CHAPTER 10 GIS DATABASE

10.1 Data Collection

10.1.1 Map

The 1/50,000 Topographic Maps issued by Survey and Mapping Department were collected. As shown in the index map of Figure 10-1, Lake Kyoga Basin is covered by 104 Topographic Maps. The 1/50,000 Topographic Maps were projected on the coordinate system shown in Table 10-1, and Arc 1960 (New Arc) which is commonly utilized in Eastern Africa countries was adopted as a datum.

| | | , I8I | L |
|--------------------|---------------------------|------------------------|-----------------------|
| Grid | UTM Zone 36 | Latitude of Origin | Equator |
| Projection | Transverse Mercator | Scale Factor of Origin | 0.9996 |
| Spheroid | Clark 1880 (Modified) | False Coordinates | 500,000 m Easting |
| Unit | Meter | of Origin | 10,000,000 m Northing |
| Meridian of Origin | 33 degrees E of Greenwich | Datum | Arc 1960 |

Table 10-1 Coordinate System of 1/50,000 Topographic Map

Source: Survey and Mapping Department

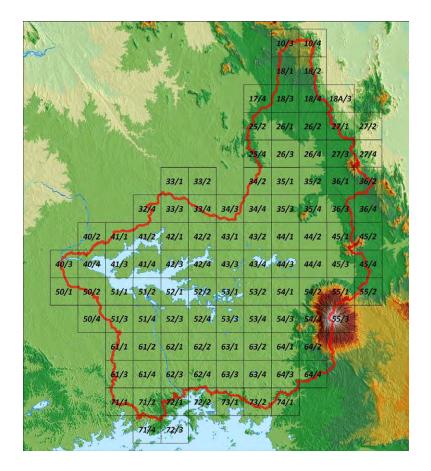


Figure 10-1 Index Map of 1/50,000 Topographic Maps

10.1.2 GIS Data

GIS data (vector data) listed in Table 10-2 were collected. Most of basic information, e.g. administrative boundaries, transportations and town, was created and by the National Biomass Study of Forest Department. All collected data were defined on the coordinate system projected on UTM (Zone 36) and Arc 1960 datum.

| Items | Туре | Source |
|---|---------|--------------------------|
| Administrative boundary of District, County, Sub-County and Parish | Polygon | National Biomass Project |
| Geology | Polygon | DWRM |
| Land use | Polygon | National Biomass Project |
| Open Water | Polygon | DWRM |
| Protected Area | Polygon | NFA |
| River | Line | DWRM |
| Soil | Polygon | DWRM |
| Road and Railway | Line | National Biomass Project |
| Town | Point | National Biomass Project |

Table 10-2 Collected GIS Data

10.1.3 DEM and Satellite Image

Digital Elevation Model (DEM) and satellite image data listed in Table 10-3 were collected as raster data. The utilized SRTM-3, LANDSAT/ETM+ and TM data were obtained from the website of United States Geological Survey (USGS) on free of charge basis.

(1) LANDSAT/ETM+ and TM Data

ETM+ (Enhanced Thematic Mapper Plus) and TM (Thematic Mapper) are the sensor for observation programs of land areas of the Earth, and was developed by the National Aeronautics and Space Administration (NASA) of the United States and mounted on the earth observation satellite LANDSAT of NASA. The five scenes of the ETM+ data acquired at 3 seasons (June and September of 2002, and January of 2003), and the five TM data acquired at September of 1984 and January of 1986 were utilized in the study.

(2) Space Shuttle/SRTM-3 Data

SRTM (Shuttle Rader Topography Mission) obtained the elevation data on a near global scale to generate the most complete digital topographic database of the Earth by Space Shuttle. SRTM data is a digital elevation model (DEM) generated by the method of radar interferometry. The spatial resolution of SRTM data is 1 arc-second (about 30m; SRTM-1) in the United States and 3 arc-seconds (about 90m; SRTM-3) in the World. In the study, SRTM-3 data covering the area of 3 degrees laterally (32°E to 35°E) and 4 degrees vertically (0° to 4°N), was utilized.

| Data | Acquisition Date | Number of data | Spatial Resolution | Coordinate System | Datum |
|--------------|-------------------------------|----------------------------------|---|--------------------------------|----------|
| LANDSAT/ETM+ | 2002/06 2002/09 2003/01 | 5 scenes 5 scenes 5 scenes | 30 m (in Visible and SWIR*) 60 m (in TIR*) | UTM | WGS 1984 |
| LANDSAT/TM | 1984/09 1986/01 | 5 scenes 5 scenes | 30 m (in Visible and SWIR*) 120 m (in TIR*) | UTM | WGS 1984 |
| SRTM-3 | - | 49 scenes | 3 second | Geographic (Decimal Degree) | WGS 1984 |

| Table 10- | 3 Collected | DEM | and | Satellite | Image | Data |
|-----------|--------------------|-----|-----|-----------|-------|------|
|-----------|--------------------|-----|-----|-----------|-------|------|

*SWIR: Short Wave Infrared, TIR: Thermal Infrared(

10.2 Designing GIS Database

A framework of GIS database consisting of the collected data and newly processed data was designed. The details of GIS database construction were described below.

10.2.1 Unifying the Coordinate System

The coordinate system of collected data and processed data is not consistent. The data projected on UTM is intermingled with the data on Geographic (Decimal Degree) coordinate system. Similarly, the collected data is based on either Arc 1960 or WGS 1984. In this study, the coordinate system of GIS database was unified into UTM projection and Arc 1980 datum, the same projected coordinate system as with 1/50,000 Topographic Map, and the data on different coordinate system were re-projected on the unified coordinate system.

10.2.2 GIS Database Configuration

The component of GIS database is shown in Figure 10-2. The GIS database consists of 16 units; basic information, administration, topography, geology, hydrogeology, hydrology, meteorology, water quality, socio-economy, water resources, water supply, disaster, simulation, water balance, water potential and satellite image. The configuration of database and detail of each unit are shown in Table 10-4.



