabled to access water from stream or swamp for lowland rice production. Dominant soils over the regions are classified as Vertisols and Gleysols basing on the soil map of Uganda. Further detailed information is available for the Environmental Impact Assessment (EIA) report conducted under the PISD-2.

The regional soil itself was found to have moderate potential of soil loss according to a short-term instantaneous field observation conducted using a runoff plot. The runoff plot[2] measures 0.49 m wide by 5 m long (2.45 m^2), with the long axis oriented down the slope with gradient of 4.2 %.

Changes in runoff coefficient, defined as runoff divided by the corresponding rainfall both expressed as depth (mm) over catchment area of the plot, and soil loss are presented in the figures below. Mean runoff coefficient in relation to total soil loss during a 7-month period shows relatively low due to lack of observation period (less than 1 year) and also to a gentle slope gradient studied. It is; however, implying that corresponding soil loss amount falls within realistic range of soil loss from bare plots under natural rainfall of tropical climate countries as reported by Roose (1976) and Rose (2001) (**Figure-A**). This may be explained more clearly from **Figure-B** showing relationship between cumulative rainfall and corresponding soil loss. Labrière *et al.* (2015) reported that annual mean soil loss ranged from 1,495.5 to 2,458.3 g/m^2/year from runoff plots with tilled bare soil under natural/simulated rainfall; *n*=800 events, across 21 humid-tropical countries of West/Central/East Africa, South-east Asia, North East Australia, America and North Pacific Ocean, covering tropical rainforest and tropical monsoon regions, with the median values for annual rainfall (only for measured-cases), slope length and steepness were 2,444 mm, 16.4 m and 16.5 %, respectively. Under the presenting study the unit area soil loss of 2,009 g/m^2 was observed for the 7-month monitoring period.

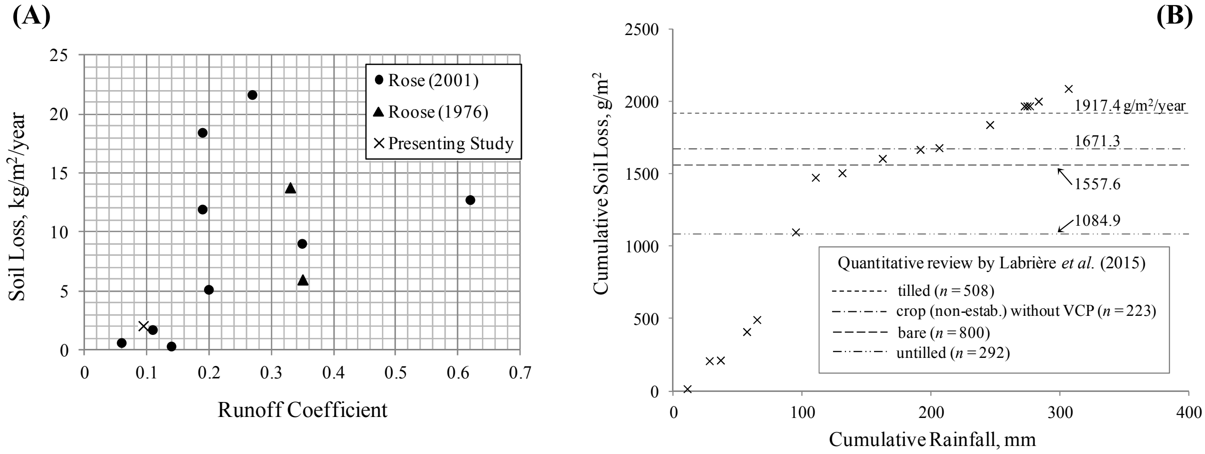


Figure: (A) Relationship between average annual runoff coefficient and soil loss (kg/m^2/year). Data set obtained from the presenting study were projected against that from the past literature including field runoff-plot study under natural rainfall across tropical climate countries of West Africa (Roose, 1976) and Southeast Asia/ Oceania (Rose, 2001). Field monitoring period of the presenting study was limited

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2 The single hydrologically isolated runoff plot was installed on a typical upland maize cultivation field in Mbale (nearby the district production office), and was maintained on bare surface during the observation period from 26th September 2015 to 27th April 2016 under natural rainfall. At the bottom (lower) of plot is a settling basin for collecting runoff/sediment, by referring to practical and low cost setup proposed by Kobayashi (2008). The rainfall amount was measured recorded for each event using a rain gauge, manually.

to 7 months while others present 1-year annual mean values for the minimum 20 m^2 to the largest 5,000 m^2 plot with slope gradient 1.25 to 50%. **(B)** Cumulative soil loss observed during a 7-month observation period in relation with cumulative rainfall and mean soil loss (g/m^2/year) reviewed by Labrière *et al.* (2015) using event data from the field runoff studies across 21 humid-tropical countries. VCP in the legend denotes vegetation-related conservation practice(s).

4. Method of soil loss estimation from the project site using USLE

(1) Quantification of average soil loss

The average soil loss (A) due to water erosion per unit area per year (t/ha) was estimated using an empirically based model, Universal Soil Loss Equation (USLE) developed by USDA-ARS (Wischmeier and Smith, 1978). The amount of potential soil erosion is calculated as

$$A = R \text{ x } K \text{ x } L \text{ x } S \text{ x } C \text{ x } P$$

where A is the average soil loss due to water erosion (ton ha^{-1} per year), R the rainfall and runoff erosivity factor (MJ mm ha^{-1} h^{-1} per year), K the soil erodibility factor (ton h MJ^{-1} mm^{-1}), L the slope length (m), S the slope steepness (%), C the cover and management practice factor, and P the support practice. The USLE, which was developed for field use in the USA, uses inputs and produces output in US customary units, thus factor values were converted to SI units (Système International d'Unitès) for presentation purpose. The calculation can basically be applicable and useful to estimate annual soil loss but not for event-to-event erosion. The application of this estimate is to enable farmers and soil conservation advisers <”planners”> to select combinations of land-use, cropping practice, and conservation practices, which will keep the soil loss down to an acceptable level (Hudson, 1993). Details of the variables for individual factor of the equation are shown below.

Table: Variable for individual factor of the USLE.

Component for Factor	Variable and description
Rainfall Erosivity Factor: R (MJ mm ha^{-1} h^{-1})	
$R = \sum E \text{ x } I_{30}$ $E = E_k \text{ x } r$ $E_k = 0.119 + 0.0873 \log_{10} I \quad (I \le 76.2 \text{ mm/h})$ $E_k = 0.283 \quad (I > 76.2 \text{ mm/h})$	where E is individual total storm kinetic energy in MJ ha^{-1} and I_{30} the maximum 30-min intensity in mm h^{-1}, E_k is the rainfall energy per unit depth of rainfall (MJ ha^{-1} mm^{-1} h^{-1}) r rainfall amount (mm), and I rainfall intensity for particular increment in a rainfall event (mm h^{-1}). The factor product EI quantifies the effects of raindrop impact and reflects the amount and rate of runoff likely to be associated with the rain (Wischmeier and Smith, 1978).
data/ measurement/ relevant information:	
Measured rainfall during March/2015 to February/2016 of Atari and Sironko were 924 mm and 1,183 mm, respectively, and these amount meet with or fall within the range of rainfall distribution; 901-1,100 mm, covering lower-belt of Mt. Elgon region while overall farmlands range 900 – over 2,100 mm (NEMA, 2009) if extended to mountainous areas. Meteorological stations (with a data-loggers) were installed nearby the site of Atari and Sironko, presenting flood plain area. The rainfall data with 10-min interval were used to calculate the individual total storm kinetic energy.	
Soil Erodibility Factor: K (t h MJ^{-1} mm^{-1})	

$100K' = 2.1M^{1.14}(10^{-4})(12-a)+3.25(b-2)+2.5(c-3)$ $M = (si+vfs)(100-cl)$ $K = 0.1317 \cdot K'$	where *a* is organic matter content, O.M. (%), *b* soil structure code under USDA, *c* soil permeability as permeability coefficient in cm/sec, *Si* content of silt (%), *vfs* content of very fine sand (%) and *Cl* (< 0.002 mm) clay content (%). *K'* is US customary unit therefore needs to be converted to SI units by factoring 0.1317. *K* value specifies the tendency of the soil to erode. The formula is applicable if the combined content (%) of soil and very fine sand (0.1-0.05mm) below 70% for estimation of *K'* value. The factor reflects the ease with which the soil is detached by splash during rainfall and/or surface flow; related to the integrated effect of rainfall, runoff and infiltration and accounts for the influence of soil properties on soil loss during storm runoff events (Angima *et al*., 2003).

data/ measurement/ relevant information:

Parameters were determined based on the basic soil physical characteristics investigated by the Environmental Impact Survey conducted by the PISD Project during 2015 September/October (wet season) and 2016 February (dry season). The soil samples were collected from top layer (A1) and air dried at about 25°C for 5 days to eliminate the moisture followed by sieving through a 2 mm mesh to remove debris and other non-soil materials including stones and plant roots. The sieved soil sample were then analysed from the Soil, Plant and Water analytical Laboratory at the Department of Agricultural and Environmental Science, Makerere University. Soil particle size distribution was determined using the hydrometer method to separate particles using the British Standard mesh-size (civil engineering). Soil samples were collected from 3 plots of each of two rice fields and one upland field within the project planning site to composite for representativeness over the site (in the wet and the dry seasons). Soil permeability (rate) was measured *in situ* by a simple filed percolation test using a dug hole. Soils of rangeland (bush/grassland) were categorized as upland soils due to their topographic location and therefore the same *K* value were applied across these fields.

Slope Length Factor: *LS*

$LS = (L'/22.1)^m (65.41\sin^2\theta + 4.56\sin\theta + 0.065)$ $m = 0.5$ (ps ≥ 5.0 ps : slope steepness %) $= 0.4$ (3.5 ≤ ps ≤ 4.5) $= 0.3$ (1.0 ≤ ps ≤ 3.0) $= 0.2$ (ps < 1.0)	where θ is slope gradient in degree. Measurements for *LS* were taken from the top of each field plot to its position down-slope (edge) where deposition was more than detachment and the length was less than 200 m. The factor accounts for the effect for the effect of slope length and slope gradient on erosion (Angima *et al*., 2003).

data/ measurement/ relevant information:

Field slope length and gradient were determined using the 1:50,000 topographic map (1-m contour interval) developed for Atari and Sironko by the Aerial Photo Survey conducted for the PISD Project during the dry season February 2016. Maximum slope length was identified by taking consideration of erosion or deposit dominant area and related boundaries of landuse of each site. Aerial photos were also referred to overview ground conditions of the site. Field plots under different landuse were categorized into groups by range of maximum slope length to determined *LS* factor, individually.

Cover management factor: *C*

C (dimensionless ratio) *0≦C≦1*	*C*-factor is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from a clean-tilled, continuous fallow. This factor represents the reducing effects of plant canopy and plant residue on soil erosion.

data/ measurement/ relevant information:

C-factor was determined by reviewing and referring to previous field studies (literature) in which the USLE was directly applied for their individual evaluation purposes. The literature discussed mostly on erosion impacts under landuse difference or conversion from scale of rice-paddy plots to watershed comprising lowland paddies and others. Similarity in climate, annual precipitation, topographic location, feature of rice paddy practices were considered to select and adopt a value for the factor.

Support practice factor: *P*

P (dimensionless ratio) *0≦C≦1*	*P*-factor is defined as the ratio of soil loss with a specific support practice to the corresponding soil loss with up and down the slope culture, including terracing, contour tillage, and permanent barriers or strips. The value varies depending on the slope length and steepness.

data/ measurement/ relevant information:

P-factor was determined also by reviewing and referring to the literature in which the USLE was directly applied. The literature discussed mostly on erosion impacts under landuse difference or conversion from scale of rice-paddy plots to watershed comprising lowland paddies and others. Similar consideration was taken into account for practical purpose. Note that *P*-factor value was changed from 1.0 (= no conservation measure, ploughing up and down slope directions) to 0.6 for the developed scenario where enhanced farm practices (plot arrangement, tillage and land husbandry) are to be expected. Range of slope gradient falls within 1–2 % or less than that.

Table: Current landuse (area, ha) for Atari and Sironko project areas calculated by the Arc-GIS database.

Scenarios

Present

Atari:

Landuse	Area, ha
Bush (rangeland)	28
Grass field (rangeland/grazing)	196
Cultivated field	219
Paddy field	211
Total	654

Sironko:

Landuse	Area, ha
Bush (rangeland)	380
Grass field (rangeland/grazing)	594
Cultivated field	341
Paddy field	144
Total	1,459

Developed (land converted)

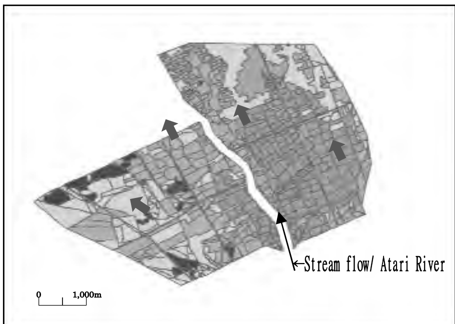
Atari:

Landuse	Area, ha
Paddy field	570
Other cultivated land	84
Total	654

Sironko:

Landuse	Area, ha
Paddy field	1,000
Other cultivated land	459
Total	1,459

Note: Broadleaf area, river (0-2ha), swamp, road and other spaces excluded for analytical purpose. Area of unit farm plots (rice/other crop) under the developed condition assumed as 50 x 150 (m^2) and 50 x 200 (m^2) for Atari and Sironko, respectively.



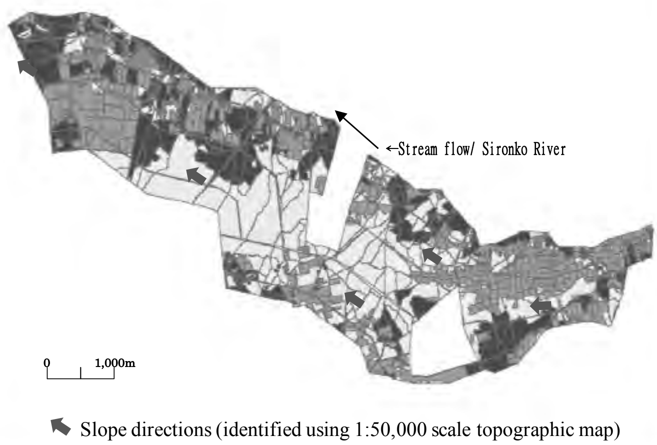


Figure: Landuse map for the project planning area of Atari (left) and Sironko (right) under present condition.

Figure: Aerial view of the left bank Atari commanding typical landuse condition. Arrows indicate direction of slope (maximum slope length) with very gentle steepness. The aerial photograph obtained during the aerial photo survey conducted for the PISD Project in February 2015.

5. Result

Individual parameters for USLE equation are summarized below for both Atari and Sironko. Data presented here are meant to show process of soil loss estimation using the empirical model that hinder some key process of soil erosion by water.

Table: Summary of *R* value (rainfall erosivity) for Atari and Srironko (present/developed).

Site: Atari

Month, 2015/16	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total	Total Rainfall, mm
R , MJ・mm/ha・h	183	729	406	1,083	26	167	79	277	152	761	1,381	0	5,244	924
%	3.5	13.9	7.7	20.6	0.5	3.2	1.5	5.3	2.9	14.5	26.3	0.0	100.0	-

Site: Sironko

Month, 2015/16	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Total	Total Rainfall, mm
R , MJ・mm/ha・h	233	1,073	1,057	439	53	713	511	116	1,192	180	20	0	5,585	1,183
%	4.2	19.2	18.9	7.9	1.0	12.8	9.2	2.1	21.3	3.2	0.4	0.0	100.0	-

Table: Summary of *K* value (soil erodibility) for Atari and Srironko (present/developed).

Site: Atari

Site	Soil type	Percentage, %				*M***	*a*	*b*	Coefficient of permeability	*c*	*K'*	*K*
		Sand	Clay (Cl)	Silt (Si)	VFS*		O.M, %	Structure		Permeability		t・h/MJ・mm
Lowland Rice	Sandy Clay Loam	50.0	36.0	14.0	16.5	1952	4.86	3	10^{-5}	3	0.1170	0.0154
Upland	Sandy Clay Loam	52.0	36.0	12.0	13.0	1600	5.25	3	10^{-5}	3	0.0962	0.0127

Site: Sironko

Site	Soil type	Percentage, %				*M***	*a*	*b*	Coefficient of permeability	*c*	*K'*	*K*
		Sand	Clay (Cl)	Silt (Si)	VFS*		O.M, %	Structure		Permeability		t・h/MJ・mm
Lowland Rice	Sandy Loam	60.0	26.0	14.0	18.0	2368	3.94	2	10^{-4}	3	0.1189	0.0157
Upland	Sany Loam	58.0	36.0	10.0	20.5	1952	3.88	2	10^{-5}	3	0.0961	0.0127

*VFS: Very Fine Sand, 0.18-0.063mm instead of 0.1-0.05mm (USDA)

***M* = (Si+VFS) (100-Cl)

b : Soil Structure
1 very fine granular
2 fine granular
3 med. or coarse granular
4 blocky, platy or massive

c : Permeability
6 very slow
5 slow
4 slow to med.
3 moderate
2 mod. to rapid
1 rapid

Site: Atari

Site	Soil type	*K* , t・h/MJ・mm
developed farm area	Sandy Clay Loam	0.0140

**K* value as an average value of lowland and upland areas, Atari (assumption: soil material of top layer removed and spread over the development area during construction period under the project implementation)

Site: Sironko

Site	Soil type	*K* , t・h/MJ・mm
developed farm area	Sandy Clay Loam	0.0142

**ditto* (for Sironko)

Table: Summary of *LS* value (topographic factor) for Atari and Srironko (present/developed).

Site: Atari

Slope category	Landuse of Segment	No of plot	L', m	θ, °	ps, %	m	LS
Atari, Right bank upper	Paddy field small	35	30	0.23	0.40	0.2	0.090
	Paddy field med	60	50	0.23	0.40	0.2	0.099
	Paddy field large	64	80	0.23	0.40	0.2	0.109
	Cultiv. land small	9	20	0.23	0.40	0.2	0.083
	Cultiv. land med	15	40	0.23	0.40	0.2	0.095
	Cultiv. land large	10	80	0.23	0.40	0.2	0.109
	Grass land med	4	60	0.23	0.40	0.2	0.103
Atari, Right bank lower	Paddy field small	20	30	0.12	0.21	0.2	0.080
	Paddy field med	40	80	0.12	0.21	0.2	0.097
	Cultiv. land small	120	20	0.12	0.21	0.2	0.073
	Cultiv. land med	15	50	0.12	0.21	0.2	0.088
	Cultiv. land large	11	100	0.12	0.21	0.2	0.101
	Grass land med	6	100	0.12	0.21	0.2	0.101
	Bush med	0					
Atari, Left bank	Paddy field small	10	20	0.33	0.58	0.2	0.092
	Paddy field med	19	50	0.33	0.58	0.2	0.110
	Paddy field large	13	80	0.33	0.58	0.2	0.121
	Cultiv. land small	35	20	0.33	0.58	0.2	0.092
	Cultiv. land med	58	60	0.33	0.58	0.2	0.114
	Cultiv. land large	4	100	0.33	0.58	0.2	0.126
	Grass land small	30	30	0.33	0.58	0.2	0.099
	Grass land med	35	60	0.33	0.58	0.2	0.114
	Grass land large	10	200	0.33	0.58	0.2	0.145
	Bush med	13	100	0.33	0.58	0.2	0.126

Site: Sironko

Slope category	Landuse/Size	No of plot	L', m	θ, °	ps, %	m	LS
Sironko, upper	Paddy field med	170	80	0.13	0.23	0.2	0.098
	Cultiv. land med	40	60	0.13	0.23	0.2	0.092
	Grass land med	30	80	0.13	0.23	0.2	0.098
	Bush med	25	120	0.13	0.23	0.2	0.106
Sironko, middle	Paddy field med	15	80	0.14	0.24	0.2	0.099
	Paddy field large	2	200	0.14	0.24	0.2	0.119
	Cultiv. land med	110	80	0.14	0.24	0.2	0.099
	Grass land med	111	80	0.14	0.24	0.2	0.099
	Bush med	40	120	0.14	0.24	0.2	0.107
Sironko lower	Paddy field small	0					
	Cultiv. land small	90	40	0.08	0.14	0.2	0.081
	Cultiv. land med	30	80	0.08	0.14	0.2	0.092
	Cultiv. land large	12	200	0.08	0.14	0.2	0.111
	Grass land med	50	80	0.08	0.14	0.2	0.092
	Bush med	53	120	0.08	0.14	0.2	0.100

Site: Atari

Location	Landuse/Size	No of plot	L', m	θ, °	ps, %	m	LS
over developed area	Paddy rice	760	150	0.23	0.401	0.2	0.124
	Upland crop	112	150	0.23	0.401	0.2	0.124

*reclaimed unit field plot sized as 150m(L) by 50m

Site: Sironko

Location	Landuse/Size	No of plot	L', m	θ, °	ps, %	m	LS
over developed area	Paddy rice	1,000	200	0.12	0.209	0.2	0.116
	Upland crop	459	200	0.12	0.209	0.2	0.116

*reclaimed unit field-plot sized as 200m(L) by 50m

Table: Summary of *C* (crop management factor) and *P* (conservation practice factor) value for Atari and Srironko (present/developed).

C Factor:
P Factor:

Landuse	*C*	*P*
Rice paddy (lowland)	0.28	0.1
upland crop, cultivated	0.35	1
bush (rangeland)	0.10	1
grassland (rangeland/grazing-yard/prairie)	0.10	1

Under developed conditions

Landuse	*C*	*P*
Rice paddy	0.28	0.1
Cultivated with upland crop	0.35	0.6

Factors in litelature:

Literature	Landuse	*C* Factor	*P* Factor
Roose (1976)	Rice paddy (lowland), intensive fertilization	0.1-0.2	
West Africa (coastal countries)	Cultural techniques: corn, sorghum, millet	0.4-0.9	
annual rainfall 500-2100 mm	Crop cover of slow development	0.3-0.8	
	Over-grazed savannah or prairie	0.1	
	Bare soil continuously fallowed	1	
Wischmeier and Smith (1978)	No mulch (0% grand cover)	1	
USDA-ARS *In* the Manual for USLE	If rows and tillage are in the direction of slope/ when terrace is not maintained and overtopping is frequent		1
	Contouring (slope 1-2%)		0.6
	Farm planning area (slope 1-2%)		
	-contour factor		0.6
	-stripcrop factor		0.3
JICA (1999)	Paddy (terrace)	0.01	0.04
Indonesia, West Java (ann. rainfall 2,000 mm)	Uplands (contour bund)	0.4	0.5
Komamura et al. (2000)	Forest	0.001	
Thailand, South	Paddy	0.028	
SCL - CL soil	Perrenial crop	0.2	
	Urban	0.45	
	Orchard	0.15	
	Bare land	0.8	
	Others	0.225	
Ohbayashi et al. (2002)	Paddy land	0.1	
China, Sichuan	Paddy-wheat	0.111	
Calcareous soil	Wheat(rape)-s.poteto+corn	0.227	
	Wheat(rape)-corn	0.339	
Yoshikawa et al. (2004)	Paddy land, flat plane	0.38	0.6
Japan	Paddy land, slope side	0.02	0.5
	Paddy land, abandoned, slope side	0.04	0.5
	Upland field: corn	0.4	
	Mowing grass	0.02	1
	- longitudinal ridge/flat ridge		1
Paiboonsak et al. (2005)	Paddy field	0.28	0.1
Thailand, Northest (rainfall 950-1300 mm)	Crop field	0.6	1
lowland restricted to paddy			
Vezina et al. (2006)	Paddy field	0.55	0.1
Vietnam, northern highland (mean rainfall 1500mm/yr)			
paddy rice (2 cycles) alluvial plains (0-10° slope)			
Unoki et al. (2009)	Forest	0.005	
Japan, Hokkaido	Wheat	0.2	if no conserv. meas., *P*=1
volcanic ash soil	Other than wheat	0.4	
	Grassland	0.02	
	Bare land	1	
	Water body	0	
Shinde et al. (2009)	Paddy	0.28	
India	Corn	0.35	
annual rainfall 1300 mm (monsoon)	Forest	0.004	
	Range	0.1	
	Wetland	0.4	
	Water body	1	
	- land with 0-2 % slope		0.6
Chen et al. (2012)	Rice cultivation	0.1	0.01
Northern Taiwan	- abandaned	0.05	0.01
terraced paddy system	- green manure amendment	0.25	0.01
Lai et al. (2015)	Paddy field/ non-irrigated farmland	0.06	0.11
China, south	0-5% slope		
typical hilly area, 1500-2400 mm rain			
OMAF*	grain corn	0.4	
Ontario, Canada	silage corn	0.5	
	cereals (spring & winter)	0.4	
	seasonal horticultural crops	0.5	
	fruit trees	0.1	
	hay and pasture	0.02	
	up&down slope		1
	cross slope		0.75
	contour farming		0.5
	strip cropping, cross slope		0.37
	strip cropping, contour		0.25

*OMAFRA: Ontario Ministry of Agriculture, Food and Rural Affairs

Table: Summary of computed soil loss *A* (t) as 1-year basis under present condition of Atari and Sironko.

Site: Atari River Basin

Location	Landuse/Size	No of plot	*R* (MJ・mm/ha・h)	*K* (t・h/MJ・mm)	*L*・*S*	*C* (0≦*C*≦1)	*P* (0≦*P*≦1)	*A* (t/ha per year)	Area within the Project Site (ha)	Soil Loss (t per year)
Right bank, upper	Paddy field small	35	5,244	0.0154	0.090	0.28	0.1	0.2030		
	Paddy field med	60	5,244	0.0154	0.099	0.28	0.1	0.2248		
	Paddy field large	64	5,244	0.0154	0.109	0.28	0.1	0.2469		
Right bank, lower	Paddy field small	20	5,244	0.0154	0.109	0.28	0.1	0.2469		
	Paddy field med	40	5,244	0.0154	0.097	0.28	0.1	0.2191		
Left bank	Paddy field small	10	5,244	0.0154	0.092	0.28	0.1	0.2073		
	Paddy field med	19	5,244	0.0154	0.110	0.28	0.1	0.2490		
	Paddy field large	13	5,244	0.0154	0.121	0.28	0.1	0.2735		
						---------- average ----------		0.2338	211	49.3
Right bank, upper	Cultiv. land small	9	5,244	0.0127	0.083	0.35	1.0	1.923		
	Cultiv. land med	15	5,244	0.0127	0.095	0.35	1.0	2.209		
	Cultiv. land large	10	5,244	0.0127	0.109	0.35	1.0	2.537		
Right bank, lower	Cultiv. land small	120	5,244	0.0127	0.073	0.35	1.0	1.706		
	Cultiv. land med	15	5,244	0.0127	0.088	0.35	1.0	2.049		
	Cultiv. land large	11	5,244	0.0127	0.101	0.35	1.0	2.354		
Left bank	Cultiv. land small	35	5,244	0.0127	0.092	0.35	1.0	2.130		
	Cultiv. land med	58	5,244	0.0127	0.114	0.35	1.0	2.653		
	Cultiv. land large	4	5,244	0.0127	0.126	0.35	1.0	2.939		
						---------- average ----------		2.278	219	499
Right bank, upper	Grass land med	4	5,244	0.0127	0.103	0.10	1.0	0.684		
Right bank, lower	Grass land med	6	5,244	0.0127	0.101	0.10	1.0	0.673		
Left bank	Grass land small	30	5,244	0.0127	0.099	0.10	1.0	0.660		
	Grass land med	35	5,244	0.0127	0.114	0.10	1.0	0.758		
	Grass land large	10	5,244	0.0127	0.145	0.10	1.0	0.964		
						---------- average ----------		0.748	196	147
Right bank, upper	Bush med	0	5,244	0.0127	0.000	0.10	1.0	0.000		
Right bank, lower	Bush med	0	5,244	0.0127	0.000	0.10	1.0	0.000		
Left bank	Bush med	13	5,244	0.0127	0.126	0.10	1.0	0.840		
						---------- average ----------		0.280	28	7.84
			Total Soil Loss from the Project Area, ton/year							**703**

Site: Sironko Wetland

Location	Landuse/Size	No of plot	*R* (MJ・mm/ha・h)	*K* (t・h/MJ・mm)	*L*・*S*	*C* (0≦*C*≦1)	*P* (0≦*P*≦1)	*A* (t/ha per year)	Area within the Project Site (ha)	Soil Loss (t per year)
Upper	Paddy field med	170	5,585	0.0157	0.098	0.28	0.1	0.240		
Middle	Paddy field med	15	5,585	0.0157	0.099	0.28	0.1	0.243		
	Paddy field large	2	5,585	0.0157	0.119	0.28	0.1	0.291		
Lower	Paddy field med	0	5,585	0.0157	0.000	0.28	0.1	0.000		
						---------- average ----------		0.193	144	28
Upper	Cultiv. land med	40	5,585	0.0127	0.092	0.35	1.0	2.287		
Middle	Cultiv. land med	110	5,585	0.0127	0.099	0.35	1.0	2.450		
Lower	Cultiv. land small	90	5,585	0.0127	0.081	0.35	1.0	1.993		
	Cultiv. land med	30	5,585	0.0127	0.092	0.35	1.0	2.289		
	Cultiv. land large	12	5,585	0.0127	0.111	0.35	1.0	2.749		
						---------- average ----------		2.354	341	803
Upper	Grass land med	30	5,585	0.0127	0.098	0.10	1.0	0.692		
Middle	Grass land med	111	5,585	0.0127	0.099	0.10	1.0	0.700		
Lower	Grass land med	50	5,585	0.0127	0.092	0.10	1.0	0.654		
						---------- average ----------		0.682	594	405
Upper	Bush med	25	5,585	0.0127	0.106	0.10	1.0	0.751		
Middle	Bush med	40	5,585	0.0127	0.107	0.10	1.0	0.759		
Lower	Bush med	53	5,585	0.0127	0.100	0.10	1.0	0.709		
						---------- average ----------		0.740	380	281.1
			Total Soil Loss from the Project Area, ton/year							**1,517**

Table: Summary of computed soil loss *A* (t) as 1-year basis under "developed" condition of Atari and Sironko.

Site: Atari River Basin

Location	Landuse/Size	No of plot	*R* (MJ・mm/ha・h)	*K* (t・h/MJ・mm)	*L*・*S*	*C* (0≦*C*≦1)	*P* (0≦*P*≦1)	*A* (t/ha per year)	Area within the Project Site (ha)	Soil Loss (t per year)
Atari	Paddy rice	760	5,244	0.0140	0.124	0.28	0.10	0.2551	570	145.4
under development	Upland crop	112	5,244	0.0140	0.124	0.35	0.60	1.9133	84	161
		Total Soil Loss from the Project Area								**306**

Site: Sironko Wetland

Location	Landuse/Size	No of plot	*R* (MJ・mm/ha・h)	*K* (t・h/MJ・mm)	*L*・*S*	*C* (0≦*C*≦1)	*P* (0≦*P*≦1)	*A* (t/ha per year)	Area within the Project Site (ha)	Soil Loss (t per year)
Sironko	Paddy rice	1,000	5,585	0.0142	0.116	0.28	0.10	0.2575	1,000	257.5
under development	Upland crop	459	5,585	0.0142	0.116	0.35	0.60	1.9314	459	887
		Total Soil Loss from the Project Area								**1,144**

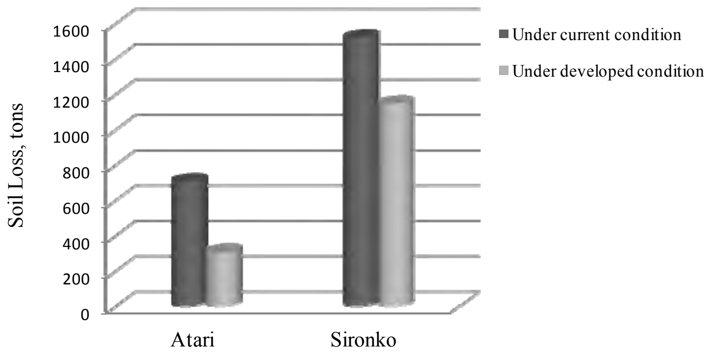


Figure: Estimated volume of soil loss from the planning area (over 1-year period).

6. Discussion

In the study, we evaluated potential soil loss from cultivated land of two development planning areas of Atari and Sironko under the scenarios including present landuse and the developed condition with paddy system for a single year using the data set of 1-year rainfall, basic soil and landuse information. Soil loss amount (t/year) and unit area of soil loss amount (t/ha/year) estimated by applying the USLE were summarized in the table below. Both year-based and unit area soil loss amount from Atari and Sironko shows significant differences reflecting scale difference being associated with inherit landuse difference over the two sites under landuse-conversion. Magnitude of soil loss is greater for Sironko than that of Atari implying severer potential of soil erosion due mainly to spatial landuse patterns within the planning area which comprise of lowland paddies, cultivated land and rangelands. This may be reasonable result regarding closed value ranges of slope gradient, soil properties and the total storm kinetic energy of rainfall (5,244 and 5,585 MJ mm/ha/h for Ataria and Sironko, respectively) across two sites and these are reflected by the factors of *LS*, *K* and *R*. Higher amount of soil loss for Sironko is attributed to increased cultivated land (with upland crop) for sediment source under the scenario of "developed condition" where vast area of rangelands having relatively higher ability of buffering are converted to the cultivated land. Consequently it is estimated greater mitigation of soil loss for Atari than for Sironko, as indicated by the percent mitigation.

Table: Estimated volume of soil loss (t/ha) from the planning area for 1-year observation period.

Condition	Atari	Sironko
Under current condition	703 t (1.07 t/ha/year)	1,517 t (1.04 t/ha/year)
Under developed condition (paddy and cultivated fields)	306 t (0.47 t/ha/year)	1,144 t (0.78 t/ha/year)
Total cultivated area* yielding soil loss	654 ha	1,459 ha
Percent mitigation	**56 %**	**25 %**

*landuse data calculated for areal distribution of individual landuse based on Arc-GIS analysis. The total area includes Bush, Cultivated field, Grassland and Paddy field as current landuse basis; while, residential area, road, swamps, and other spaces were excluded.

Percent mitigation, degree of soil loss mitigation under different landuse setup, is defined as

$$\text{Percent Mitigation (\%)} = \frac{(S_0 - S_{conserv})}{S_0} \text{x}100$$

where S_0 is soil loss estimated for current condition (t/year), and $S_{conserv}$ is soil loss estimated for developed condition (t/year).

Ranges of soil loss (t/ha/year) estimated by the presenting study are compare with the previous field studies conducted for various landscape and landuse conditions within Uganda (see the table below). Soil loss amount of the two sites under the present or the developed condition falls within the range of low gentle slope gradient that can be found on hillslope position of cultivated field with slope gradient of a few percentages (1-6%), as is estimated by Brunner *et al*. (2008).

Table: Example of measured mean annual soil loss from dominant landuse system in Uganda.

Range of soil loss (t/ha/year)	Landscape	Landuse	Author
34 - 207	Plateau	Footpaths and agricultural fields	De Meyer *et al*. (2011)*
40 - 45	Plateau	Maize, maize-bean intercrop	Majaliwa (1998)*
35.99	Mountainous hill slopes (10-25%), Mt. Elgon region	Annual crops (maize)	Semalulu *et al*. (2014)
20	Plateau	Annual cropping	Nakileza (2005)*
3.3	Hillslope position as summit, 1-2% slope	Maize cropping on soil of Sandy Clay to Sandy Clay Loam	Brunner *et al*. (2008)**
2.5	Hillslope position as upper-shoulder, 2% slope	*Ditto*	
2.0 (average)	Entire hillslope from summit to valley, 1-6% slope	Maize cropping on soil of Sandy Clay/ Sandy Loam to Sandy Clay Loam	
0.01 - 0.32	Plateau	Forest	Kizza *et al*. (2013)*

* after Bamutaze (2015)

**estimated by a process-based physical prediction model, Water Erosion Prediction Project (WEPP, developed by USDA-Agricultural Research Service) using input parameters including soil texture, rock fragments, organic matter and Cation Exchangeable Capacity (CEC), land management, tillage option, meteorological data and delineation of overland flow elements for individual hillslope unit.

Table: Categorization of soil erosion risk for Mt. Elgon region by Jiang *et al*. (2014).

Erosion risk	Threshold (t/ha/year)
Very low	Soil Loss ≤ 2
Low	2 ≤ Soil Loss ≤ 10
Moderate	10 ≤ Soil Loss ≤ 50
High	50 ≤ Soil Loss ≤ 100
Very high	Soil Loss ≥ 100

7. Summary, Limitation of Data Interpretation and Implication for Necessity of Conservation

The study assessed the effects of landuse conversion from upland-crop dominant system to rice paddy system on potential soil loss using the empirical model USLE with available meteorological and soil data. The result of this study show that development of paddy system conserve soil of cultivated land more effectively than present condition. This is clearly shown by the mitigation percentage estimated for soil loss were 56 % and 25 % for Atari and Sironko, respectively, under the scenario of landuse conversion of the presenting study although the amount of potential soil loss as yearly basis (t/ha/year); some 0.5-1.0 t/ha/year, show very-low risk level for Atari and Sironko under two scenarios (see the table above). The ranges of erosion risk well agree with that of the lowland area analyzed and reported by Jiang *et al*. (2014) for Manafwa catchment close to Mbale. It is, however, limitation exists when interpreting these results due to the following reasons.

- USLE is not a precise research tool to study the process of erosion (Hudson, 1993).
- Validity of output data may only be verifiable if data from field measurements and simulated soil loss are compared though it is not our intension in this study.
- USLE may evaluate annual soil loss from paddy system where water-tapping/ drained off condition exist season to season despite the fact that several studies attempted to apply USLE directly for paddy system with deliberations on determining the factors of Crop and Management to approximate potential ability of the paddies to reduce outflow of sediments downward (Roose, 1976; Paiboonsak *et al*., 2005; Chen *et al*., 2012, for instance).

For example, the USLE may present soil loss output by rill, inter-rill or sheet erosion but not channel erosion over developed gully network and associated sediment transport toward in and out of the farm plots are not taken into account (Nishimura, 1998) while the process-based physical models will present this. Consequently, the results may not provide information on sediment outflow into river system and hence impact on sedimentation and relevant water quality for environment aspect. Nevertheless it is still valuable to estimate loss or replacement of top soil from farmers’ field to out of or within the plot indicating loss of farm input and other labour and financial input by the farmers on their properties as a foundation for crop production.

For more précised analysis, Soil Water Assessment Tool (SWAT) model, developed by USDA ARS, coupling with the USLE (Sakaguchi *et al.*, 2014) applicable for soil loss from paddy area, would be practical to evaluate event-to-event sedimentary discharge based on individual parameters representing regional topography, soils, landuse, farm practice, precipitation and hydrologic aspects at watershed scale. It is clear that paddy system involve complicated sedimentary and hydrological behaviour such as overflows from paddy fields during water management, paddling and drying of paddy soil where in the process transportation of sediments involve dynamics through annual farm practices.

Overall the presented result of evaluation suggests a necessity of soil conservation practices for the project site through the proposed project plan (irrigation scheme development). Nutrient losses, as NPK basis, from the top soil due to cultivation without any conservation practices can lead "Financial Loss" about US$ 172 ha/year in mountainous area of Mt. Elgon region (almost twice of that for fields with conservation) as estimated by Semalulu *et al*. (2014) for example. This holds true that prolonged soil loss process may result in serious depletion of soil fertility and hence loss of financial investment which the small-scale farmers catered for within their limited affordability despite different severity according to topographical location. Slight or very gentle slope-gradient over the project sites of Atari or Sironko involve potential erosion risk which is critically related to land preparation for upland and lowland crops (paddy rice etc) associated with surface water management. This was observed and revealed by the sedimentary outflow occurred over the lowland of Tabagonyi area in Bulambuli District near Atari (see the Figure below).

Figure: sedimentary outflow from paddy area due to inappropriate field-arrangement (land levelling, levee making, puddling and re-levelling) and related land husbandry. Photo was taken by the PISD Study Team during the survey in Atari area (Tabagonyi, Bulambuli District).

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Appendix B

Topographic Mapping by Aerial Photography Survey

Creation of the Topographic Mapping by Aerial Photography Survey

Contents

1. Aerial Photography Topographic Survey

1.1 Purpose of Creation of the Topographic Map

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 Sironko and Atari Sites and only contour lines for the Namatala and the proposed dam and reservoir sites.

1.2 Overview of Work

(1)Target Area of Survey

The target area of Aerial Photo Survey at the Phase 1 was shown in Figure 1.1.