Figure 10-2 Component of GIS Database

| Folder (Unit) | File Name | Ext. | Type of shp | Description | Source |
|--------------------|-----------------------|------|----------------|--|-------------------------------|
| 01_Basic_Info | catchment_kyoga | shp. | polygon | Study area detected from SRTM-3 data | JICA Study Team |
| | map_landuse | shp. | polygon | Land use map at 1996 | National Biomass Study |
| | protected_area | .shp | polygon | Protected area | NFA |
| | town | .shp | point | Major towns | National Biomass Study |
| | transportation | .shp | line | Roads, ferries and railways | National Biomass Study |
| 02_Administrative | admin_01district | .shp | polygon | Administrative boundary of district | National Biomass Study* |
| | admin_02county | shp. | polygon | Administrative boundary of county | National Biomass Study* |
| | admin_03subcoun ty | shp. | polygon | Administrative boundary of sub-county | National Biomass Study* |
| | admin_04parish | .shp | polygon | Administrative boundary of parish | National Biomass Study* |
| 03_Topography | dem_ug | .img | | SRTM-3 DEM data of Uganda | USGS |
| | dem_ug_shade | .img | | Shaded relief image generated by SRTM-3 data | JICA Study Team |
| | dem_ug_slope | .img | | Slope analysis image generated by SRTM-3 data | JICA Study Team |
| | topo_##_# | .img | | 1/50,000 Topographic map (##_#: map number) | Survey and Mapping Dept. * |
| 04_Geology | map_geology | .shp | | Geological map of Uganda | DWRM |
| | map_soil | shp. | | Soil map of Uganda | DWRM |
| | interp_lineament | shp. | | Lineament map interpreted by DEM and satellite image | JICA Study Team |
| $05_Hydrogeology$ | station_gw | .xls | point | Monitoring data of boreholes | DWRM |
| | station_gw | shp. | | Location of monitoring bore holes | JICA Study Team |
| | bedrock | .xls | | Depth of bedrocks | DWRM |
| | bedrock | .img | | Distribution of estimated bedrock's depth | JICA Study Team |
| | drill_depth | .xls | | Depth of boreholes | DWRM |
| | drill_depth | .img | | Distribution of estimated borehole's depth | JICA Study Team |
| | | | | | |

Table 10-4Configuration of GIS Database (1)

The Development Study on Water Resources Development and Management for Lake Kyoga Basin Final Report -Supporting- Chapter 10 GIS Database

| Folder (Unit) | File Name | Ext. | Type of shp | Description | Source |
|-----------------|----------------------|------|-------------|---|-----------------|
| 05_Hydrogeology | drill_static | .xls | | Static water level of boreholes | DWRM |
| | drill_static | .img | | Distribution of estimated static water level | JICA Study Team |
| | drill_tds | .xls | | TDS of boreholes | DWRM |
| | drill_tds | .img | | Distribution of estimated TDS | JICA Study Team |
| | drill_yield | .xls | | Groundwater yield of boreholes | DWRM |
| | drill_yield | .img | | Distribution of estimated groundwater yield | JICA Study Team |
| 06_Hydrology | station_sw | .xls | | Monitoring data of gauging stations | DWRM |
| | station_sw | ghs. | point | Location of gauging stations | JICA Study Team |
| | river | shp. | line | Stream net work | DWRM |
| | river_dem | ghs. | line | Stream network detected from SRTM-3 data | JICA Study Team |
| | water | ghs. | poly gon | Open water area | DWRM |
| | water_dem | ghs. | poly gon | Open water area provided by USGS | USGS |
| | wetland | ghs. | poly gon | Distribution of Wetland | DWRM |
| 07_M eteorology | station_meteo | .xls | | Monitoring data of meteorological stations | DWRM |
| | station_meteo | ghs. | point | Location of meteorological stations (precipitation) | JICA Study Team |
| | precipitation_annual | .img | | Estimated annual precipitation | JICA Study Team |
| | precipitation_m## | .img | | Estimated monthly precipitation (##: month) | JICA Study Team |
| | station_temp | dus. | point | Location of meteorological stations (precipitation) | JICA Study Team |
| | temperature_annual | .img | | Estimated annual temperature | JICA Study Team |
| | temperature_m## | .img | | Estimated monthly temperature (##: month) | JICA Study Team |
| | station_evapo | shp. | point | Location of meteorological stations (evaporation) | JICA Study Team |
| | evapo_potential_m## | .img | | Estimated monthly potential evaporation (##: month) | JICA Study Team |

Table 10-4Configuration of GIS Database (2)