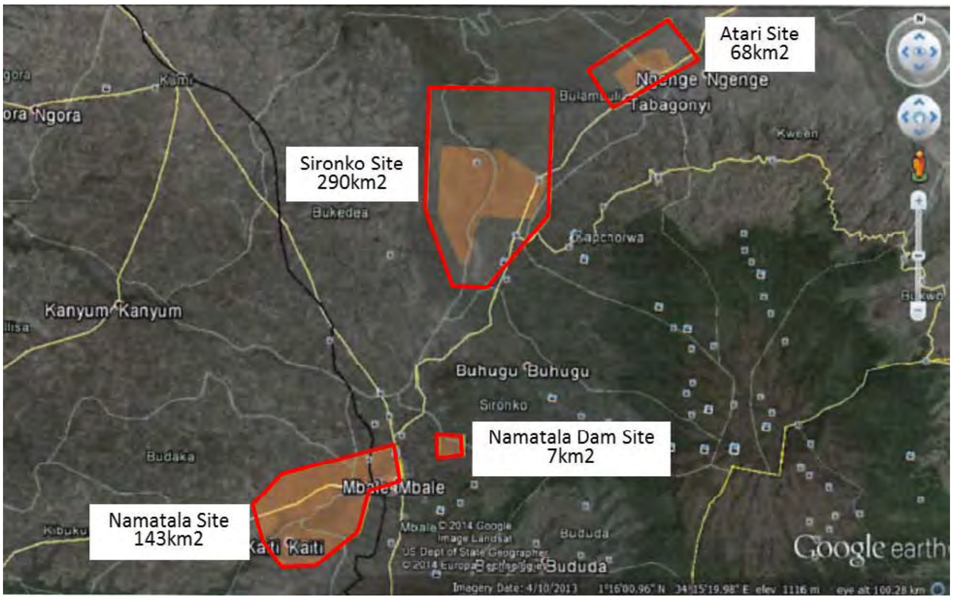


Figure 1.1 Map of the Target Area of Phase-1

The target area of Creating Topographic Map at the Phase 1 was shown in Figure 1.2.

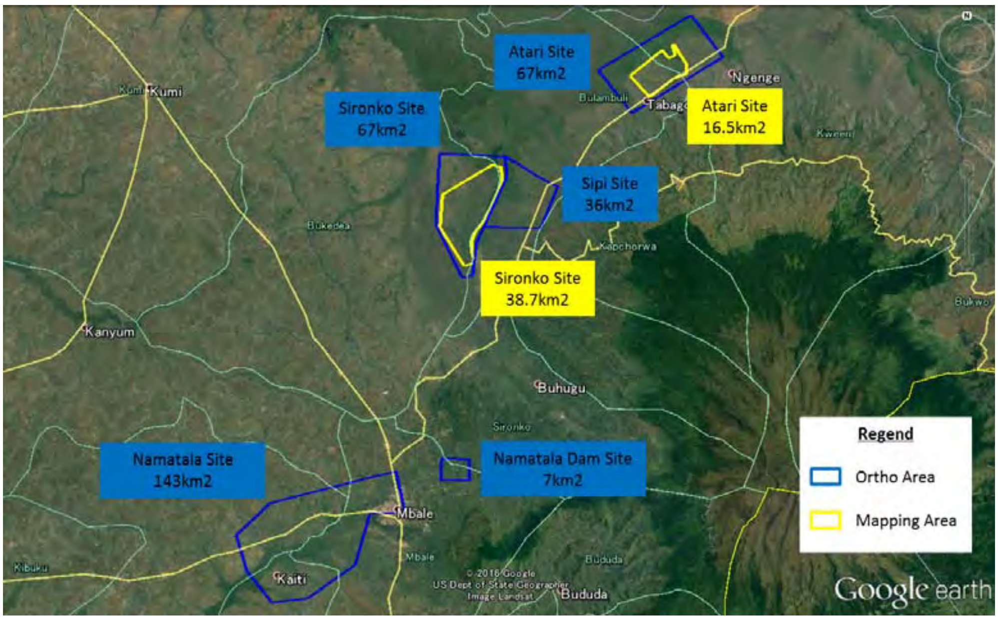


Figure 1.2 Map of the Target Area of Phase 1

(2)Specification of Survey

Scale of the topographic map that created in this work was 1/5,000. Topographic Mapping Survey was required high technology in order to satisfy the required accuracy, and needed to ensure the work schedule. Since this work was carried out working in Japan.

In Survey Operation Manual of JICA (JICA, 2006), the interval of contour lines of 1/5,000 scaled topographic maps are defined as 5m. Though, for the topographic map created in this study, the contour interval was to be 1m, because height information was very important factor to the route selection of main canals and hydraulic study. The positional accuracy of the other feature was according to the accuracy criteria of scale of 1 / 5,000 topographic map.

The specification of the topographic map created in this work is shown in Table 1.

Table 1 Specification of the Topographic Map

<table>
<tr><th>Items</th><th colspan="2">Contents</th></tr>
<tr><td>Work Method</td><td colspan="2">Construct Stereo model with digital photogrammetry workstation, acquire coordinate value of terrain and features, and generate digital plotting data.</td></tr>
<tr><td>Work items</td><td colspan="2">1) Planning, Preparation (consultation of acquiring items and criterions included), 2) Control Point Survey, 3) Aerial Photography, 4) Level Survey, 5) Aerial Triangulation, 6) Ortho Image, 7) Digital Plotting, 8) Field Identification, 9) Digital Editing, 10) Organizing Deliveries (Report making)</td></tr>
<tr><td colspan="3">F/S target 2 sites (Sironko site, Atari site)</td></tr>
<tr><td>Work Area</td><td colspan="2">F/S target 2 sites (Sironko, Atari) : approximately 55km^2</td></tr>
<tr><td rowspan="2">Specification</td><td>Error range of Aerial triangulation</td><td>Horizontal position : Within 0.3m
Elevation : Within 0.3m</td></tr>
<tr><td>Positional accuracy of Topographic map</td><td>Horizontal position : within 0.7mm on map
Elevation : within 0.5m</td></tr>
<tr><td>Acquiring items</td><td colspan="2">Roads, Buildings, Water body, Vegetation, etc. : Equivalent as 1/5,000 scale map
Contour (intermediate counter interval : 1m), etc. : Equivalent as 1/1,000 scale map</td></tr>
</table>

1.3 The Contents of Survey Work

(1)Advance Consultation – Phase 1 in Uganda -

For implementation of the survey, Study team had an advance consultation with Ramani about the work contents, notes, and so on. The main agenda was as follows.

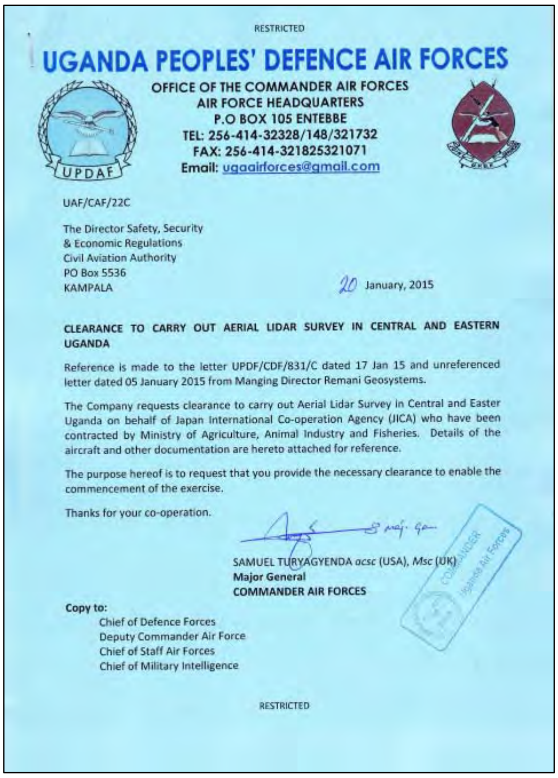
- Confirmation of safety measures
- Confirmation of work specifications
- Creation of workers list
- Confirmation of routes and way of daily contact
- Confirmation of contact system in emergency
- Confirmation of equipment
- Confirmation of work schedule
- Confirmation of deliverables

(2)Acquisition of Permission for the Aerial Photography – Phase 1 in Uganda -

Study team prepared an application form for the photography by compiling the details required for the acquisition of the permission which Study team had learned from the information which it had collected and submitted the form to the relevant authorities.

In response to the application, study team obtained permissions for the aerial photography of the target area and its surrounding area from Uganda People's Defense Air Forces on 20th January 2015 and from

Uganda Civil Aviation Authority on 27th January 2015.



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AIR FORCE HEADQUARTERS
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FAX: 256-414-321825321071
Email: ugaairforces@gmail.com

UAF/CAF/22C

The Director Safety, Security
& Economic Regulations
Civil Aviation Authority
PO Box 5536
KAMPALA

20 January, 2015

CLEARANCE TO CARRY OUT AERIAL LIDAR SURVEY IN CENTRAL AND EASTERN UGANDA

Reference is made to the letter UPDF/CDF/831/C dated 17 Jan 15 and unreferenced letter dated 05 January 2015 from Manging Director Remani Geosystems.

The Company requests clearance to carry out Aerial Lidar Survey in Central and Easter Uganda on behalf of Japan International Co-operation Agency (JICA) who have been contracted by Ministry of Agriculture, Animal Industry and Fisheries. Details of the aircraft and other documentation are hereto attached for reference.

The purpose hereof is to request that you provide the necessary clearance to enable the commencement of the exercise.

Thanks for your co-operation.

SAMUEL TURYAGYENDA *acsc* (USA), *Msc* (UK)
Major General
COMMANDER AIR FORCES

Copy to:
Chief of Defence Forces
Deputy Commander Air Force
Chief of Staff Air Forces
Chief of Military Intelligence

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CIVIL AVIATION AUTHORITY
UGANDA

Head Office Building
Entebbe International Airport
P.O. Box 5536, Kampala, Uganda

CAA/05/ACL/32

27 January 2015

Uganda Peoples' Defence Air Forces
Office of the Commander Air Forces
Air Force Headquarters
Plot 7 Combe Close
P.O. Box 105 Entebbe
Fax: + 256 414 321825/321071

Attn: Samuel Turyagyenda *acsc* (USA), *Msc* (UK)
Major General

Dear Sir

RE: CLEARANCE TO CARRY OUT AERIAL LIDAR SURVEY IN CENTRAL AND EASTERN UGANDA

Reference is made to your letter UAF/CAF/22C dated 20 January 2015 regarding the above mentioned subject.

We have noted that M/s Ramani Geosystems has been contracted by the Ministry of Agriculture, Animal Industry and Fisheries, Uganda to carry out an Aerial Lidar Survey on irrigation scheme development in Central and Eastern Uganda on behalf of Japan International Cooperation Agency (JICA).

This is to inform you that M/S Ramani Geosystems is permitted to carry out Aerial Lidar Survey for Ministry of Agriculture, Animal Industry and Fisheries under clearance number **CAA/UGA/20150126/328B**. The permit is valid from 15 January 2015 to 31 March 2015.

Please advise the crew to quote the above clearance number as and when necessary.

Before mounting the survey flights, M/S Ramani Geosystems is required to:

1) get a military clearance from UPDF Liaison Office, Entebbe International Airport – Tel. 0711 778621/ 0392 948969

2) liaise with the Directorate of Air Navigation Services (ANS), Civil Aviation Authority, for proper co-ordination of the operations. The contact

E-mail: aviation@caa.co.ug
Website: www.caa.co.ug
For Aircraft / Flight Clearance requests

Figure 1.3 Flight Permissions (Left: from UPDF, Right: from UCAA)

(3)Request for Cooperation to the Local Authorities – Phase 1 in Uganda -

Study team requested the cooperation for the survey work to local authorities. Study team explained the implementation of Aerial Photo Survey for Phase 1 to District officers and S/C officers in the target area, and confirmed the contact person who can be a guide when the survey team was entering local area.

(4)Monumentation of GCPs – Phase 1 in Uganda -

Five Ground Control Points (GCP) were established in each site (Namatala, Sironko, and Atari site). The positions of GCP establishments were basically at public land and were decided by advices from local guide. In addition, one GCP were established in Namatala Dam site to be used as the ground reference station at the time of aerial photography.

The GCPs were made by 50 cm diameter concrete with white paint to be used as signalization for aerial photos. Moreover, the GCPs were established in consideration of the durability, since they were used as a reference for following survey in this Study.

Figure 1.4 Monumentation work and Monumented GCP

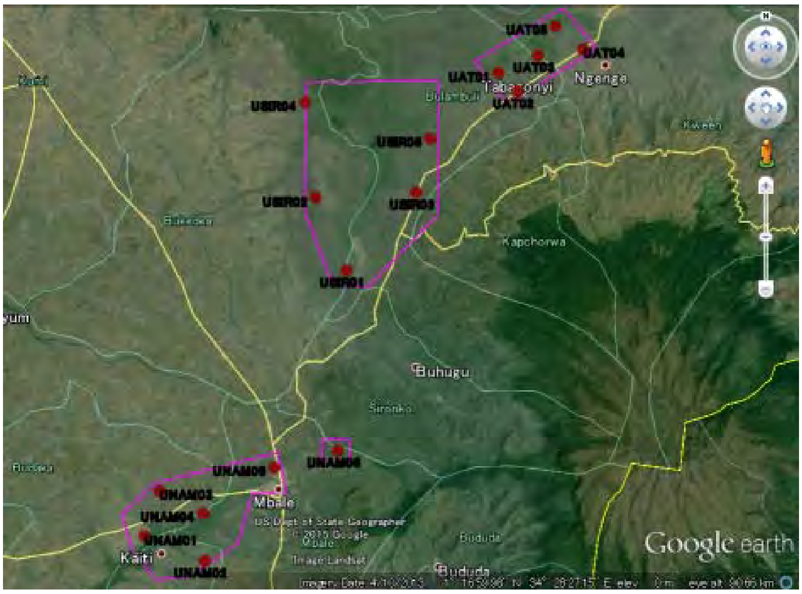


Figure 1.5 GCPs Location Map

(5)GNSS Observation (Static method) – Phase 1 in Uganda -

In order to obtain the horizontal coordinates of the established GCPs, they were observed with GNSS receivers. By analyzing the data obtained by observations with specialized software, the GCP coordinates were calculated with enough accuracy required for the digital plotting work in Phase-2.

Figure 1.6 GNSS Observation Work

(6)Minor order Leveling – Phase 1 in Uganda -

In order to obtain the elevation of the established GCPs, they were carried out leveling survey from existing Bench Mark. The existing Bench Mark was used after accuracy check between the other Bench Mark. In this work, the "BM263" was adopted as the origin of the .elevation.

Figure 1.7 Left: BM263, Right: Leveling work

(7)Aerial Photography – Phase 1 in Uganda -

The Aerial Photography was performed according to the working specifications in the target area. One established GCP in each site was used as the ground base station.

Study team confirmed that the aerial photos have enough accuracy and quality required for the digital plotting work in Phase-2.

Figure 1.8 Equipment of Aerial Photography

(8)Block Adjustment of Aero Triangulation – Phase 1 in Uganda -

The Aerial Photos data and GNSS/IMU data acquired in aerial photography were loaded into the digital photographic survey system. GCPs, pass points, and tie points in it were observed, and adjustment calculation was conducted using by the Bundle adjustment method. In the adjustment calculation, exterior orientation elements of Aerial Photos required for the creation of three-dimensional (stereo) models in the digital plotting work were obtained.

(9)Creation of Ortho Image – Phase 2 in Japan -

Using the survey results of Phase 1, Ortho image was created. Ground resolution of Ortho image is 0.1m, and the area of created the image covered whole area of Aerial photography.

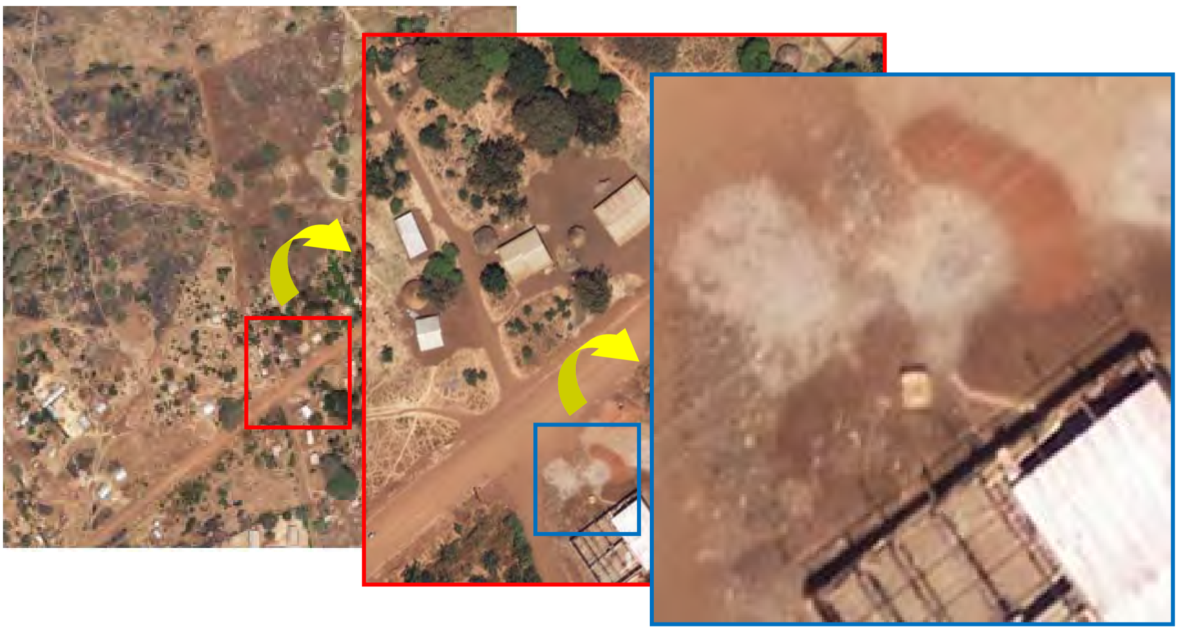


Figure 1.9 Sample of Ortho Image (GSD: 0.1m)

(10)Digital Plotting – Phase 2 in Japan -

By using the aerial photo images and aerial triangulation results in digital plotter, Digital plotting work was carried out. In the Digital plotting work, the required feature and terrain for creating map data was obtained in digital format, and stored in the CAD file.

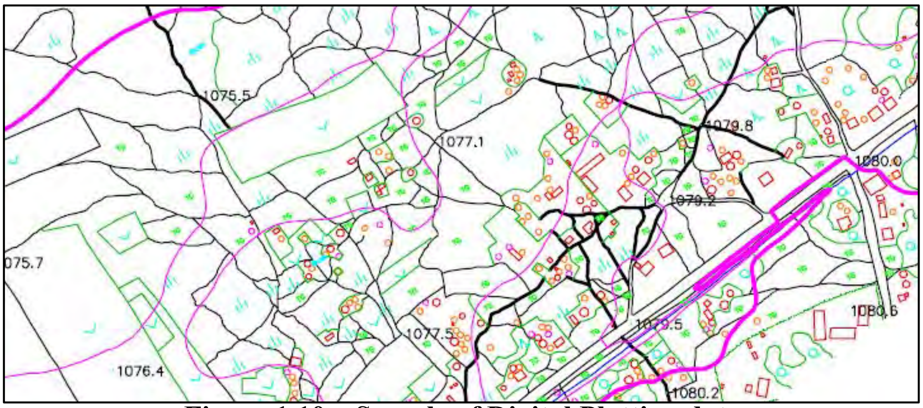


Figure 1.10 Sample of Digital Plotting data

(11)Field Verification - Phase-2 in Uganda -

By using topographic map after plotting and ortho image, the information that cannot be interpreted from the aerial photo was surveyed and confirmed in the field. And then, the field verification data was created. Surveyed items were the facility name, vegetation, small canals, wells, features that were difficult to be interpreted in plotting process, and the like.

Figure 1.11 Left: Sample of Field Verification data, Right: Wood bridge that was difficult to be interpreted from aerial photo

(12)Digital Editing - Phase-2 in Japan -

Based on the field verification data, the Digital Editing work in which the result of field verification was incorporated to the topographic map data was carried out. In this process, polygon data was created for each vegetation, and the structured data that is available in GIS was also created.

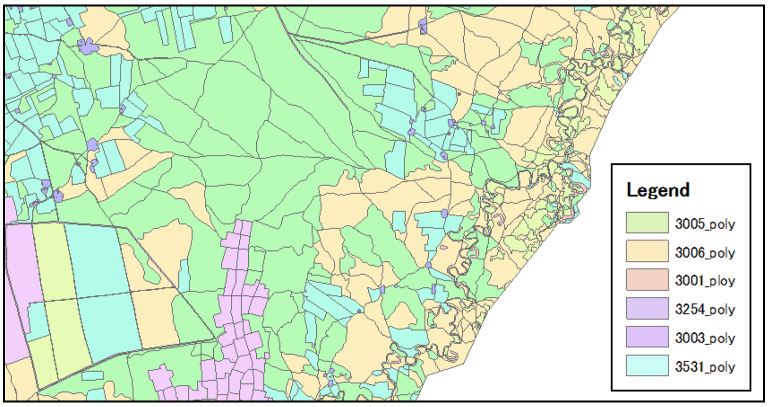


Figure 1.12 Sample of Structured Data

(13)Organizing Deliveries – Phase 2 in Japan -

By organizing topographic map data, image data, and the other data and converting the data format for use in subsequent study, the required deliverables data was created.

1.4 Deliveries

The deliveries of this work were as below.

- Aerial Photo Data (Tiff) 1set
- Result of Control Point Survey 1 set
- Aerial Triangulation Data 1 set
- Ortho Image Data (Tiff) 1 set
- Topographic Map Data (DWG, PDF) 1 set
- Structured Data (Shape) 1 set

1.5 Quality Control

The quality control to created deliverables was carried out as following.

(1)Quality Control to Control Point Survey and Aerial Photography

Study team supervised the work of Ramani, Inc., a local subcontractor, in the field. Moreover, we checked the error of the survey results based on the Survey Operation Manual of JICA, and confirmed that the error was within the limited value.

(2)Quality Control to Aerial Triangulation

Because the Ramani's survey result contained the accuracy control table, study team checked the contents of accuracy control table, and the error was confirmed to be within the limited value of the Survey Operation Manual of JICA.

(3)Quality Control to Ortho image data

By comparing the positions of the distinct features in ortho image and in plotted map data, study team checked the error in ortho image. As a result, we conformed that the error was within the limited value provided by the Survey Operation Manual of JICA.

(4)Quality Control to Topographic Map Data

In each process of creating topographic map data, study team carried out quality control by using the accuracy control table that has been defined in the Survey Operation Manual of JICA. Further, by re-plotting the same feature as the feature that was included in topographic map data, i.e. final deliveries, we compared the position coordinates of the two results. As a result, we conformed that the error was within the limited value provided by the Survey Operation Manual of JICA.

2. Aerial Photo Data

2.1 Overview of Aerial Photography

(1)Target Area of Aerial Photography

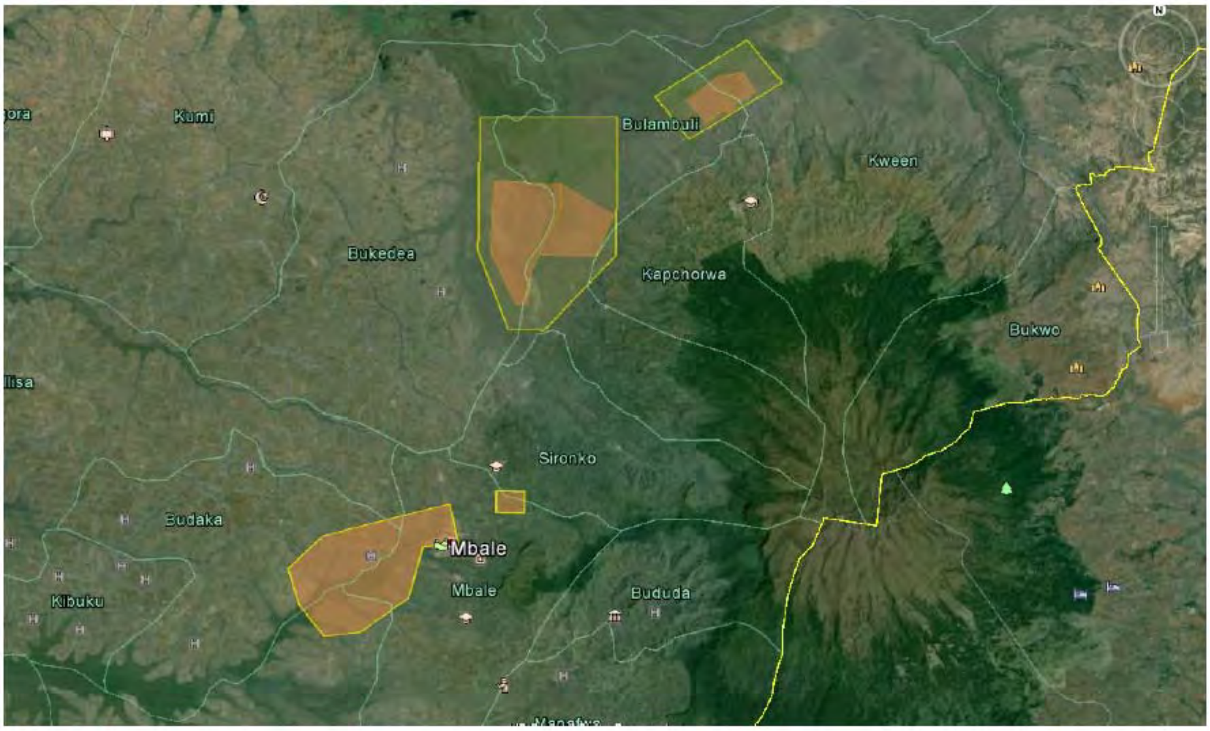


Figure 2.1 Target Area of Aerial Photography

(2)Quantity of Aerial Photography

Table 2.1 Aerial Photography Specifications Table

BLOCK	DATE FLOWN	HOURS	Strips	Events	GSD	CONDITIONS
Namatala	2015-02-09	4.3	14	552	10	Clear skies
Namatala Dam	2013-12-13	0.4	3	33	10	Clear skies
Sironko	2015-02-13	0.6	1	44	10	High Clouds
	2015-02-14	4.25	10	585	10	Clear skies
	2015-02-16	2.83	0	0	10	Overcast
	2015-02-18	4.1	8	516	10	Clouds to the south
	2015-02-19	2.6	10	462	10	Clear skies
Atari	2015-02-13	3.5	8	329	10	Clouds to the North
	2015-02-19	1.7	8	123	10	Clear Skies

2.2 Atari Site

(1)Photo Index Map

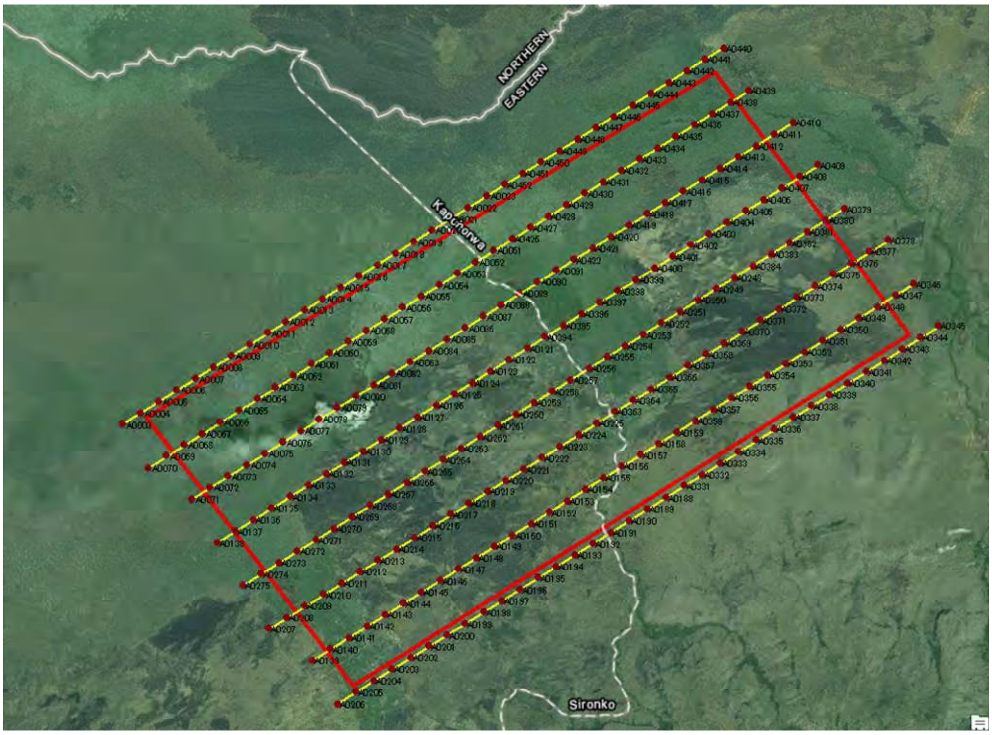


Figure 2.2 Index Map of Atari Site

(2)Sample of Aerial Photo

Figure 2.3 Sample of Aerial Photo in Atari Site

2.3 Sironko Site

(1)Photo Index Map

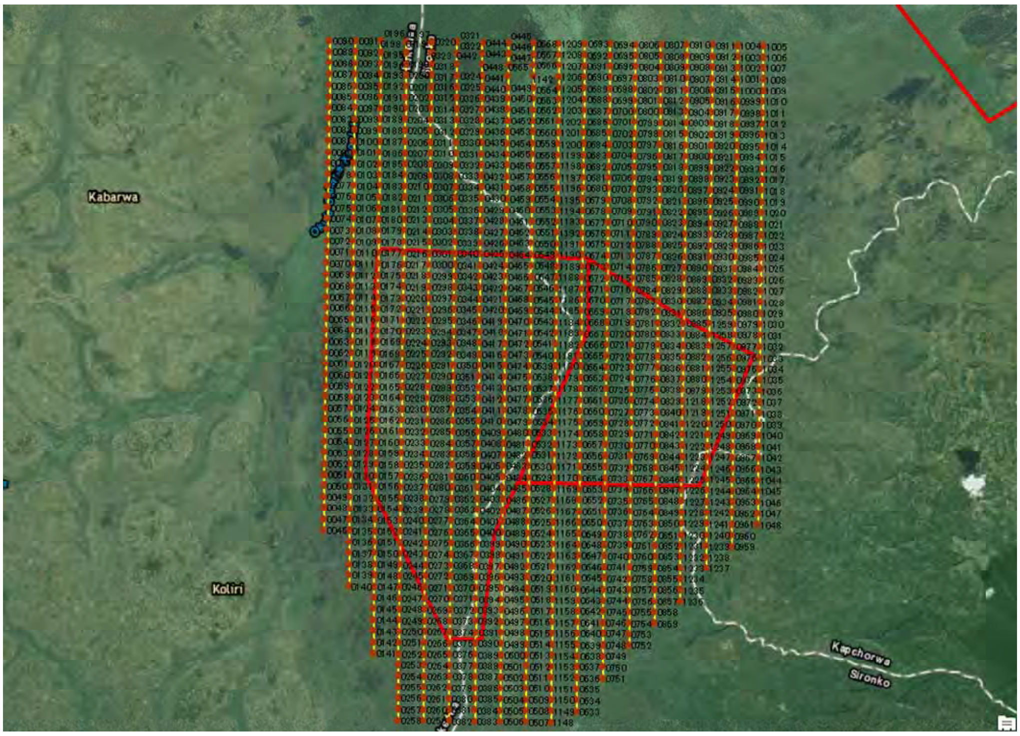


Figure 2.4 Index Map of Sironko Site

(2)Sample of Aerial Photo

Figure 2.5 Sample of Aerial Photo in Sironko Site

2.4 Namatala Site

(1)Photo Index Map

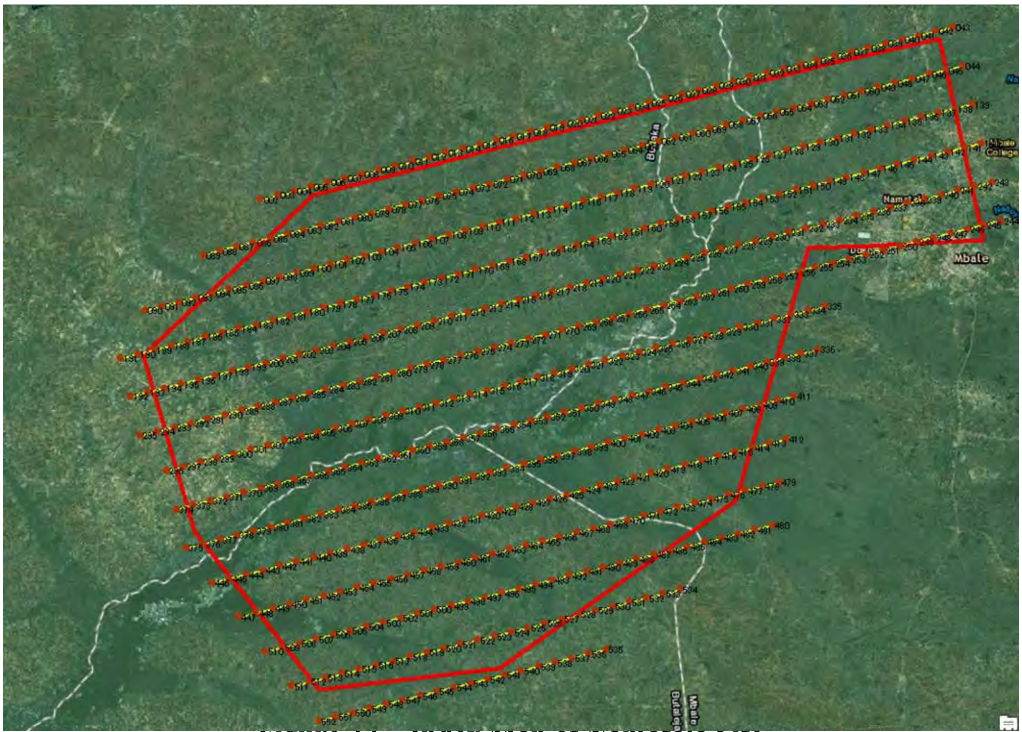


Figure 2.6 Index Map of Namatala Site

(2)Sample of Aerial Photo

Figure 2.7 Sample of Aerial Photo in Namatala Site

2.5 Namatala Dam Site

(1) Photo Index Map

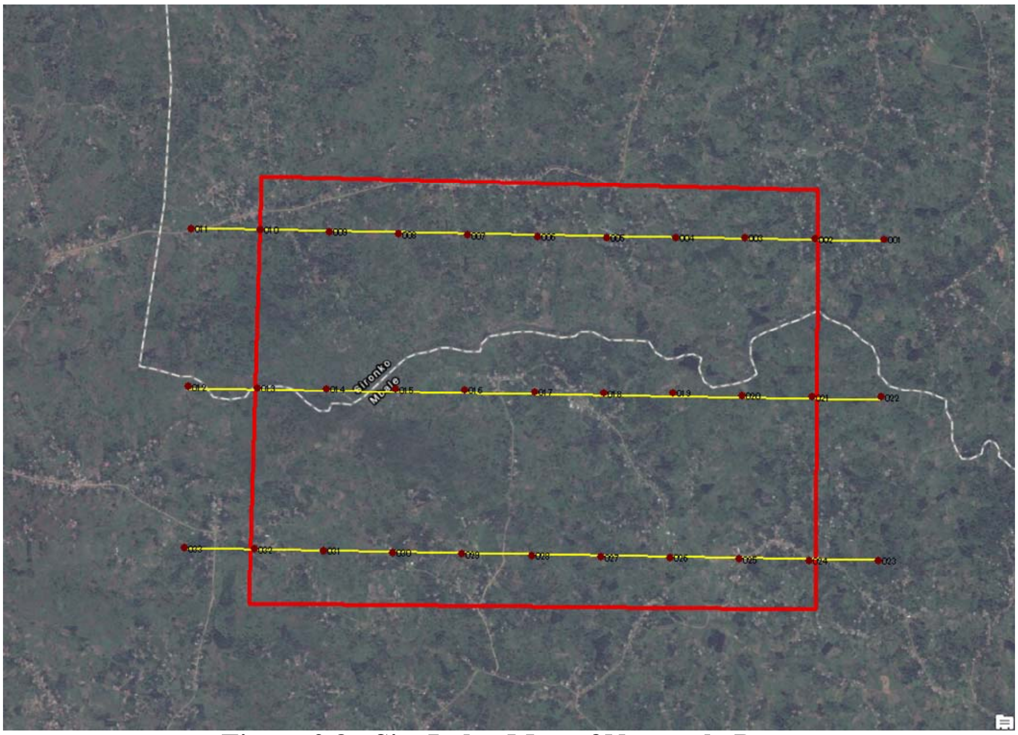


Figure 2.8 Site Index Map of Namatala Dam

(2)Sample of Aerial Photo

Figure 2.9 Sample of Aerial Photo in Namatala Dam Site

3. Result of Control Point Survey

3.1 GNSS Survey

(1)Index Map of GNSS Survey

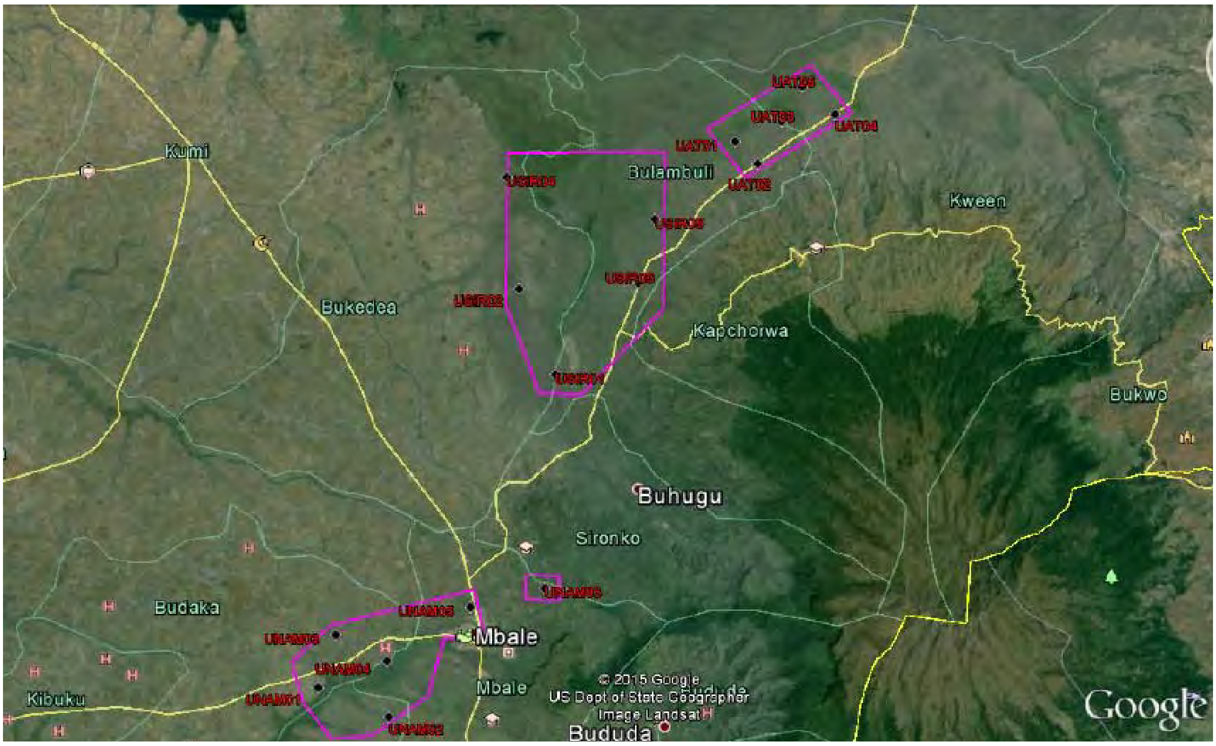


Figure 3.1 Index Map of GNSS Survey (Whole Area)