| 07.Mactorology entin_unitation isp point Location of meteronological stations (unshine) J1CAStudy Team 08.Water_Quality station_wat isp >>> Baintated monthly sunshine hours (W#: month) J1CAStudy Team 08.Water_Quality station_wat isp >>> Monitoring data of water quality survey DMRM 08.Water_Quality station_wat show J1CAStudy Team's Wq survey in airy J1CAStudy Team 09.Water_Quality sho >>> Location of sampling point for water quality survey J1CAStudy Team 09.Socio_Economy sho >>> Location of sampling point for water quality J1CAStudy Team 09.Socio_Economy sho >>> Location of statistististic point for water quality J1CAStudy Team 09.Socio_Economy sho >>> ZOC Essent J1CAStudy Team's Wq survey in dip 09.Socio_Economy sho >>> ZOC Essent J1CAStudy Team's Wq survey in dip 09.Socio_Economy sho >>> ZOC Essent J1CAStudy Team's Wq survey in dip 09.Socio_Economy sh | Folder (Unit) | File Name | Ext. | Type of shp | Description | Source |
|--|--------------------|---------------------------|------|----------------|---|-----------------|
| sumshine_m##imgis the term of the term onth our (##: month)station_wq:xls:xlsis the term of sampling point for water qualitystation_wq:shp:shpis the term of sampling point for water qualitystation_wq:shp:shpis the term of te | 07_Meteorology | station_sunshine | ghs. | point | of meteorological stations | JICA Study Team |
| station_wq.xls.xlsMonitoring data of water quality survey surveystation_wqshpshpshplocation of sampling point for water quality surveystation_wqshpshplocation of sampling point for water quality surveysurvey_wq_rainyshpshplocation of sampling point for water quality | | sunshine_m## | img. | | Estimated monthly sunshine hours (##: month) | JICA Study Team |
| station_wq.shpLocation of sampling point for water quality survey_arrainysurvey_wq_rainy.shp.shpLocation of sampling point for water quality survey_wq_rainysurvey_wq_rainy.shp.shpResult of JICA Study Team's Wq survey in rainy seasonsurvey_wq_dry.shppolygonResult of JICA Study Team's Wq survey in dry season2002_census.shppolygonBoundary of district with population and density eeason2002_census.shppolygonBoundary of sub-county with population and density densityadmin_01district_pop.shppolygonBoundary of sub-county with population and densityadmin_02sounty_pop.shppolygonBoundary of sub-county with population and densityadmin_03subcounty_p.shppolygonBoundary of sub-county with population and densitysubmin_02sounty_pop.shppolygonBoundary of sub-county with population and densitysubmin_03subcounty_pop.shppolygonBoundary of sub-county submins | 08_Water_Quality | station_wq | .xls | | Monitoring data of water quality survey | DWRM |
| survey_wq_rainy shp Result of JICA Study Team's WQ survey in rainy survey_wq_dry shp season season survey_wq_dry shp molygon Result of JICA Study Team's WQ survey in dry survey_wq_dry shp polygon season season 2002_census xls polygon Boundary of district with population and density admin_01district_pop shp polygon Boundary of subcounty with population and density admin_03subcounty_p shp polygon Boundary of subcounty with population and density admin_04parish_pop shp polygon Boundary of subcounty mith population and density admin_04parish_pop shp polygon Boundary of subcounty mith population and density admin_04parish_pop shp polygon Boundary of subcounty mith population and density admin_04parish_pop shp polygon Boundary of subcounty mith population and density admin_04parish_pop shp polygon Boundary of subcounty mith population and density admin_04parish_pop shp polygon Boundary of subcounty with population and de | | station_wq | ghs. | | | JICA Study Team |
| survey_wq_dryshpshpResult of JICA Study Team's WQ survey in dry 2002_census xls xls xls $reason$ 2002_census xls xls $2002_census data$ 2002_census xlp $polygon$ $Boundary of district with population and densityadmin_01district_popshppolygonBoundary of sub~county with population and densityadmin_03subcounty_pshppolygonBoundary of sub~county with population and densityadmin_03subcounty_pshppolygonBoundary of sub~county with population and densityadmin_04parish_popshppolygonBoundary of sub~county with population and densitysurvey_eeshppolygonBoundary of sub~county with population and densitysurvey_eeshppolygonBoundary of sub~county with population and densitysurvey_eeshppolygonBoundary of sub~county with population and densitysurvey_eeshppointLocation of sub~county with populati$ | | survey_wq_rainy | ghs. | | Result of JICA Study Team's WQ survey in rainy season | JICA Study Team |
| 2002 -census $xils$ $zol2$ Census data 4000 $admin_01district_popshppolygonBoundary of district with population and densityadmin_01district_popshppolygonBoundary of county with population and densityadmin_02county_popshppolygonBoundary of sub-county with population and densityadmin_02subcounty_popshppolygonBoundary of sub-county with population and densityadmin_04parish_popshppolygonBoundary of sub-county with population and densitysurvey_seeshppolygonBoundary of sub-county with population and densitysurvey_seeshppointList of deep wellswell_deepshppointLocation of eep wellswell_deepshppointLocation of shallow wellswell_shallowshppointLocation of suprosected springswell_shallow$ | | survey_wq_dry | ghs. | | Result of JICA Study Team's WQ survey in dry season | JICA Study Team |
| admin_01district_pop.shppolygonBoundary of district with population and densityadmin_02county_pop.shppolygonBoundary of sub-county with population and densityadmin_02subcounty_p.shppolygonBoundary of sub-county with population and densityadmin_03subcounty_p.shppolygonBoundary of sub-county with population and densityadmin_04parish_pop.shppolygonBoundary of sub-county with population and densityees.shppolygon.shppolygoneeswell_deep.shppointI.ist of deep wellswell_deep.shppointList of deep wells.well_deep.shppointList of shallow wells.well_deep.shppointLocation of shallow wells.well_deep.shppointLocation of shallow wells.well_shallow.shppointLocation of shallow wells.protected_spring.shppointLocation of shallow wells.protected_spring.shppointLocation of were supply ratio.water_supply_ratio.shppointLocation of water supply ratio.water_supply_ratio.shppolygonDistribution of water resources.well_shallow.shppolygonDistribution of water resources.well_shallow.shppointLocation of water supply ratio.well_shallow.shppointDouton of water supply ratio. | 09_Socio_Economy | 2002_census | .xls | | 2002 Census data | UBOS |
| admin_02county_popshppolygonBoundary of county with population and densityadmin_03subcounty_p.shppolygonBoundary of sub-county with population andadmin_04parish_pop.shppolygonBoundary of sub-county with population andadmin_04parish_pop.shppolygonBoundary of parish with population and densityadmin_04parish_pop.shppolygonBoundary of parish with population and densityadmin_04parish_pop.shppolygonBoundary of parish with population and densityadmin_04parish_pop.shppolygonList of deep wellswell_deep.shppointLocation of deep wellswell_shallow.shppointLocation of shallow wellswell_shallow.shppointLocation of protected springswell_shallow.shppointLocation of water supply facilitywell_shallow.shppointLocation of water supply ratiowell_shallow.shppointLocation of water supply ratiowell_shallow.shppointDistribution of water resourceswell_shallow | | admin_01district_pop | dys. | polygon | Boundary of district with population and density | UBOS |
| admin_03subcounty_p opshppolygonBoundary of sub-county with population and densityop.shppolygonBoundary of parish with population and densityadmin_04parish_pop.shppolygonBoundary of parish with population and densitysurvey_see.shppointResult of JICA Study Team's SE surveywell_deep.shppointList of deep wellswell_deep.shppointLocation of deep wellswell_shallow.shppointLocation of shallow wellswell_shallow.shppointLocation of protected springswell_shallow.shppointLocation of protected springsprotected_spring.shppointLocation of water supply facilitywater_supply_ratio.shppointLocation of water supply ratiowater_supply_ratio.shppolygonDistribution of water supply ratiowater_supply_ratio.shppolygonDistribution of water resourceswater_supply_ratio.shppolygonDistribution of water portected spring time at water resourceswater_supply.shppolygonDistribution of water populat | | admin_02county_pop | dys. | polygon | Boundary of county with population and density | UBOS |
| admin_04parish_pop.shppolygonBoundary of parish with population and densitycess.shppointResult of JICA Study Team's SE surveycesswell_deep.shppointList of deep wellswell_deep.shppointLocation of deep wellswell_shallow.shppointLocation of deep wellswell_shallow.shppointLocation of deep wellswell_shallow.shppointLocation of shallow wellswell_shallow.shppointLocation of water supply ratiowater_supply_ratio.shppolygonDistribution of water supply ratiowater_supply_ratio.shppolygonDistribution of water resourceswater_pay.shppolygonDistribution of water resources< | | admin_03subcounty_p op | ghs. | polygon | of sub-county with population | UBOS |
| survey_see:shppointResult of JICA Study Team's SE surveyceswell_deep.xls.xlsList of deep wellswell_deep.shppointLocation of deep wells.xlswell_shallow.xlsrotList of shallow wells.xlswell_shallow.xlspointLocation of shallow wells.xlswell_shallow.shppointLocation of shallow wells.xlsprotected_spring.shppointLocation of shallow wells.xlsprotected_spring.shppointLocation of shallow wells.xlsprotected_spring.shppointLocation of shallow wells.xlswell_shallow.shppointLocation of shallow wells.xlsprotected_spring.shppointLocation of protected springs.xlswater_supply_facility.shppointLocation of water supply facility.xlswater_supply_facility.shppolygonDistribution of water supply ratio.xlswater_supply_ratio.shppolygonDistribution of water supply ratio.xlswater_supply_ratio.shppolygonDistribution of water resources.xlswater_supply_facility.shppolygonDistribution of water resources.xlswater_supply_ratio.shppolygonDistribution of water resources.xlswater_supply.shppolygonDistribution of water resources.xlswater_supply.shppolygonDistribu | | admin_04parish_pop | shp. | polygon | Boundary of parish with population and density | UBOS |
| ceswell_deep.xlsDist of deep wellswell_deep.shppointLocation of deep wellsawell_shallow.xlspointLocation of shallow wellsawell_shallow.xlspointLocation of shallow wellsawell_shallow.shppointLocation of shallow wellsaprotected_spring.xlspointLocation of shallow wellsaprotected_spring.shppointLocation of shallow wellsaprotected_spring.shppointLocation of water supply facilityawater_supply_ratio.shppointLocation of water supply ratioawater_supply_ratio.shppolygonDistribution of water supply ratioawating_time.shppolygonDistribution of water supply ratioawating_time.shppolygonDistribution of water resourcesawilling_to_pay.shppolygonDistribution of water per montha | | survey_se | dys. | point | Result of JICA Study Team's SE survey | JICA Study Team |
| well_deep.shppointLocation of deep wellswell_shallow.xls.xlsList of shallow wellswell_shallow.shppointLocation of shallow wellsprotected_spring.xlsTist of protected springsprotected_spring.xlspointLocation of shallow wellsprotected_spring.xlspointLocation of shallow wellsprotected_spring.shppointLocation of protected springswapply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shppolygonDistribution of water supply ratiowilling_to_pay.shppolygonDistribution of water per month | 10_Water_Resources | well_deep | .xls | | List of deep wells | DWRM |
| well_shallow.xlsList of shallow wellswell_shallow.shppointLocation of shallow wellsprotected_spring.xlspointLocation of shallow wellsprotected_spring.xlspointLocation of shallow wellsprotected_spring.shppointLocation of shallow wellsprotected_spring.shppointLocation of protected springssupply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowilling_to_pay.shppolygonDistribution of water pay for water per month | | well_deep | dys. | point | Location of deep wells | JICA Study Team |
| well_shallow.shppointLocation of shallow wellsprotected_spring.xls.xlsList of protected springsprotected_spring.shppointLocation of protected springssupply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowater_supply_ratio.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_to_pay.shpPolygonDistribution of water resources | | well_shallow | .xls | | List of shallow wells | DWRM |
| protected_spring.xlsList of protected springsprotected_spring.shppointLocation of protected springssupply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowater_supply_ratio.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_to_pay.shppolygonDistribution of water supply ratio | | well_shallow | shp. | point | Location of shallow wells | JICA Study Team |
| protected_spring.shppointLocation of protected springssupply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowater_supply_ratio.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of water supply ratio | | protected_spring | .xls | | List of protected springs | DWRM |
| supply_facility.shppointLocation of water supply facilitywater_supply_ratio.shppolygonDistribution of water supply ratiowaiting_time.shpPolygonDistribution of waiting time at water resourceswilling_to_pay.shppolygonDistribution of willing to pay for water per month | | protected_spring | .shp | point | Location of protected springs | JICA Study Team |
| ratio .shp polygon Distribution of water supply ratio .shp Polygon Distribution of waiting time at water resources .shp polygon Distribution of willing to pay for water per month | 11_Water_Supply | supply_facility | shp. | point | Location of water supply facility | DWD |
| .shpPolygonDistribution of waiting time at water resources.shppolygonDistribution of willing to pay for water per month | | water_supply_ratio | shp. | polygon | Distribution of water supply ratio | DWD |
| .shp polygon Distribution of willing to pay for water per month | | waiting_time | shp. | Polygon | Distribution of waiting time at water resources | DWD |
| | | willing_to_pay | shp. | polygon | Distribution of willing to pay for water per month | DWD |