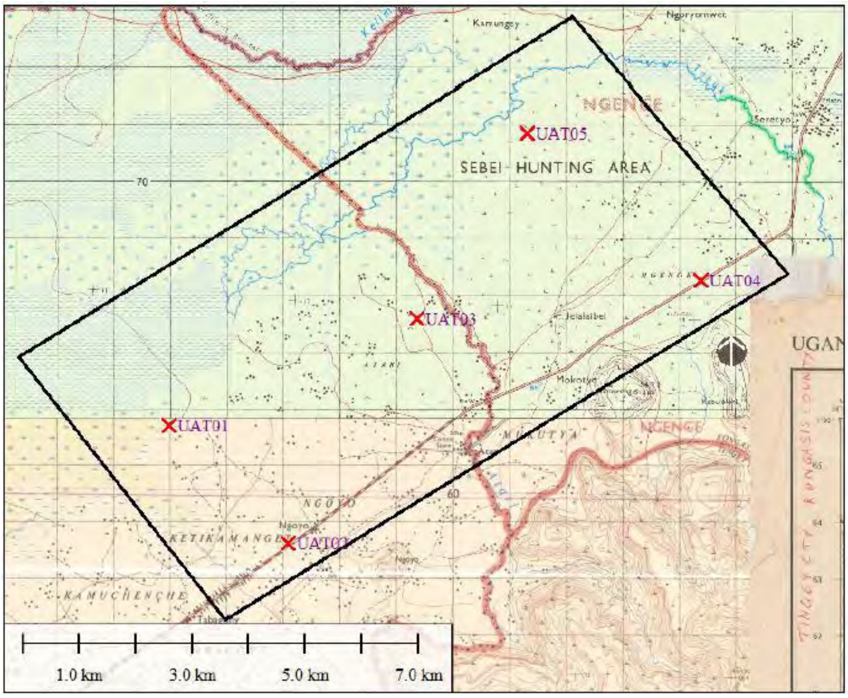


Figure 3.2 Index Map of Atari Site

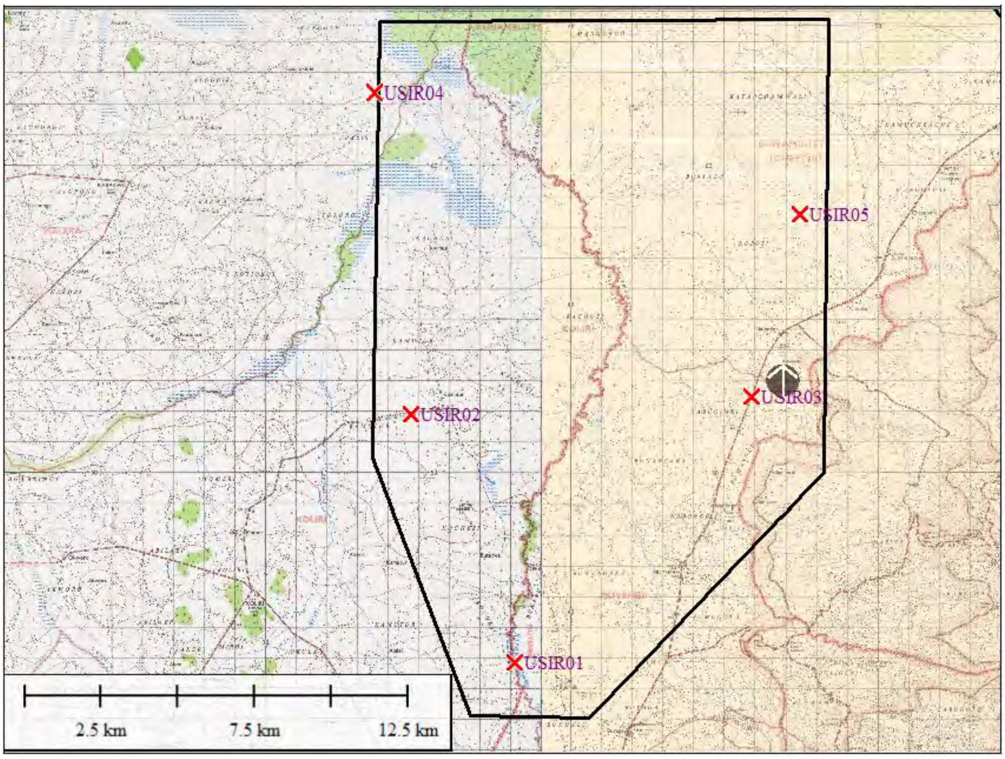


Figure 3.3 Index Map of Sironko Site

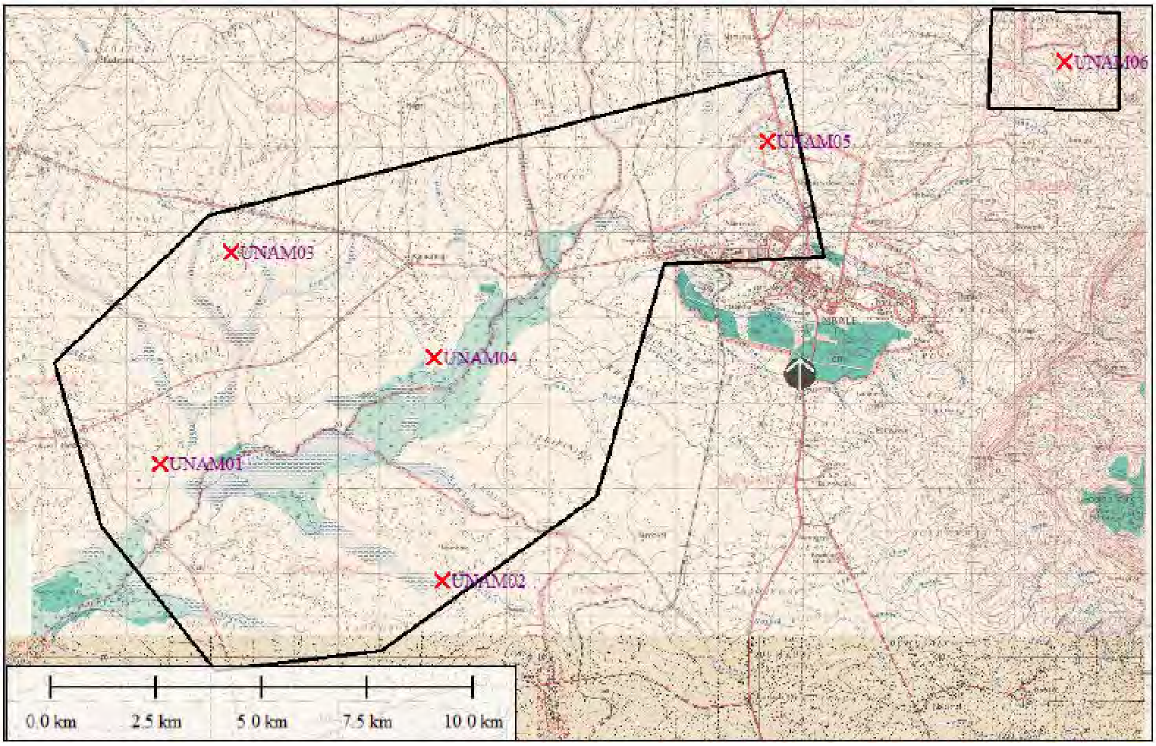


Figure 3.4 Index Map of Namatala Site

(2)Ground Control Report

GPS Ground Control Report

Client	Pasco Corporation		**Project No.**	2340-32554		
Coordinates						
Station ID	UAT01	**Type**	GCP			
Processing Level	Datum	Projection	Height Datum	Latitude / Northing	Longitude / Easting	Height(m)
Raw Gps	WGS84	Geo	WGS84	1° 29' 45.71518" N	34° 23' 38.15915" E	1050.634
Processed	WGS84	UTM N36	Levelled	165405.999	655072.851	1058.405

Comments	

Photos

Observation Details

Date	4-Feb-15
Start Time (Local)	13:53:09
End Time (Local)	14:19:32
Slant Height (m)	0.00
Vertical Height (m)	1.270
Pillar Height (m)	0.00
Antenna Offset (m)	0.255
Pin Height (m)	0.00
True Vertical H (m)	1.525
Antenna Radii (m)	0.00

GPS Unit Serial No.	GS15 / 1509715	File Name	
GPS Model No.	GS15 GNSS Receiver	Important Notes	
Antenna Type	GS15 Tripodshort	Levelled	
Misc	L1/L2		
Processing Software	Leica GeoOffice		

Figure 3.5 Sample of Ground Control Report

(3)Network Map

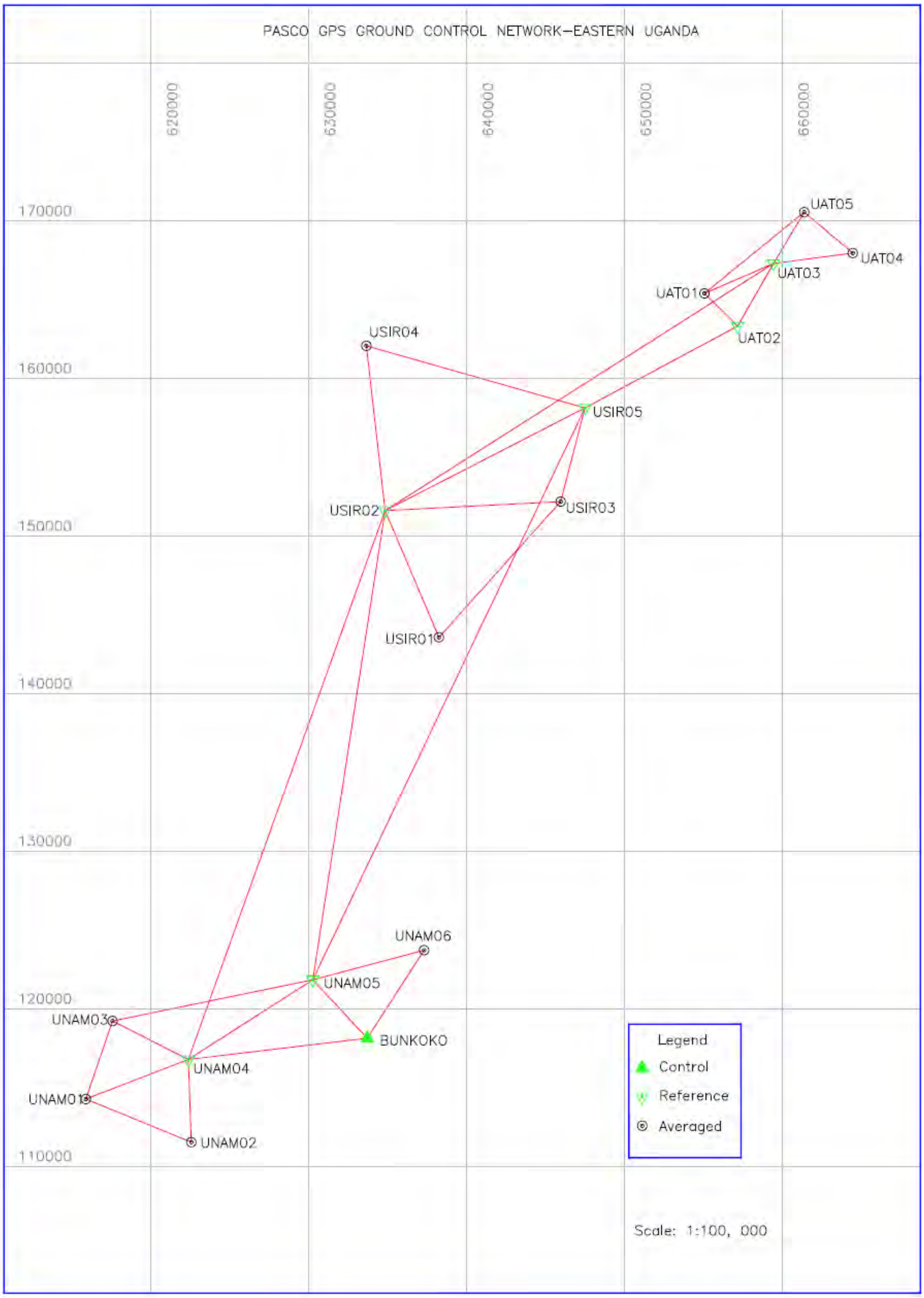


Figure 3.6 Network Map of GNSS Survey

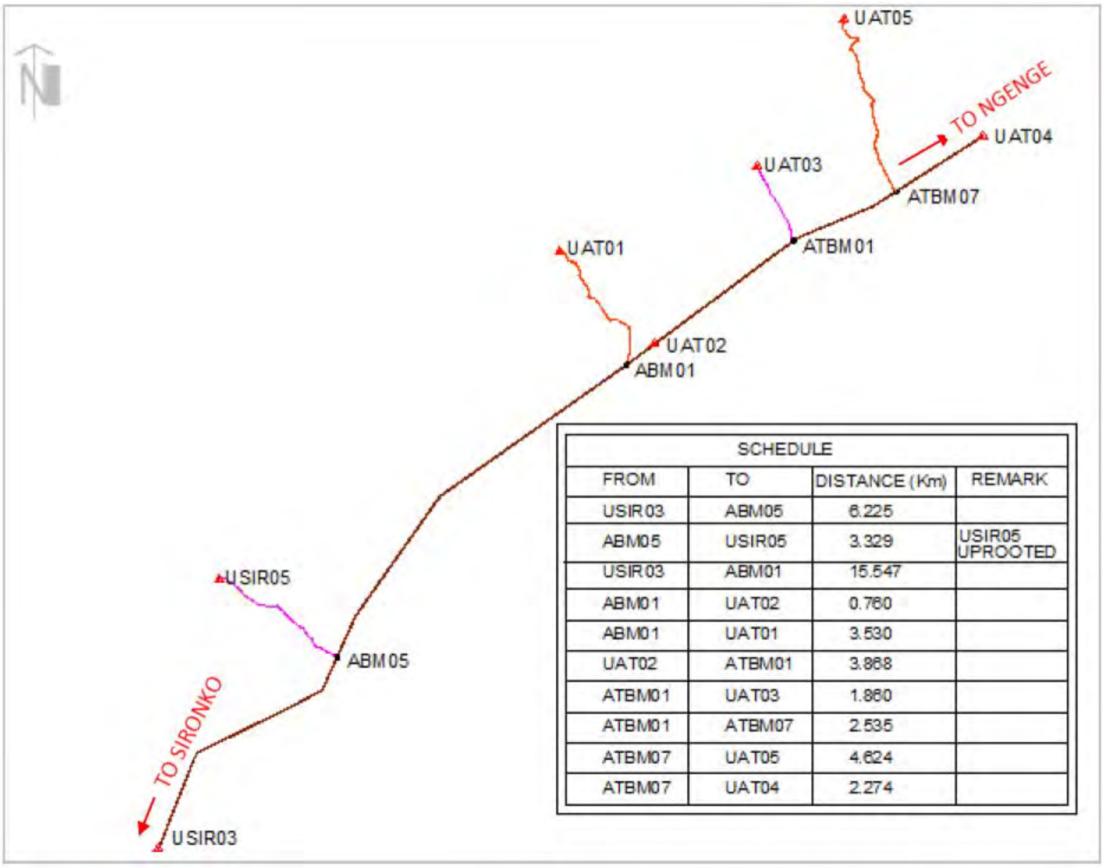
(4)Table of Result

POINT ID	EASTING	NORTHING	LEVELED HT	Orthometric Heights EGM_2008	Remarks
UAT01	655072.851	165405.999	1058.405	1061.002	
UAT02	657178.857	163330.093	1074.536	1077.113	
UAT03	659452.412	167301.120	1067.157	1069.792	
UAT04	664470.571	167965.417	1086.311	1088.978	
UAT05	661391.511	170557.398	1067.407	1070.112	
UNAM01	615880.325	114275.482	1080.829	1082.312	
UNAM02	622559.614	111536.040	1089.875	1091.402	
UNAM03	617567.157	119228.580	1099.336	1100.873	
UNAM04	622371.097	116786.962	1087.094	1088.637	
UNAM05	630260.614	121849.721	1123.272	1124.760	
UNAM06	637310.010	123720.267	1252.334	1253.852	
USIR01	638245.725	143579.863	-	1082.961	
USIR02	634835.692	151617.745	1061.859	1063.298	
USIR03	645958.607	152187.272	1072.995	1075.340	
USIR04	633648.924	162077.065	1049.899	1051.098	
USIR05	647500.368	158131.576	-	1062.331	

Figure 3.7 Result Table of GNSS Survey

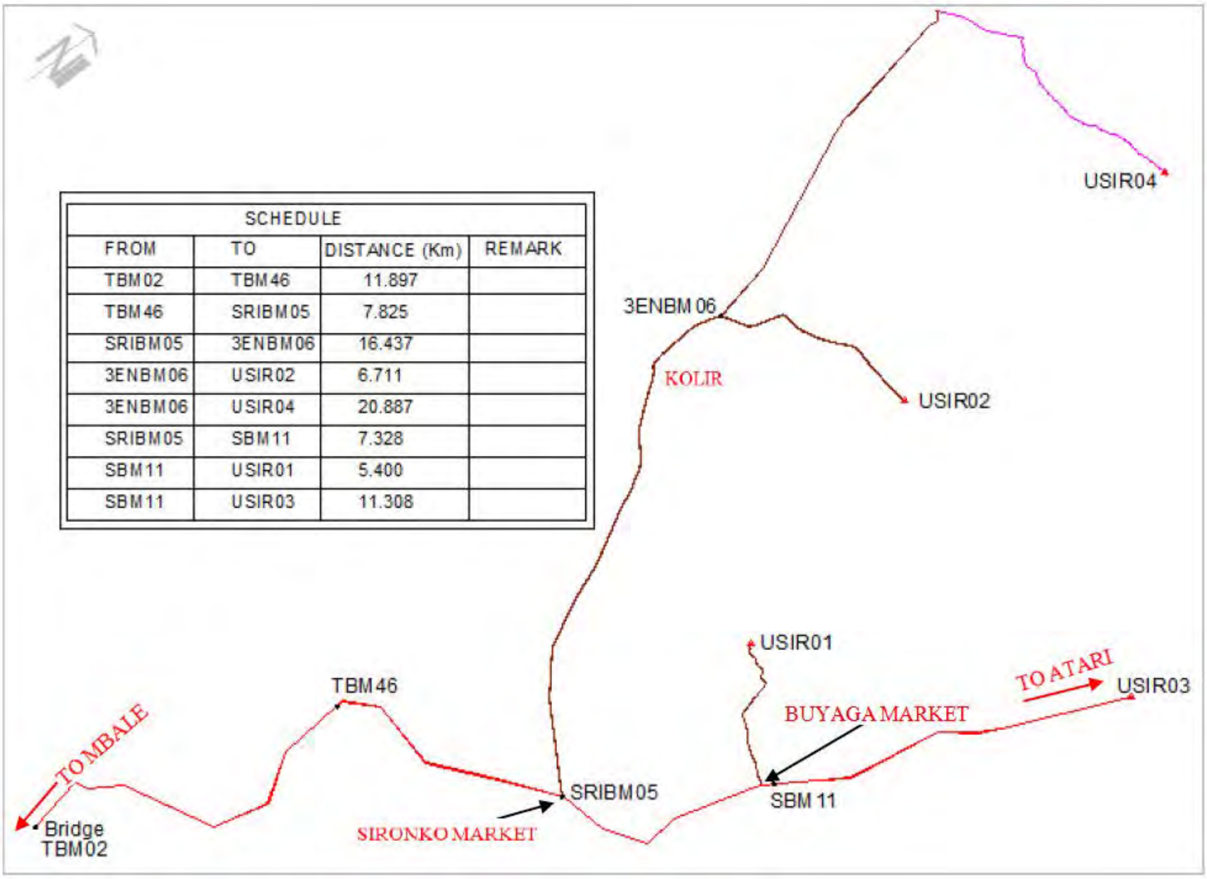
3.2 Leveling Survey

(1)Route Map



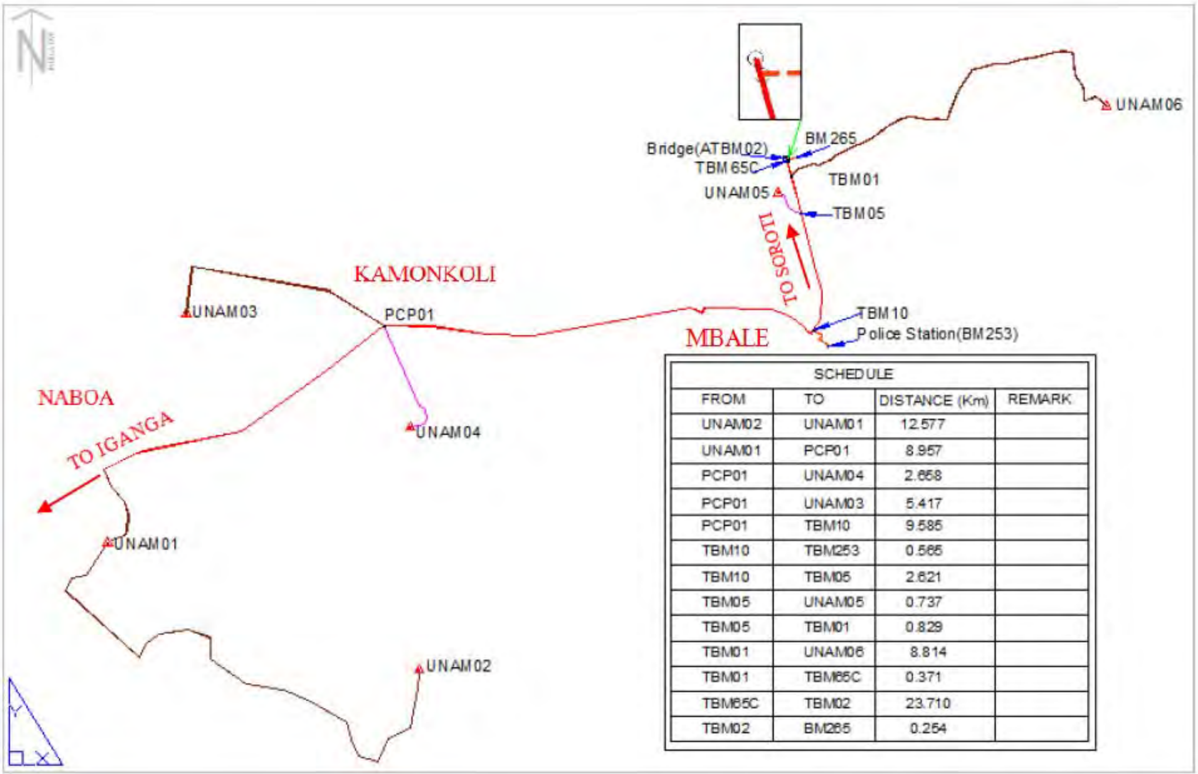
FROM	TO	DISTANCE (Km)	REMARK
USIR03	ABM05	6.225	
ABM05	USIR05	3.329	USIR05 UPROOTED
USIR03	ABM01	15.547	
ABM01	UAT02	0.760	
ABM01	UAT01	3.530	
UAT02	ATBM01	3.868	
ATBM01	UAT03	1.860	
ATBM01	ATBM07	2.535	
ATBM07	UAT05	4.624	
ATBM07	UAT04	2.274	

Figure 3.8 Route Map of Leveling in Atari Site



SCHEDULE			
FROM	TO	DISTANCE (Km)	REMARK
TBM02	TBM46	11.897	
TBM46	SRIBM05	7.825	
SRIBM05	3ENBM06	16.437	
3ENBM06	USIR02	6.711	
3ENBM06	USIR04	20.887	
SRIBM05	SBM11	7.328	
SBM11	USIR01	5.400	
SBM11	USIR03	11.308	

Figure 3.9 Route Map of Leveling in Sironko Site



SCHEDULE			
FROM	TO	DISTANCE (Km)	REMARK
UNAM02	UNAM01	12.577	
UNAM01	PCP01	8.957	
PCP01	UNAM04	2.658	
PCP01	UNAM03	5.417	
PCP01	TBM10	9.585	
TBM10	TBM253	0.565	
TBM10	TBM05	2.621	
TBM05	UNAM05	0.737	
TBM05	TBM01	0.829	
TBM01	UNAM06	8.814	
TBM01	TBM65C	0.371	
TBM65C	TBM02	23.710	
TBM02	BM265	0.254	

Figure 3.10 Route Map of Leveling in Namatala Site

(2)Result Table of Leveling

POINT ID	LEVELLED HEIGHT	SITE	COMMENTS
UAT01	1058.405	ATARI	LEVELLED
UAT02	1074.536	ATARI	LEVELLED
UAT03	1067.157	ATARI	LEVELLED
UAT04	1086.311	ATARI	LEVELLED
UAT05	1067.407	ATARI	LEVELLED
UNAM01	1080.829	NAMATARA	LEVELLED
UNAM02	1089.875	NAMATARA	LEVELLED
UNAM03	1099.336	NAMATARA	LEVELLED
UNAM04	1087.094	NAMATARA	LEVELLED
UNAM05	1123.272	NAMATARA	LEVELLED
UNAM06	1252.334	NAMATARA	LEVELLED
USIR01	Not leveled	SIRONKO	NOT LEVELLED
USIR02	1061.859	SIRONKO	LEVELLED
USIR03	1072.995	SIRONKO	LEVELLED
USIR04	1049.899	SIRONKO	LEVELLED
USIR05	Not leveled	SIRONKO	NOT LEVELLED

Table 3.1 Result Table of Leveling Survey

4. Aerial Triangulation Data

(1)Work Flow

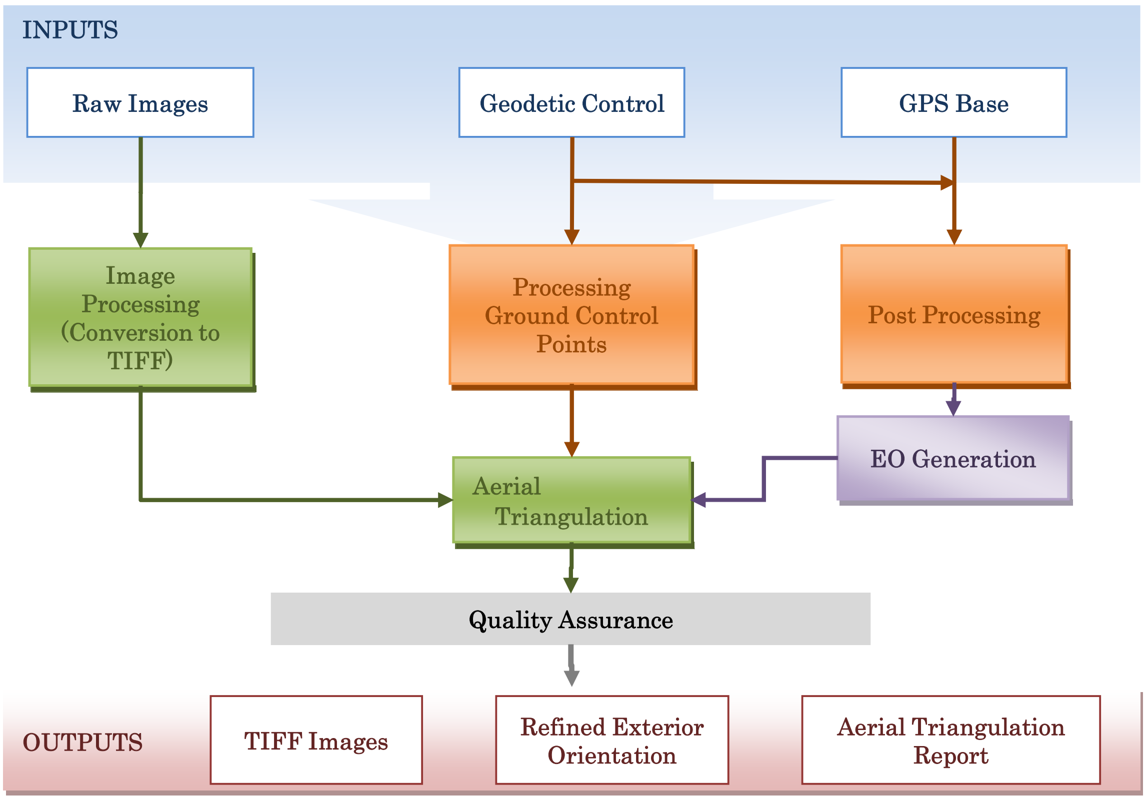


Table 4.1 Work Flow of Aerial Triangulation

(2)Post Processing of GNSS/IMU

```
*****************************************************************************************************************
 POS Exterior Orientation Computation Utility          Version  7.1
 Copyright (C) 1997-2014 by Applanix Corporation       [Nov 6 2014]
 All rights reserved.
*****************************************************************************************************************

 Parameter setup:
 POSPROC SBET file: D:¥Projects¥20150223 PASCO¥POSPac Processing¥Atari¥PP_20150213_PASCO-Atari¥Mission 1¥Proc¥sbet_Mission 1.out
 Camera mid-exposure event file: D:¥Projects¥20150223 PASCO¥POSPac Processing¥Atari¥PP_20150213_PASCO-Atari¥Mission 1¥Extract¥event1_Mission
1.dat
   Event time shift: 0.000000 sec
 Photo ID file: D:¥Projects¥20150223 PASCO¥POSPac Processing¥Atari¥PP_20150213_PASCO-Atari¥Mission 1¥Extract¥photoID1.txt
   Photo ID file format: 3 Fields (Time, Photo ID, Delay) Format
   Offset between PHOTO ID and EVENT file times: 0.000000 sec
   PHOTO ID time tolerance: 0.300000 sec
   WGS84 Height Output Selected
 Mapping frame epoch: 2015.117808
 Mapping frame datum: WGS84  ; Mapping frame projection : TM;
 central meridian = 33.000000 deg;
 latitude of the grid origin = 0.000000 deg; grid scale factor = 0.999600;
 false easting = 500000.000000 m; false northing = 0.000000 m;
 Sequence of the rotation from mapping to image frame:
    First rotation is about the 'x' axis by the 'omega' angle.
    Second rotation is about the 'y' axis by the 'phi' angle.
    Third rotation is about the 'z' axis by the 'kappa' angle.
 Kappa cardinal rotation:   90.000 deg.
 Boresight values: tx =       13.6290 arc min, ty =       -0.3790 arc min, tz =       -0.3770 arc min.
 Lever arm values: lx =        0.1230 m, ly =        0.4290 m, lz =       -0.5960 m.
Shift values: X = 0.000000 meter, Y = 0.000000 meter, Z = 0.000000 meter


 POS/AV Computed Data at Camera Perspective Centre
Grid: Universal Transverse Mercator  ;Zone: UTM North 36 (30E to 36E)  ;Datum: WGS84  ;Local Transformation: NONE  .

 Record Format:

 ID, # EVENT, TIME (s), EASTING, NORTHING, ORTHOMETRIC HEIGHT, OMEGA, PHI, KAPPA, LAT, LONG

 (position in Meters, orientation in Degrees, lat, long in Deg)


Block3_150213_01_0003     3  463912.365139  651984.067  166485.448 2539.818   -0.18564   -0.17498  121.02608  1.50581173 34.36618095
Block3_150213_01_0004     4  463918.720046  652302.658  166682.391 2534.023   -0.27647   -0.73949  120.93853  1.50759120 34.36904532
Block3_150213_01_0005     5  463925.241299  652624.698  166879.719 2534.606   -0.28400   -1.26420  121.96900  1.50937414 34.37194069
Block3_150213_01_0006     6  463931.844456  652944.753  167078.208 2523.955   -0.34233   -1.61595  120.52823  1.51116757 34.37481824
Block3_150213_01_0007     7  463938.709860  653267.815  167272.247 2525.901   -0.95237   -0.55592  122.69886  1.51292072 34.37772278
Block3_150213_01_0008     8  463945.831027  653591.080  167465.849 2519.893   -0.19519   -0.43956  120.08991  1.51466992 34.38062914
Block3_150213_01_0009     9  463953.121032  653912.479  167663.857 2522.905   -0.92250   -0.33419  122.21960  1.51645897 34.38351877
Block3_150213_01_0010    10  463960.768915  654232.419  167861.317 2531.298   -1.22302    0.49561  121.16129  1.51824306 34.38639528
Block3_150213_01_0011    11  463968.416050  654552.960  168060.360 2528.984   -1.34369    0.06378  123.12650  1.52004146 34.38927721
Block3_150213_01_0012    12  463975.723537  654874.135  168257.840 2523.961    0.38272   -0.62970  121.90271  1.52182570 34.39216482
Block3_150213_01_0013    13  463982.819225  655198.198  168451.026 2550.045    0.67401   -0.72876  120.51693  1.52357109 34.39507837
Block3_150213_01_0014    14  463989.720060  655521.917  168644.528 2552.740   -0.43598   -0.05405  120.36698  1.52531933 34.39798883
Block3_150213_01_0015    15  463996.446657  655843.515  168839.162 2546.375   -0.10390   -0.16036  121.00214  1.52707782 34.40088024
Block3_150213_01_0016    16  464003.167198  656165.813  169034.842 2538.619   -0.14206   -0.17420  120.28045  1.52884574 34.40377795
Block3_150213_01_0017    17  464009.860178  656489.618  169229.799 2529.344   -0.18859   -0.13576  122.81159  1.53060711 34.40668920
Block3_150213_01_0018    18  464016.548860  656813.415  169421.559 2530.927   -1.48005   -2.55393  123.17852  1.53233956 34.40960037
Block3_150213_01_0019    19  464023.375804  657134.389  169617.572 2535.177   -1.36602   -1.74777  118.80120  1.53411048 34.41248618
Block3_150213_01_0020    20  464030.157293  657450.423  169824.399 2546.053   -1.15050   -0.88964  122.86420  1.53597924 34.41532767
```

Figure 4.1 Sample of the Result of GNSS/IMU Post Processing GNSS/IMU

(3)Result of Aerial Triangulation

exterior orientation parameters (px, py, pz in [meter] omega,phi,kappa in [deg])

rotations from terrain to photo (rotated axes)

photo ID	px	py	pz	omega	phi	kappa
Block3_150213_01_0003	651984.037	166485.257	2535.821	-0.18681	-0.14997	121.10066
Block3_150213_01_0004	652302.768	166682.394	2529.794	-0.28553	-0.74799	120.99754
Block3_150213_01_0005	652624.850	166879.810	2530.456	-0.29492	-1.26977	122.02681
Block3_150213_01_0006	652945.061	167078.114	2519.796	-0.34700	-1.61488	120.58370
Block3_150213_01_0007	653268.048	167272.207	2521.857	-0.95981	-0.55735	122.75293
Block3_150213_01_0008	653591.244	167465.940	2515.770	-0.20762	-0.44354	120.14023
Block3_150213_01_0009	653912.781	167664.005	2518.815	-0.93822	-0.33114	122.26945
Block3_150213_01_0010	654232.395	167861.205	2527.164	-1.22963	0.48384	121.20994
Block3_150213_01_0011	654553.289	168060.571	2524.913	-1.36116	0.06258	123.17699
Block3_150213_01_0012	654874.233	168257.773	2519.795	0.38045	-0.63589	121.95211
Block3_150213_01_0013	655198.436	168451.277	2546.023	0.65849	-0.73044	120.56677
Block3_150213_01_0014	655522.201	168644.532	2548.535	-0.44299	-0.05462	120.41410
Block3_150213_01_0015	655843.556	168839.333	2542.310	-0.11599	-0.16895	121.04567
Block3_150213_01_0016	656166.234	169034.751	2534.444	-0.14464	-0.17051	120.31943
Block3_150213_01_0017	656489.695	169229.924	2525.267	-0.19841	-0.14447	122.85050
Block3_150213_01_0018	656813.932	169421.386	2526.834	-1.47835	-2.55160	123.21672
Block3_150213_01_0019	657134.571	169617.646	2531.072	-1.37425	-1.75459	118.83618
Block3_150213_01_0020	657450.608	169824.392	2541.882	-1.15827	-0.89683	122.89692

Figure 4.2 Sample of the Result of Aerial Triangulation

5. Ortho Image

(1)Atari Site

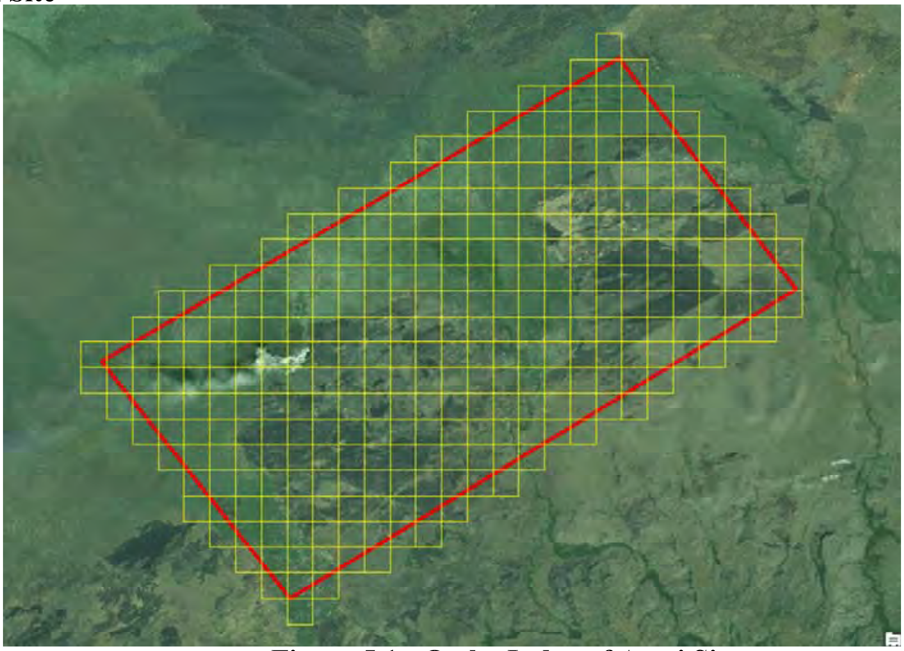


Figure 5.1 Ortho Index of Atari Site

Figure 5.2 Sample of Ortho Image in Atari Site

(2)Sironko Site

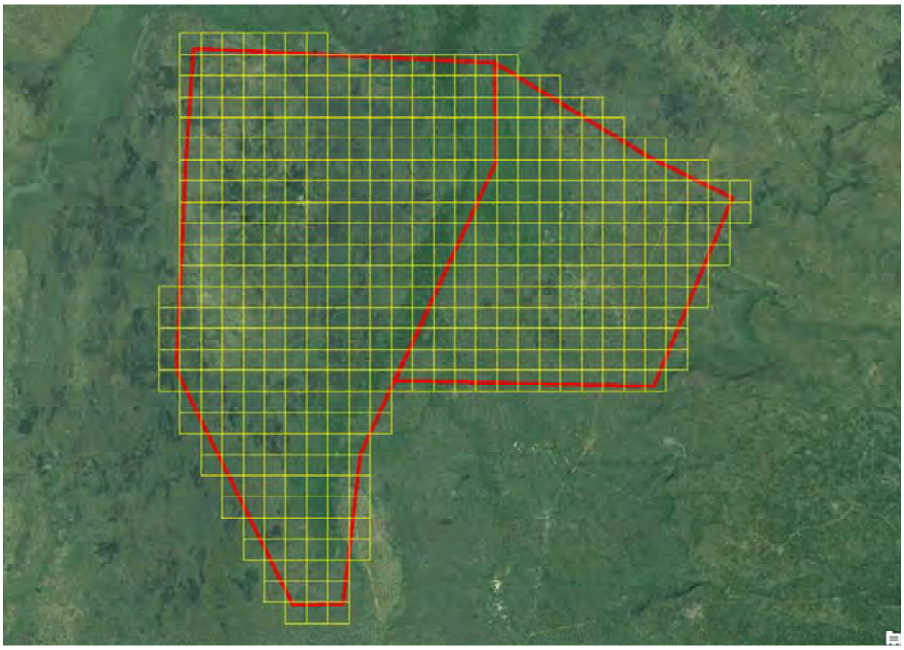


Figure 5.3 Ortho Index of Sironko Site

Figure 5.4 Sample of Ortho Image in Sironko Site

(3)Namatala Site

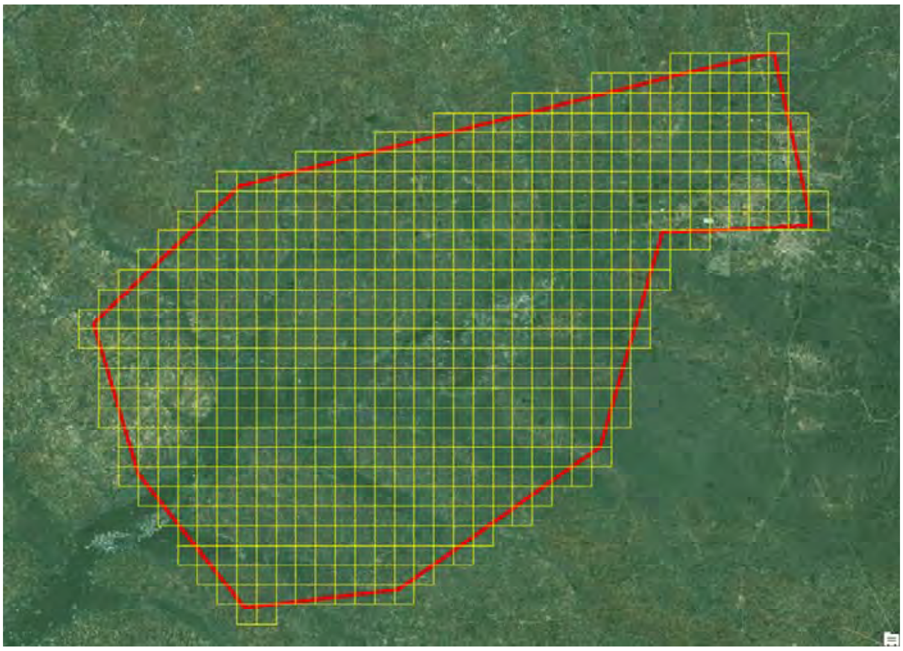


Figure 5.5 Ortho Index of Namatala Site

Figure 5.6 Sample of Ortho Image in Namatala Site

(4)Namatala Dam Site

Figure 5.7 Ortho Index of Namatala Dam Site

Figure 5.8 Sample of Ortho Image in Namatala Dam Site

6. Topographic Map Data

6.1 Atari Site

(1)Topographic Map

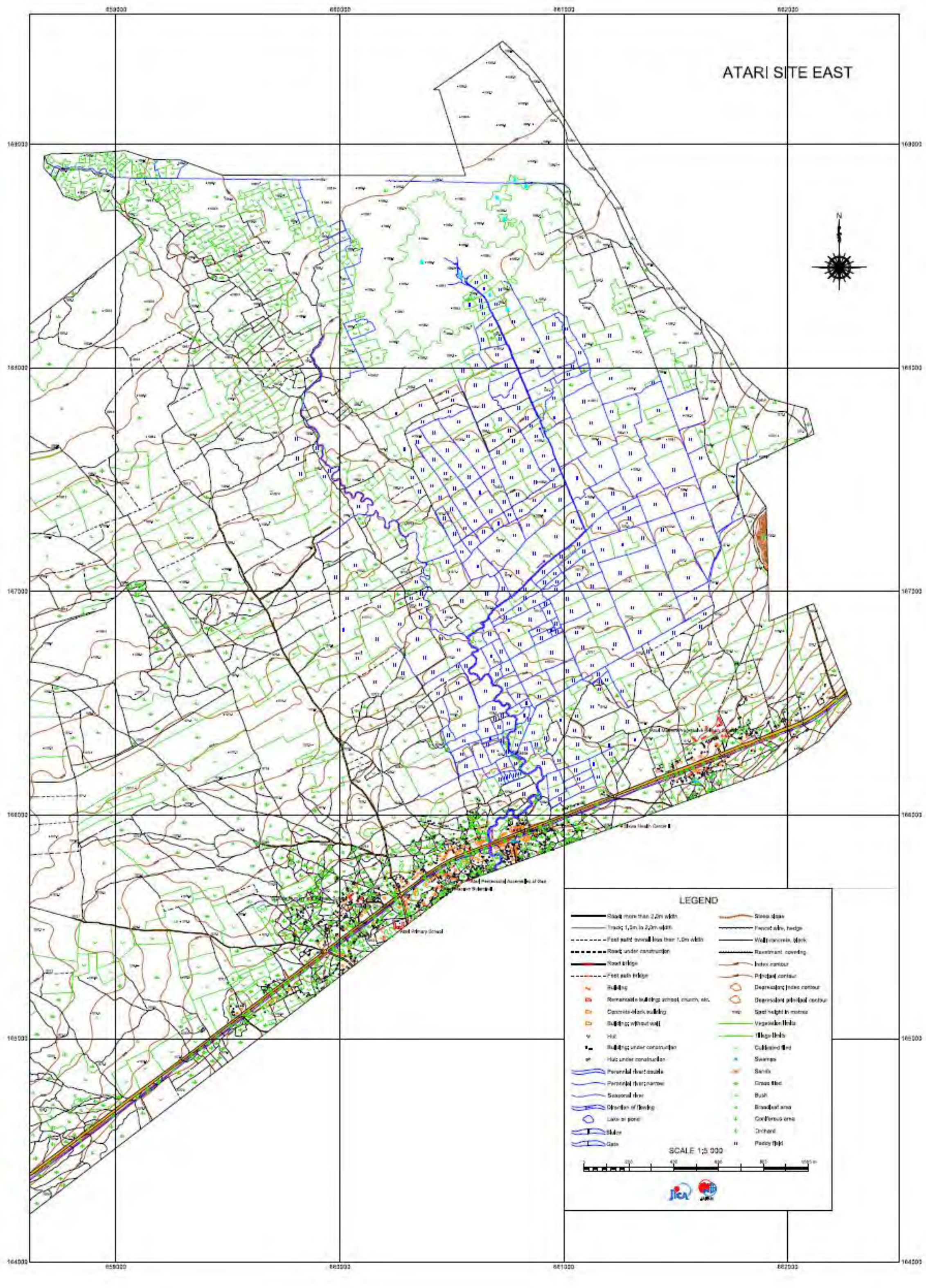


Figure 6.1 1/5,000 Topographic Map of Atari Site (East)