| n of GIS Database (3) | |
|-----------------------|--|
| Configuration | |
| Table 10-4 | |

| Source | National Biomass Study | National Biomass Study | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team | JICA Study Team |
|----------------|---------------------------------------|--------------------------------|-------------------------------------|---|--|---|------------------------------|---|---|--|---|
| Description | Distribution of flooding area at 2007 | Distribution of deforestration | Distribution of estimated water use | Distribution of estimated annual evapotranspiration | Distribution of estimated monthly evapotranspiration (##: month) | Distribution of estimated annual potential recharge | Distribution of runoff ratio | Distribution of estimated groundwater potential | Distribution of estimated surface water potential | LANDSAT image (#######: acquired year and month) | VSW Index image (######: acquired year and month) |
| Type of shp | Polygon | Polygon | Polygon | | | | | | | | |
| Ext. | dys. | dys. | ghs. | .img | img. | .img | .img | img. | .img | .img | .img |
| File Name | flooding | deforestration | water_use | evapotranspiration_an nual | evapotranspiration_m ## | recharge | runoff | potential_gw | potential_sw | landsat_ <i>#######</i> | Landsat_ <i>######</i> _vsw |
| Folder (Unit) | 12_Disaster | | 13_Simulation | 14_Water_Balanc e | | | | 15_Water_Potent ial | | 16_Satellite_Ima ge | |

Table 10-4Configuration of GIS Database (4)

CHAPTER 11 PROJECTED WATER DEMAND

11.1 Population Frame

The future population is forecasted in the "Strategic Investment Plan for the Water and Sanitation Sub Sector, July 2009" (SIP). The future population is estimated for each district in the following four (4) categories of areas until 2035 applying the published population growth which estimated till 2017 by the Uganda Bureau of Statistics (UBoS) based on the population census data for 1992 and 2002.

- Urban areas (Large towns)
- Peri-urban areas
- Rural small towns
- Rural areas (RGCs and villages)

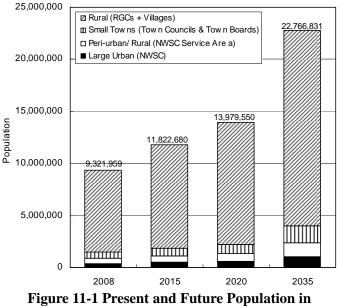
The population growth rates are set for the urban and the rural areas of each district based on the growth from 1992 to 2002, and same rates are applied for the estimation until 2035. Total population of the basin is estimated to 9,321,959 and 22,766,831 for 2008 and 2035, respectively, and the estimated values of the population for each category are summarized in the following table for some years indicative of milestones in the plan.