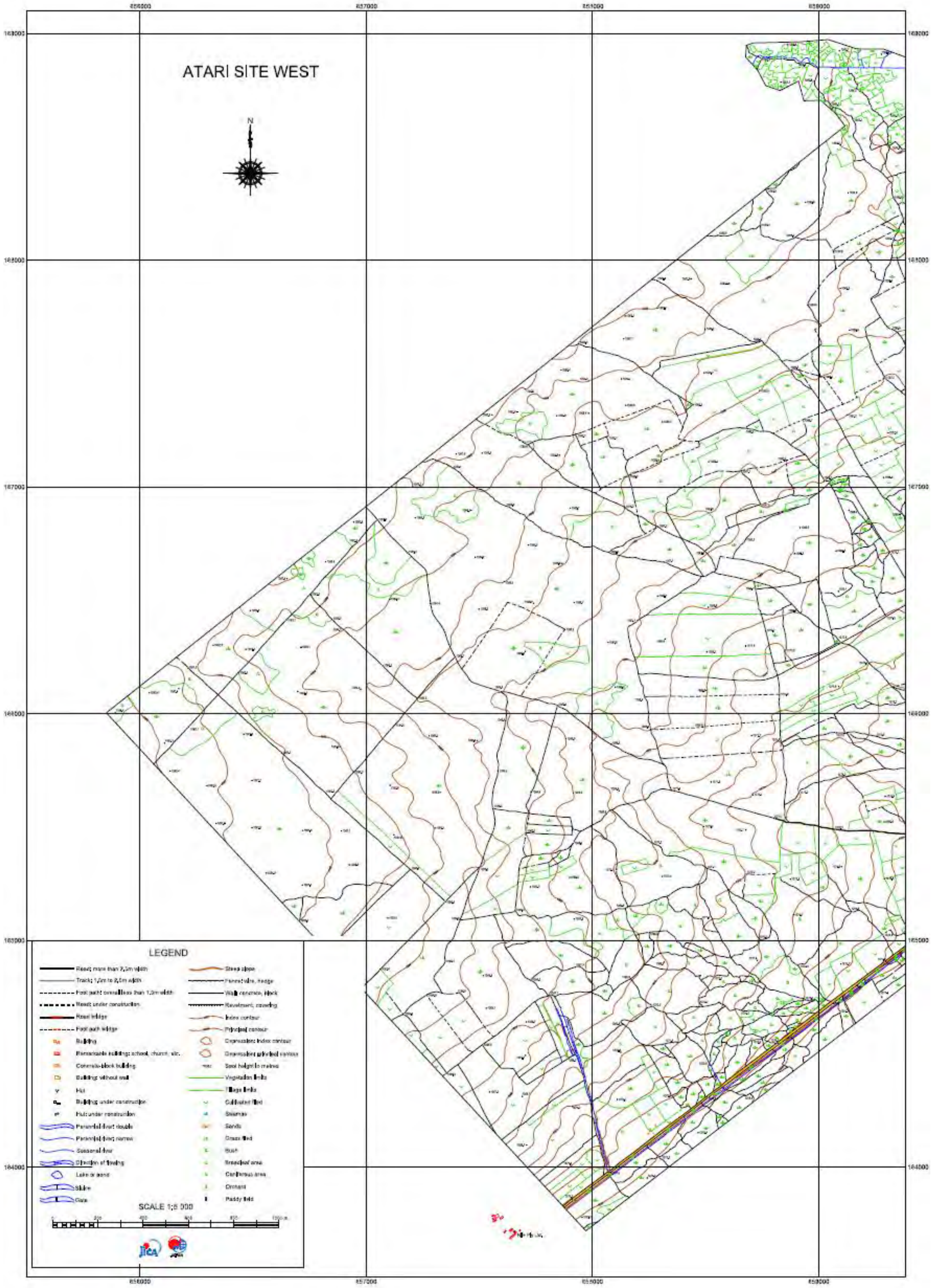


Figure 6.2 1/5,000 Topographic Map of Atari Site (West)

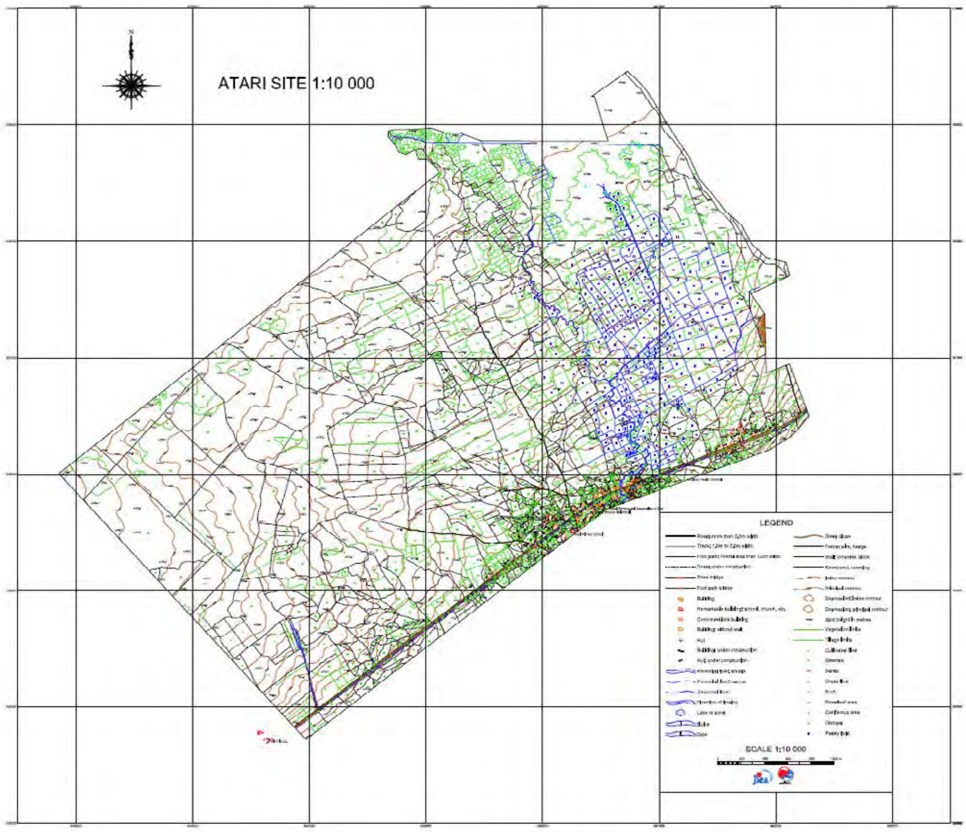


Figure 6.3 1/10,000 Topographic Map of Atari Site

(2)Ortho Photo Map

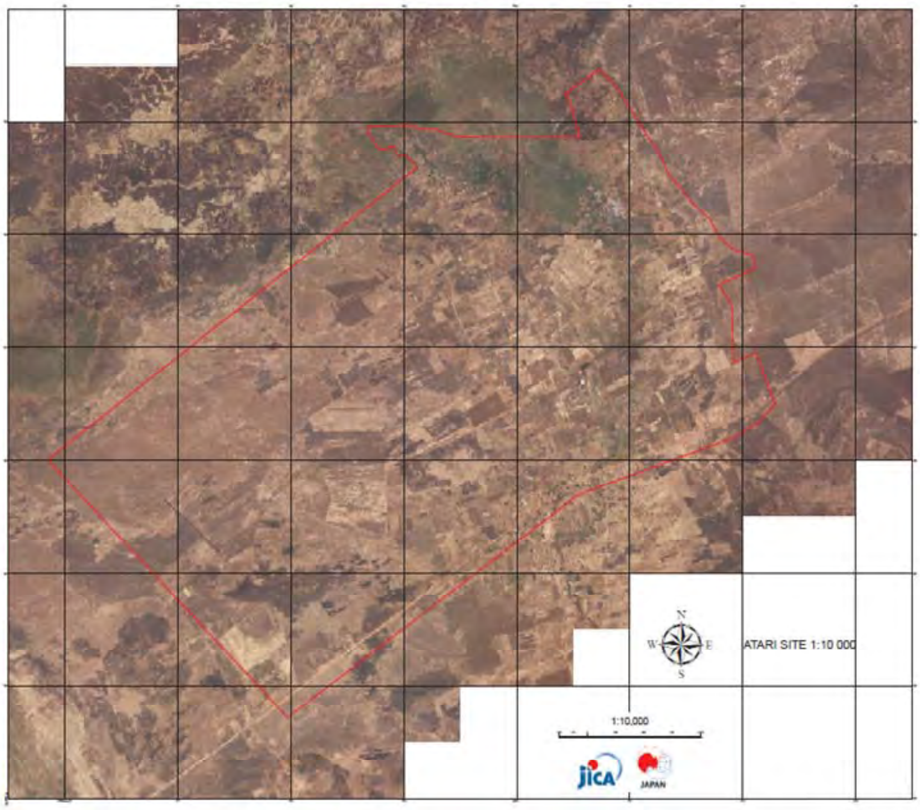


Figure 6.4 Ortho Photo Map of Atari Site

6.2 Sironko Site

(1)Topographic Map

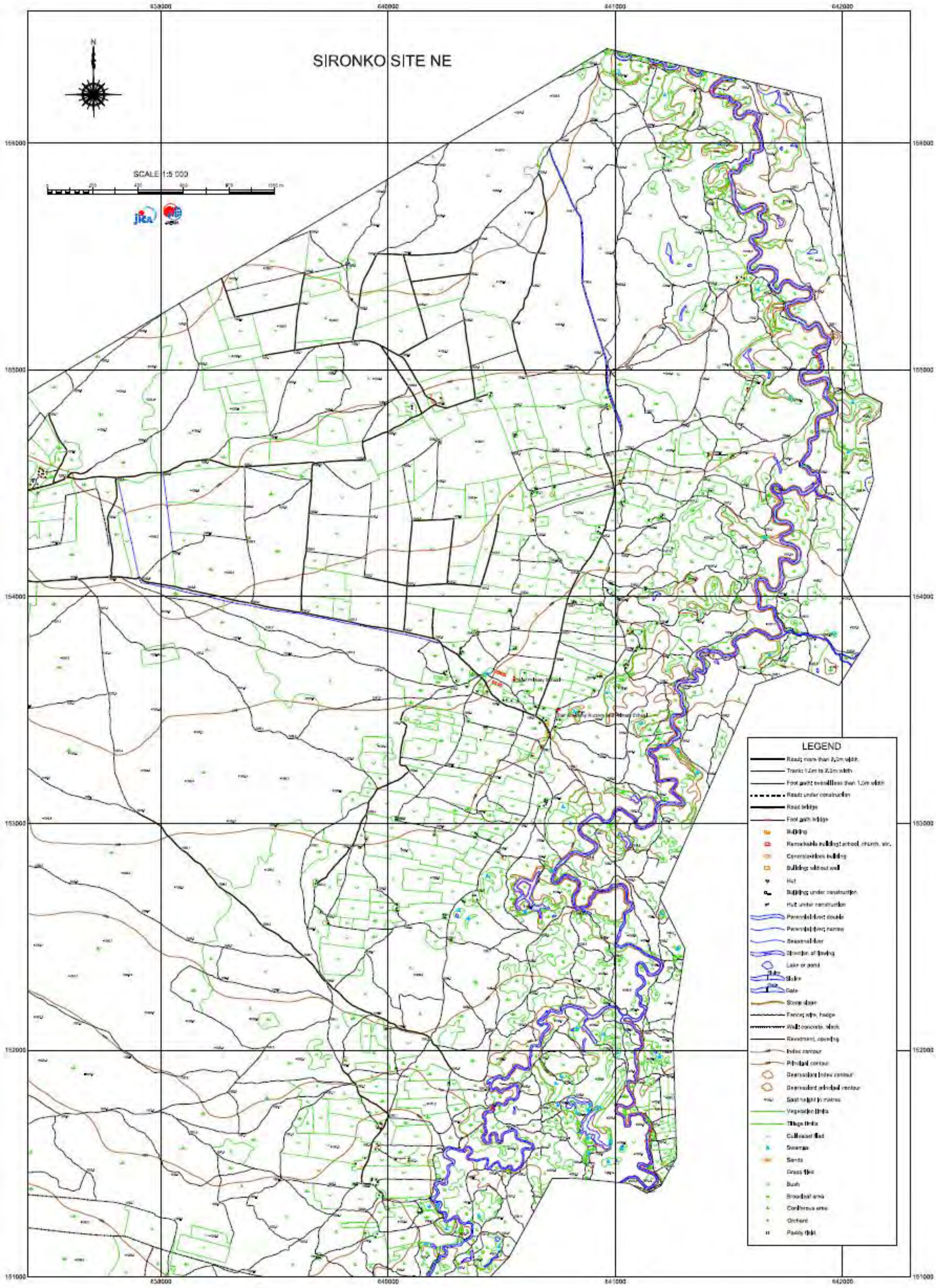


Figure 6.5　1/5,000 Topographic Map of Sironko Site (North East)

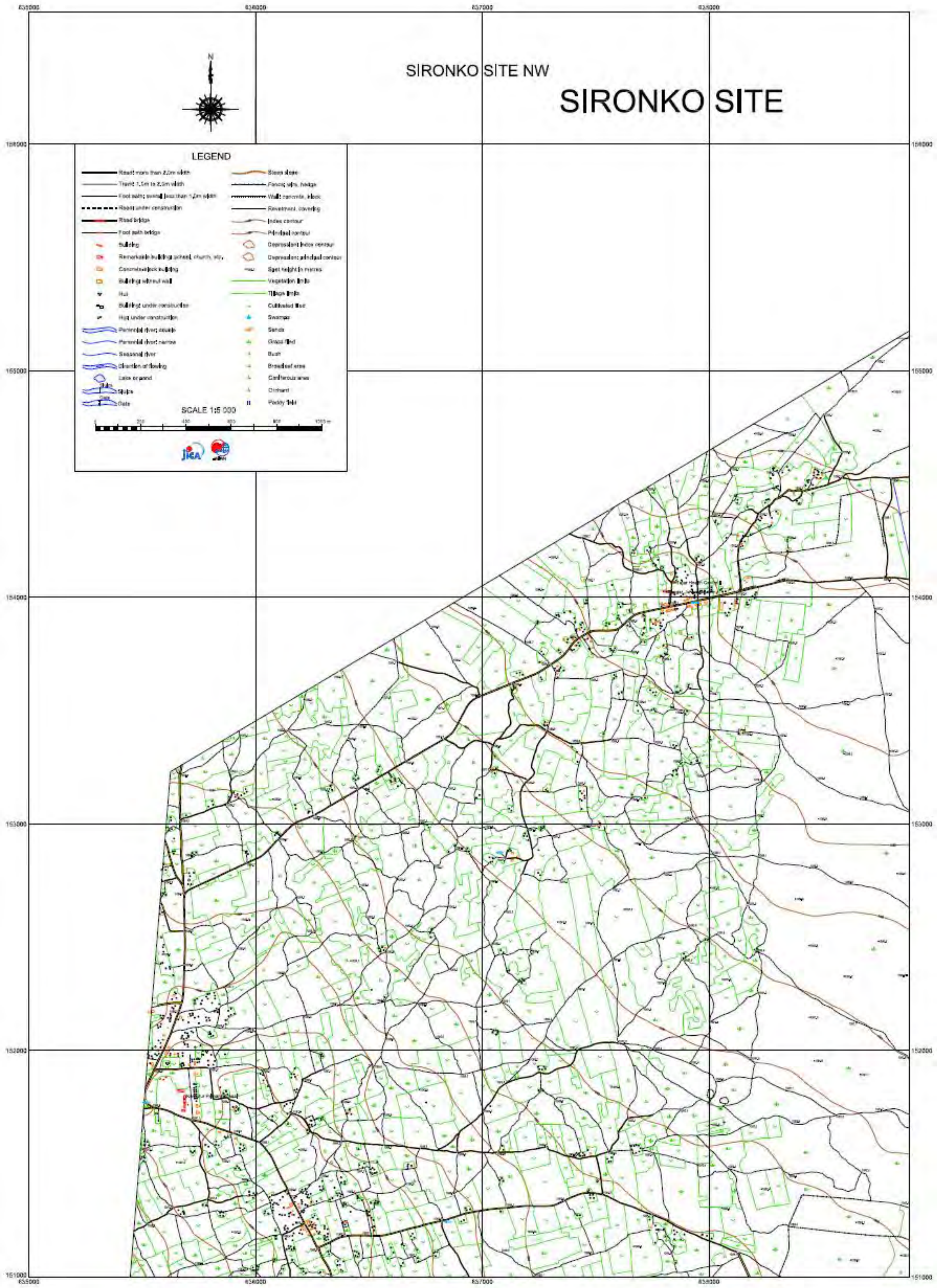


Figure 6.6 1/5,000 Topographic Map of Sironko Site (North West)