Table 11-1 Summary of Present and Future Population in Lake Kyoga Basin

| Year | Whole Population in the Basin | Large Urban (NWSC) | Peri-urban/ Rural (NWSC Service Are a) | Small Towns (Town Councils & Town Boards) | Rural (RGCs + Villages) |
|------|----------------------------------|-----------------------|--|---|----------------------------|
| 2008 | 9,321,959 | 392,351 | 481,972 | 604,295 | 7,843,341 |
| 2015 | 11,822,680 | 482,341 | 632,369 | 772,111 | 9,935,859 |
| 2020 | 13,979,550 | 587,059 | 748,386 | 925,437 | 11,718,668 |
| 2035 | 22,766,831 | 1,004,084 | 1,366,522 | 1,644,976 | 18,751,249 |

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

As seen in Figure 11-1, the rural population (RGC + Village) shares about 84% of the whole population, and its increase from 2008 to 2035 is calculated to be 239%, a bit smaller than those of urban areas calculated to be 272% for the sum of large urban, peri-urban and small towns. The projected future population of each district is tabulated in Tables 11-2, 11-3, 11-4 and 11-5 for 2008, 2015, 2020 and 2035, respectively.



Lake Kyoga Basin

| No. | District Name | Total No. of persons | Large Urban (NWSC) | Peri-urban/ rural (NWSC Service Area) | Small Towns (Town Councils & Town Boards) | Rural (RGCs+Villages) |
|-----|---------------|----------------------|-----------------------|---|---|--------------------------|
| 1 | Abim | 8,567 | 0 | 0 | 0 | 8,567 |
| 2 | Amolatar | 113,700 | 0 | 0 | 13,500 | 100,200 |
| 3 | Amuria | 168,546 | 0 | 0 | 2,100 | 166,446 |
| 4 | Apac | 140,180 | 0 | 0 | 0 | 140,180 |
| 5 | Budaka | 160,100 | 0 | 9,359 | 19,900 | 130,841 |
| 6 | Bududa | 154,120 | 0 | 0 | 3,800 | 150,320 |
| 7 | Bugiri | 366,517 | 0 | 0 | 35,500 | 331,017 |
| 8 | Bukedea | 157,000 | 0 | 0 | 37,200 | 119,800 |
| 9 | Bukwa | 18,907 | 0 | 0 | 0 | 18,907 |
| 10 | Busia | 169,711 | 0 | 0 | 25,920 | 143,791 |
| 11 | Butaleja | 192,500 | 0 | 0 | 5,100 | 187,400 |
| 12 | Dokolo | 157,732 | 0 | 0 | 16,200 | 141,532 |
| 13 | Iganga | 659,371 | 52,896 | 0 | 40,300 | 566,175 |
| 14 | Jinja | 343,118 | 37,371 | 106,129 | 16,800 | 182,818 |
| 15 | Kaabong | 90,770 | 0 | 0 | 19,500 | 71,270 |
| 16 | Kaberamaido | 168,100 | 0 | 0 | 0 | 168,100 |
| 17 | Kaliro | 188,600 | 0 | 0 | 24,322 | 164,278 |
| 18 | Kamuli | 669,900 | 0 | 0 | 13,700 | 656,200 |
| 19 | Kapchorwa | 178,593 | 0 | 0 | 11,300 | 167,293 |
| 20 | Katakwi | 150,100 | 0 | 0 | 7,500 | 142,600 |
| 21 | Kayunga | 330,900 | 0 | 0 | 22,200 | 308,700 |
| 22 | Kotido | 118,942 | 0 | 0 | 18,800 | 100,142 |
| 23 | Kumi | 345,400 | 0 | 0 | 16,400 | 329,000 |
| 24 | Lira | 92,867 | 0 | 9,607 | 0 | 83,260 |
| 25 | Luwero | 170,957 | 0 | 0 | 7,749 | 163,208 |
| 26 | Manafwa | 320,500 | 0 | 0 | 46,045 | 274,455 |
| 27 | Mayuge | 80,468 | 0 | 0 | 3,210 | 77,258 |
| 28 | Mbale | 392,900 | 82,676 | 77,098 | 0 | 233,127 |
| 29 | Moroto | 231,008 | 0 | 0 | 27,166 | 203,842 |
| 30 | Mukono | 578,418 | 127,767 | 49,571 | 34,792 | 366,288 |
| 31 | Nakapiripirit | 146,825 | 0 | 0 | 1,150 | 145,675 |
| 32 | Nakasongola | 101,459 | 0 | 0 | 7,300 | 94,159 |
| 33 | Namutumba | 196,300 | 0 | 0 | 9,800 | 186,500 |
| 34 | Pallisa | 471,800 | 0 | 0 | 54,000 | 417,800 |
| 35 | Sironko | 328,602 | 0 | 0 | 38,439 | 290,163 |
| 36 | Soroti | 499,800 | 42,121 | 2,707 | 10,000 | 444,972 |
| 37 | Tororo | 440,000 | 40,161 | 53,489 | 14,602 | 331,749 |
| 38 | Wakiso | 218,677 | 0 | 183,371 | 0 | 35,306 |
| | Total | 9,321,956 | 382,992 | 491,330 | 604,295 | 7,843,339 |

Table 11-2 Present Population within Lake Kyoga Basin in 2008

| | 1 an | | | Peri-urban/ rural | Small Towns | |
|-----|---------------|-------------------------|-------------------------|-------------------|----------------|-----------------|
| | | Total No. of | Large Urban | (NWSC Service | (Town Councils | Rural |
| No. | District Name | persons | (NWSC) | Area) | & Town Boards) | (RGCs+Villages) |
| 1 | Abim | 8,903 | 0 | 0 | 0 | 8,903 |
| 2 | Amolatar | 137,579 | 0 | 0 | 16,345 | 121,234 |
| 3 | Amuria | 222,747 | 0 | 0 | 3,716 | 219,031 |
| 4 | Apac | 175,989 | 0 | 0 | 0 | 175,989 |
| 5 | Budaka | 192,804 | 0 | 11,510 | 24,003 | 157,291 |
| 6 | Bududa | 201,447 | 0 | 0 | 4,985 | 196,462 |
| 7 | Bugiri | 484,793 | 0 | 0 | 49,197 | 435,596 |
| 8 | Bukedea | 207,472 | 0 | 0 | 49,823 | 157,649 |
| 9 | Bukwa | 24,881 | 0 | 0 | 0 | 24,881 |
| 10 | Busia | 205,603 | 0 | 0 | 31,440 | 174,163 |
| 11 | Butaleja | 241,882 | 0 | 0 | 5,100 | 236,782 |
| 12 | Dokolo | 200,023 | 0 | 0 | 20,580 | 179,443 |
| 13 | Iganga | 841,379 | 74,430 | 0 | 51,025 | 715,924 |
| 14 | Jinja | 408,580 | 39,541 | 131,067 | 20,056 | 217,916 |
| 15 | Kaabong | 124,849 | 0 | 0 | 31,062 | 93,787 |
| 16 | Kaberamaido | 221,208 | 0 | 0 | 0 | 221,208 |
| 17 | Kaliro | 231,502 | 0 | 0 | 24,322 | 207,180 |
| 18 | Kamuli | 838,551 | 0 | 0 | 17,169 | 821,382 |
| 19 | Kapchorwa | 235,384 | 0 | 0 | 15,238 | 220,146 |
| 20 | Katakwi | 197,501 | 0 | 0 | 9,849 | 187,652 |
| 21 | Kayunga | 377,869 | 0 | 0 | 25,392 | 352,477 |
| 22 | Kotido | 161,110 | 0 | 0 | 29,330 | 131,780 |
| 23 | Kumi | 455,110 | 0 | 0 | 22,168 | 432,942 |
| 24 | Lira | 116,848 | 0 | 12,864 | 0 | 103,984 |
| 25 | Luwero | 203,464 | 0 | 0 | 9,231 | 194,233 |
| 26 | Manafwa | 404,203 | 0 | 0 | 58,147 | 346,056 |
| 27 | Mayuge | 102,527 | 0 | 0 | 4,084 | 98,443 |
| 28 | Mbale | 463,136 | 98,535 | 81,561 | 0 | 283,039 |
| 29 | Moroto | 308,342 | 0 | 0 | 40,100 | 268,242 |
| 30 | Mukono | 729,119 | 179,781 | 68,698 | 41,749 | 438,891 |
| 31 | Nakapiripirit | 193,309 | 0 | 0 | 1,611 | 191,698 |
| 32 | Nakasongola | 204,133 | 0 | 0 | 8,409 | 195,724 |
| 33 | Namutumba | 235,625 | 0 | 0 | 11,759 | 223,866 |
| 34 | Pallisa | 599,918 | 0 | 0 | 68,778 | 531,140 |
| 35 | Sironko | 390,787 | 0 | 0 | 45,809 | 344,978 |
| 36 | Soroti | 645,624 | 42,604 | 3,194 | 14,273 | 585,553 |
| 37 | Tororo | 524,000 | 47,451 | 65,453 | 17,361 | 393,735 |
| 38 | Wakiso | 304,483 | 0 | 258,022 | 0 | 46,461 |
| | Total | 11,822,684 | 482,343 | 632,369 | 772,111 | 9,935,861 |
| | <i>a</i> | t Dlan for the Water on | l Conitation Cub Costor | | 1 | l |

Table 11-3 Future Population within Lake Kyoga Basin in 2015

| | | | | Peri-urban/ rural | Small Towns | |
|-----|---------------|--------------|-------------|-------------------|----------------|-----------------|
| | Distant | Total No. of | Large Urban | (NWSC Service | (Town Councils | Rural |
| No. | District Name | persons | (NWSC) | Area) | & Town Boards) | (RGCs+Villages) |
| 1 | Abim | 9,151 | 0 | 0 | 0 | 9,151 |
| 2 | Amolatar | 157,648 | 0 | 0 | 18,736 | 138,912 |
| 3 | Amuria | 272,072 | 0 | 0 | 5,587 | 266,485 |
| 4 | Apac | 207,041 | 0 | 0 | 0 | 207,041 |
| 5 | Budaka | 220,183 | 0 | 13,344 | 27,441 | 179,398 |
| 6 | Bududa | 243,912 | 0 | 0 | 6,051 | 237,861 |
| 7 | Bugiri | 592,080 | 0 | 0 | 62,111 | 529,969 |
| 8 | Bukedea | 253,190 | 0 | 0 | 61,386 | 191,804 |
| 9 | Bukwa | 30,271 | 0 | 0 | 0 | 30,271 |
| 10 | Busia | 235,799 | 0 | 0 | 36,089 | 199,710 |
| 11 | Butaleja | 284,936 | 0 | 0 | 5,100 | 279,836 |
| 12 | Dokolo | 237,009 | 0 | 0 | 24,416 | 212,593 |
| 13 | Iganga | 1,001,956 | 94,994 | 0 | 60,391 | 846,571 |
| 14 | Jinja | 463,363 | 41,168 | 152,393 | 22,761 | 247,041 |
| 15 | Kaabong | 157,424 | 0 | 0 | 43,318 | 114,106 |
| 16 | Kaberamaido | 269,134 | 0 | 0 | 0 | 269,134 |
| 17 | Kaliro | 268,848 | 0 | 0 | 24,322 | 244,526 |
| 18 | Kamuli | 984,433 | 0 | 0 | 20,173 | 964,260 |
| 19 | Kapchorwa | 286,708 | 0 | 0 | 18,866 | 267,842 |
| 20 | Katakwi | 240,272 | 0 | 0 | 11,965 | 228,307 |
| 21 | Kayunga | 415,446 | 0 | 0 | 27,948 | 387,498 |
| 22 | Kotido | 200,628 | 0 | 0 | 40,297 | 160,331 |
| 23 | Kumi | 554,233 | 0 | 0 | 27,493 | 526,740 |
| 24 | Lira | 137,722 | 0 | 15,847 | 0 | 121,875 |
| 25 | Luwero | 230,403 | 0 | 0 | 10,460 | 219,943 |
| 26 | Manafwa | 477,065 | 0 | 0 | 68,693 | 408,372 |
| 27 | Mayuge | 121,896 | 0 | 0 | 4,850 | 117,046 |
| 28 | Mbale | 521,709 | 111,694 | 84,907 | 0 | 325,108 |
| 29 | Moroto | 379,316 | 0 | 0 | 52,959 | 326,357 |
| 30 | Mukono | 863,141 | 229,451 | 86,731 | 47,555 | 499,404 |
| 31 | Nakapiripirit | 235,279 | 0 | 0 | 2,049 | 233,230 |
| 32 | Nakasongola | 247,432 | 0 | 0 | 9,303 | 238,129 |
| 33 | Namutumba | 268,452 | 0 | 0 | 13,394 | 255,058 |
| 34 | Pallisa | 712,223 | 0 | 0 | 81,751 | 630,472 |
| 35 | Sironko | 442,288 | 0 | 0 | 51,924 | 390,364 |
| 36 | Soroti | 777,365 | 42,953 | 3,595 | 18,402 | 712,415 |
| 37 | Tororo | 593,690 | 53,456 | 75,605 | 19,646 | 444,983 |
| 38 | Wakiso | 385,835 | 0 | 329,308 | 0 | 56,527 |
| | Total | 13,979,552 | 573,716 | 761,730 | 925,437 | 11,718,670 |