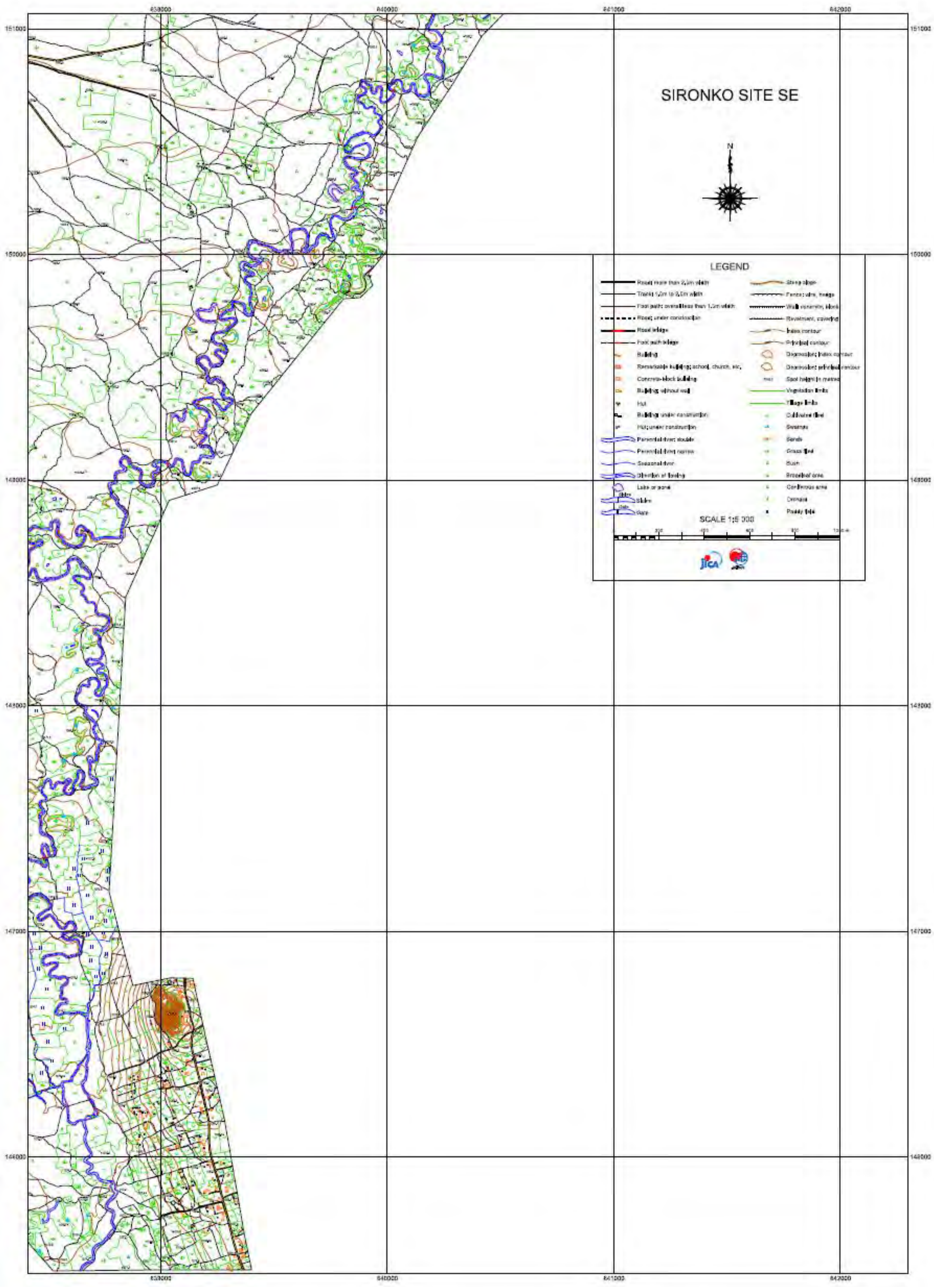


Figure 6.7 1/5,000 Topographic Map of Sironko Site (South East)

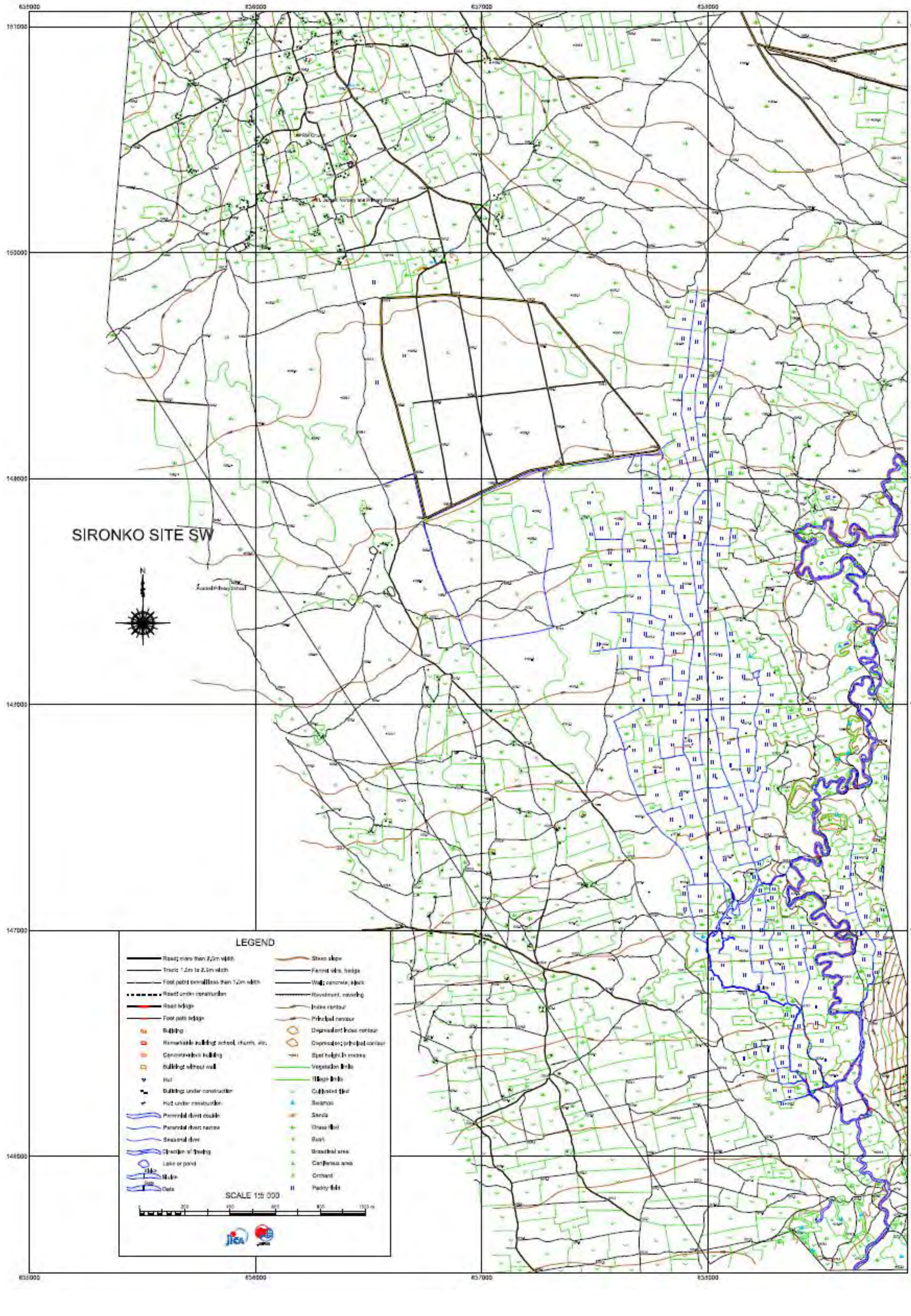


Figure 6.8 1/5,000 Topographic Map of Sironko Site (South West)

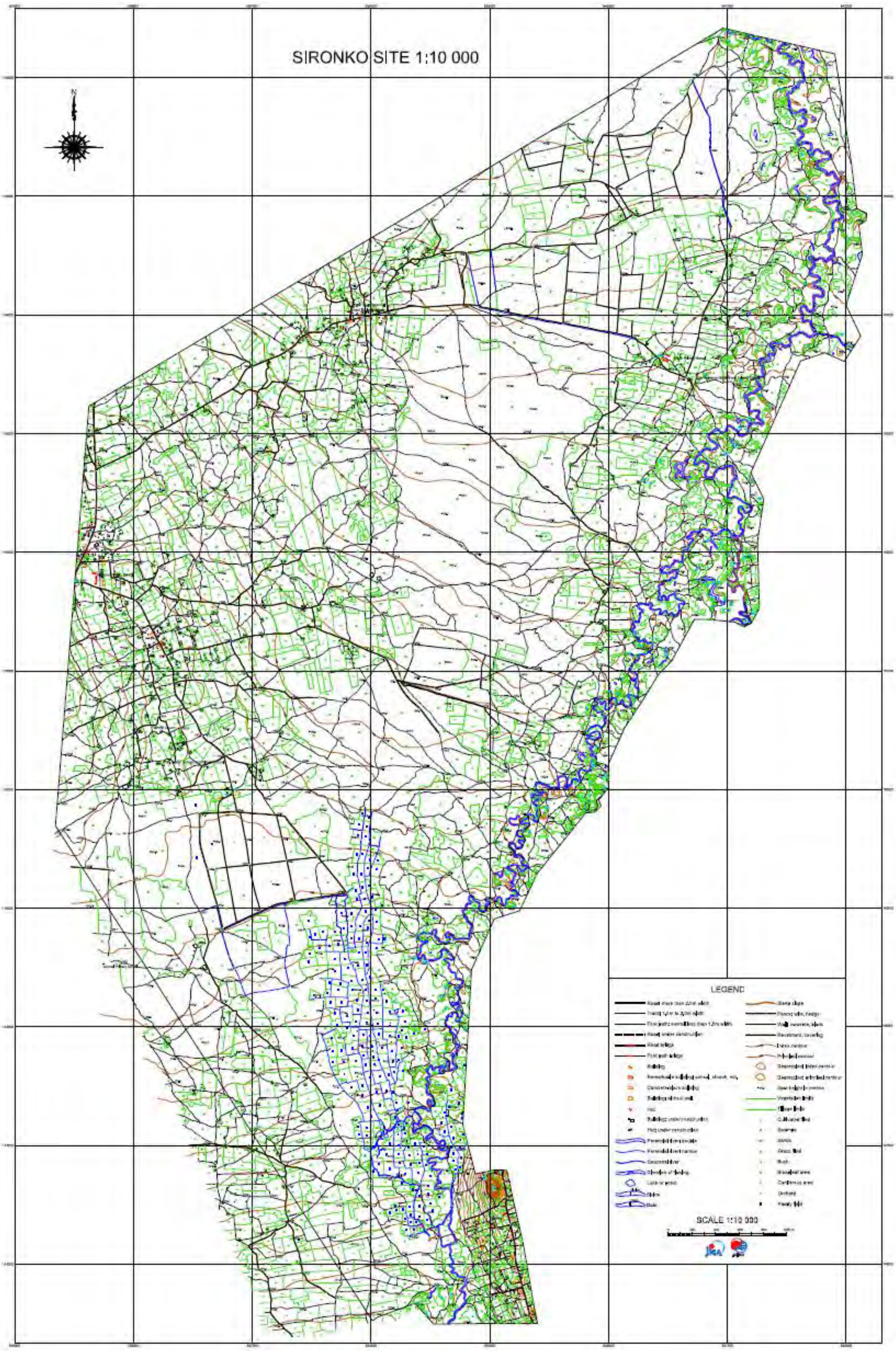


Figure 6.9 1/10,000 Topographic Map of Sironko Site

(2) Ortho Photo Map

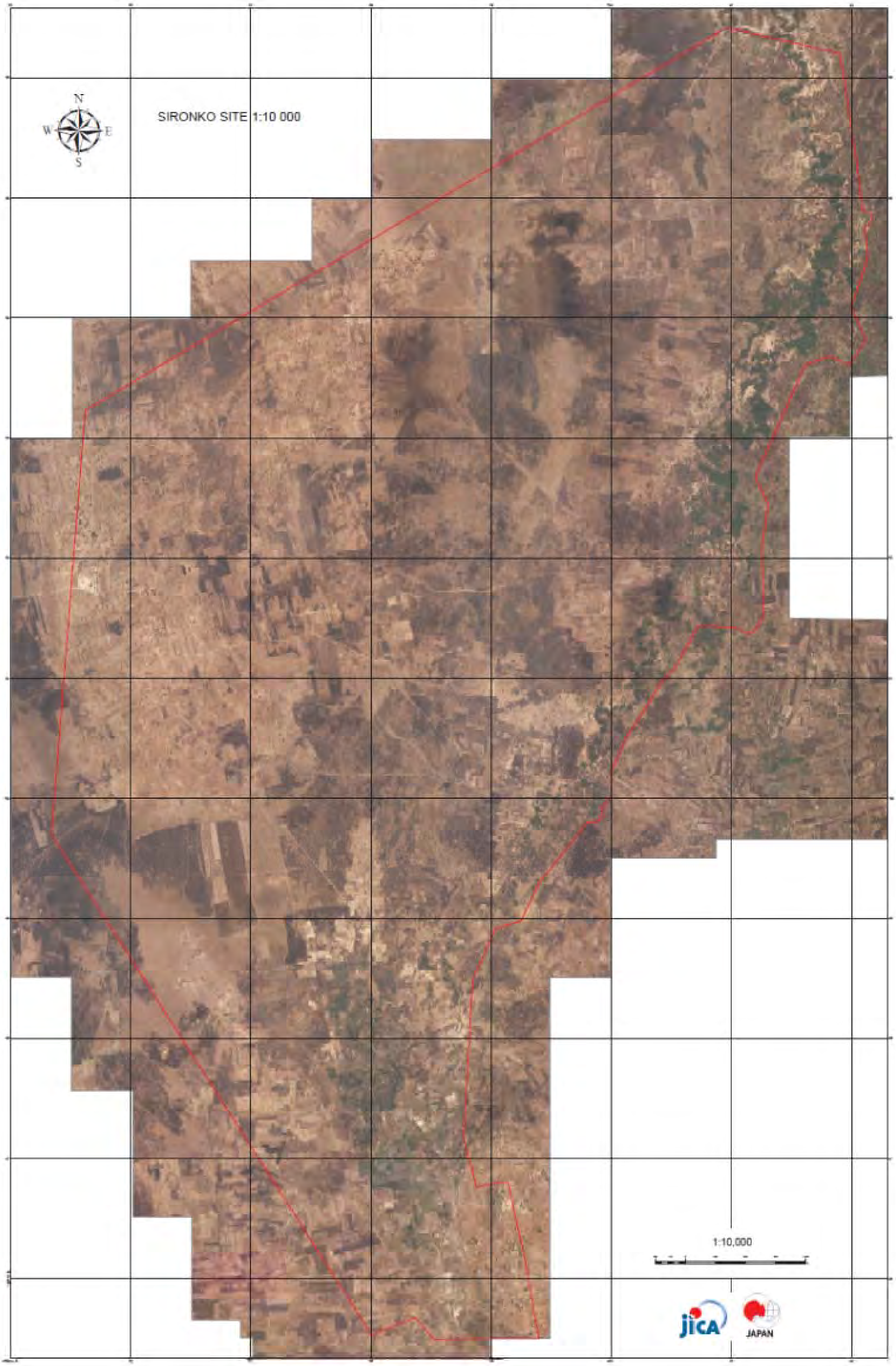


Figure 6.10 Ortho Photo Map of Sironko Site

7. Structured Data

(1)Atari Site

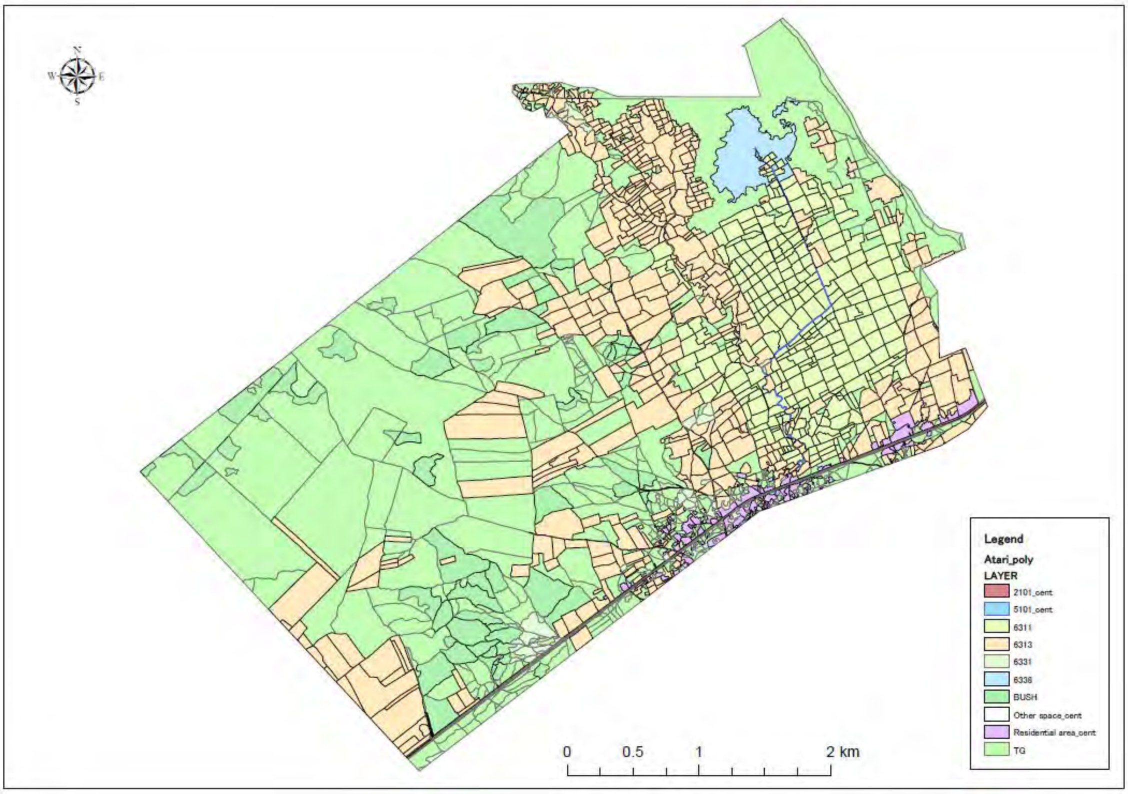


Figure 7.1 Structured Data of Atari Site

(2)Sironko Site

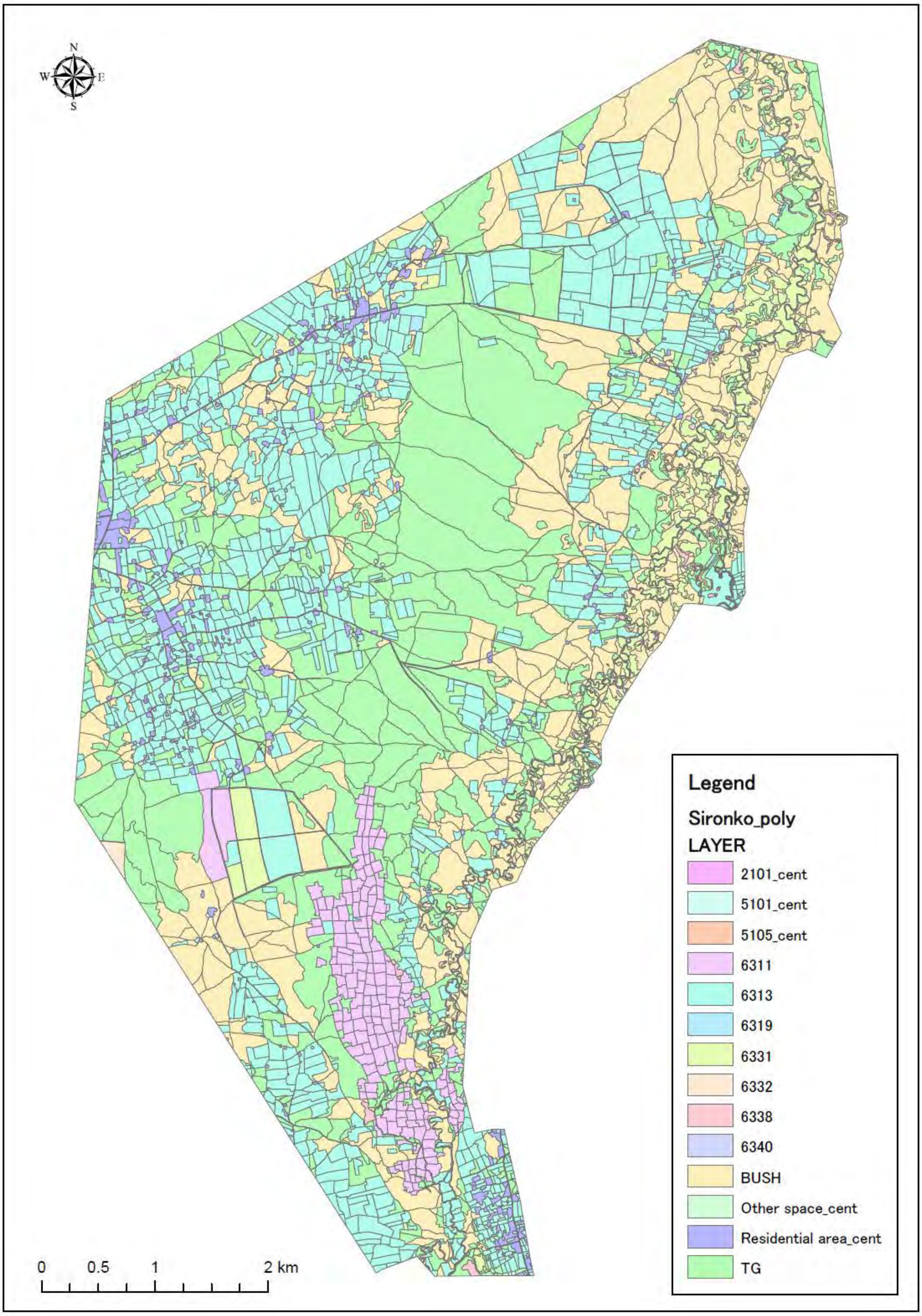


Figure 7.2 Structured Data of Sironko Site