Table 11-4 Future Population within Lake Kyoga Basin in 2020

| No. | District Name | Total No. of persons | Large Urban (NWSC) | Peri-urban/ rural (NWSC Service Area) | Small Towns (Town Councils & Town Boards) | Rural (RGCs+Villages) |
|-----|---------------|----------------------|-----------------------|---|---|--------------------------|
| 1 | Abim | 9,937 | 0 | 0 | 0 | 9,937 |
| 2 | Amolatar | 237,191 | 0 | 0 | 28,224 | 208,967 |
| 3 | Amuria | 663,190 | 0 | 0 | 18,982 | 644,208 |
| 4 | Apac | 337,109 | 0 | 0 | 0 | 337,109 |
| 5 | Budaka | 327,963 | 0 | 20,789 | 41,005 | 266,169 |
| 6 | Bududa | 432,964 | 0 | 0 | 10,823 | 422,141 |
| 7 | Bugiri | 340,513 | 0 | 0 | 124,979 | 215,534 |
| 8 | Bukedea | 460,236 | 0 | 0 | 114,808 | 345,428 |
| 9 | Bukwa | 54,517 | 0 | 0 | 0 | 54,517 |
| 10 | Busia | 355,696 | 0 | 0 | 54,582 | 301,114 |
| 11 | Butaleja | 467,026 | 0 | 0 | 5,100 | 461,926 |
| 12 | Dokolo | 394,296 | 0 | 0 | 40,774 | 353,522 |
| 13 | Iganga | 1,697,378 | 197,486 | 0 | 100,130 | 1,399,762 |
| 14 | Jinja | 679,189 | 46,461 | 239,540 | 33,269 | 359,919 |
| 15 | Kaabong | 322,975 | 0 | 0 | 117,477 | 205,498 |
| 16 | Kaberamaido | 484,694 | 0 | 0 | 0 | 484,694 |
| 17 | Kaliro | 426,353 | 0 | 0 | 24,322 | 402,031 |
| 18 | Kamuli | 1,592,783 | 0 | 0 | 32,720 | 1,560,063 |
| 19 | Kapchorwa | 518,172 | 0 | 0 | 35,804 | 482,368 |
| 20 | Katakwi | 432,621 | 0 | 0 | 21,453 | 411,168 |
| 21 | Kayunga | 552,124 | 0 | 0 | 37,270 | 514,854 |
| 22 | Kotido | 393,261 | 0 | 0 | 104,514 | 288,747 |
| 23 | Kumi | 1,001,074 | 0 | 0 | 52,446 | 948,628 |
| 24 | Lira | 225,848 | 0 | 29,621 | 0 | 196,227 |
| 25 | Luwero | 334,570 | 0 | 0 | 15,218 | 319,352 |
| 26 | Manafwa | 784,360 | 0 | 0 | 113,259 | 671,101 |
| 27 | Mayuge | 204,860 | 0 | 0 | 8,126 | 196,734 |
| 28 | Mbale | 751,161 | 162,684 | 95,790 | 0 | 492,687 |
| 29 | Moroto | 709,743 | 0 | 0 | 121,992 | 587,751 |
| 30 | Mukono | 1,457,583 | 477,012 | 174,525 | 70,281 | 735,765 |
| 31 | Nakapiripirit | 424,250 | 0 | 0 | 4,216 | 420,034 |
| 32 | Nakasongola | 441,453 | 0 | 0 | 12,597 | 428,856 |
| 33 | Namutumba | 397,010 | 0 | 0 | 19,795 | 377,215 |
| 34 | Pallisa | 1,191,762 | 0 | 0 | 137,283 | 1,054,479 |
| 35 | Sironko | 641,208 | 0 | 0 | 75,615 | 565,593 |
| 36 | Soroti | 1,371,602 | 44,015 | 5,126 | 39,442 | 1,283,019 |
| 37 | Tororo | 863,749 | 76,426 | 116,523 | 28,468 | 642,333 |
| 38 | Wakiso | 786,409 | 0 | 684,608 | 0 | 101,801 |
| | Total | 22,766,830 | 1,004,083 | 1,366,522 | 1,644,974 | 18,751,251 |

Table 11-5 Future Population within Lake Kyoga Basin in 2035

There are 11 sub-basins defined in the Lake Kyoga Basin (refer to Figure 11-2),. Table 11-6 shows the area and population density of sub-basins in the Lake Kyoga basin (2008). The Mpologoma sub-basin has the highest population density of 140.62 person/kim², while the lowest density of 9.94 person/km² is indicated in The sub-basins the Okok sub-basin. having rather higher population density are the Mpologoma, the Sezibwa, the Awoja, the Lumbuye and the Victoria Nile sub-basins located in the southern and eastern parts of the Lake Kyoga basin. These sub-basins are located along the major national roads and their economic activities are considered to be growing rapidly, resulting in the urgent provision of water supply facilities.

The projected future population of each sub-basin is tabulated in Tables 11-7 for 2008, 2015, 2020 and 2035.

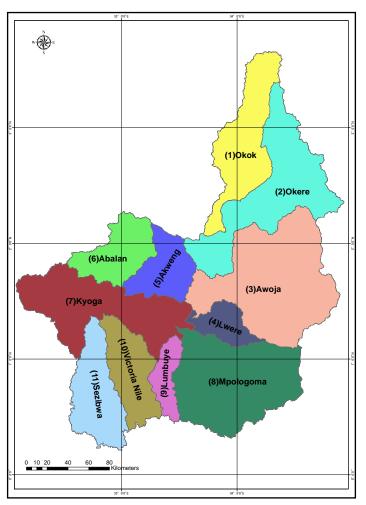


Figure 11-2 Sub-basins in Lake Kyoga Basin

| Table 11-6 Area and Population Density in Each Sub-basin | | | | | | | | | | |
|--|----------------------|-------------------------|--|-------|--|--|--|--|--|--|
| Sub-basin | Population (2008) | Area (km ²) | Population Density (person/km ²) | Order | | | | | | |
| (1) Okok | 266,139 | 5,512 | 48 | 11 | | | | | | |
| (2) Okere | 408,921 | 8,199 | 50 | 10 | | | | | | |
| (3) Awoja | 1,192,686 | 10,717 | 111 | 9 | | | | | | |
| (4) Lwere | 382,397 | 1,618 | 236 | 5 | | | | | | |
| (5) Akweng | 381,255 | 2,504 | 152 | 6 | | | | | | |
| (6) Abalan | 386,222 | 2,908 | 133 | 7 | | | | | | |
| (7) Kyoga Lakeside | 650,393 | 5,206 | 125 | 8 | | | | | | |
| (8) Mpologoma | 3,084,281 | 7,862 | 392 | 1 | | | | | | |
| (9) Lumbuye | 470,914 | 1,478 | 319 | 2 | | | | | | |
| (10) Victoria Nile | 985,698 | 3,456 | 285 | 3 | | | | | | |
| (11) Sezibwa | 1,113,054 | 4,225 | 263 | 4 | | | | | | |
| Total/Average | 9,321,959 | 53,685 | 174 | - | | | | | | |

| Sub-basin | Total No. of persons | Large Urban (NWSC) | Peri-urban/ rural (NWSC service Area) | Small Towns (Town Councils & Town Boards) | Rural (RGCs + Villages) (outside NWSC) |
|------------------------------------|----------------------|-----------------------|---|---|--|
| | | | 2008 | | |
| (1) Okok | 266,139 | 0 | 0 | 38,300 | 227,839 |
| (2) Okere | 408,921 | 0 | 0 | 29,266 | 379,655 |
| (3) Awoja | 1,192,686 | 0 | 0 | 111,989 | 1,080,697 |
| (4) Lwere | 382,397 | 16,848 | 1,083 | 4,000 | 360,466 |
| (5) Akweng | 381,255 | 25,273 | 1,624 | 6,000 | 348,358 |
| (6) Abalan | 386,222 | 0 | 9,607 | 16,200 | 360,415 |
| (7) Kyoga | 650,393 | 0 | 0 | 20,800 | 629,593 |
| (8) Mpologoma | 3,084,281 | 158,644 | 130,587 | 279,289 | 2,515,761 |
| (9) Lumbuye | 470,914 | 26,448 | 0 | 3,210 | 441,256 |
| (10) Victoria Nile | 985,698 | 37,371 | 106,129 | 30,500 | 811,698 |
| (11) Sezibwa | 1,113,054 | 127,767 | 232,942 | 64,741 | 687,604 |
| Total | 9,321,959 | 392,351 | 481,972 | 604,295 | 7,843,341 |
| | | | 2015 | | |
| (1) Okok | 357,842 | 0 | 0 | 60,392 | 297,450 |
| (2) Okere | 543,416 | 0 | 0 | 43,816 | 499,600 |
| (3) Awoja | 1,531,809 | 0 | 0 | 144,498 | 1,387,311 |
| (4) Lwere | 486,992 | 17,042 | 1,278 | 5,709 | 462,963 |
| (5) Akweng | 493,583 | 25,561 | 1,916 | 8,564 | 457,542 |
| (6) Abalan | 487,787 | 0 | 12,864 | 20,580 | 454,343 |
| (7) Kyoga | 884,466 | 0 | 0 | 24,754 | 859,712 |
| (8) Mpologoma | 3,828,767 | 183,201 | 158,524 | 346,117 | 3,140,925 |
| (9) Lumbuye | 598,659 | 37,215 | 0 | 4,084 | 557,360 |
| (10) Victoria Nile | 1,196,774 | 39,541 | 131,067 | 37,225 | 988,941 |
| (11) Sezibwa | 1,412,586 | 179,781 | 326,720 | 76,372 | 829,713 |
| Total | 11,822,680 | 482,341 | 632,369 | 772,111 | 9,935,859 |
| | , , | , | 2020 | , | , , |
| (1) Okok | 443,828 | 0 | 0 | 83,615 | 360,213 |
| (2) Okere | 666,386 | 0 | 0 | 58,546 | 607,840 |
| (3) Awoja | 1,833,831 | 0 | 0 | 173,683 | 1,660,148 |
| (4) Lwere | 579,823 | 17,181 | 1,438 | 7,361 | 553,843 |
| (5) Akweng | 594,911 | 25,771 | 2,157 | 11,041 | 555,942 |
| (6) Abalan | 576,466 | 0 | 15,847 | 24,416 | 536,203 |
| (7) Kyoga | 1,048,967 | 0 | 0 | 28,039 | 1,020,928 |
| (8) Mpologoma | 4,474,702 | 225,991 | 160,512 | 404,989 | 3,683,210 |
| (9) Lumbuye | 710,939 | 47,497 | 0 | 4,850 | 658,592 |
| (10) Victoria Nile | 1,376,146 | 41,168 | 152,393 | 42,934 | 1,139,651 |
| (11) Sezibwa | 1,673,550 | 229,451 | 416,039 | 85,963 | 942,097 |
| Total | 13,979,550 | 587,059 | 748,386 | 925,437 | 11,718,668 |
| Totur | 15,777,550 | 501,055 | 2035 | ,23,137 | 11,710,000 |
| (1) Okok | 1,028,455 | 0 | 0 | 221,991 | 806,464 |
| (2) Okere | 1,235,659 | 0 | 0 | 140,974 | 1,094,685 |
| (3) Awoja | 3,164,344 | 0 | 0 | 304,342 | 2,860,002 |
| (4) Lwere | 985,867 | 17,606 | 2,050 | 15,777 | 950,434 |
| (5) Akweng | 1,050,717 | 26,409 | 3,076 | 23,665 | 997,567 |
| (6) Abalan | 952,831 | 0 | 29,621 | 40,774 | 882,436 |
| (7) Kyoga | 1,756,003 | 0 | 0 | 40,821 | 1,715,182 |
| (8) Mpologoma | 6,452,948 | 337,853 | 233,102 | 659,748 | 5,222,245 |
| (9) Lumbuye | 1,193,680 | 98,743 | 235,102 | 8,126 | 1,086,811 |
| (10) Victoria Nile | 2,102,552 | 46,461 | 239,540 | 65,989 | 1,750,562 |
| (10) Victoria Nile (11) Sezibwa | 2,102,552 | 40,461 477,012 | 859,133 | 122,769 | 1,750,562 |
| ULL SEZIDWA | 2,043,773 | 477,012 | 039,133 | 122,/09 | 1,384,801 |

Table 11-7 Present and Future Population in Each Sub-basin

11.2 Future Water Demand

The water demands of the whole Lake Kyoga basin and the sub-basins are estimated based on SIP as presented in Table 11-8 and Table 11-9.

| Table 11-8 Prese | ent and Future W | ater Demand | for Sub-basin | s (Unit:MCM) |
|-------------------------|------------------|-------------|---------------|--------------|
| Sub-basin | 2008 | 2015 | 2020 | 2035 |
| (1) Okok | 7.7 | 12.4 | 16.1 | 26.7 |
| (2) Okere | 7.7 | 16.2 | 23.7 | 47.5 |
| (3) Awoja | 15.8 | 35.2 | 52.2 | 103.3 |
| (4) Lwere | 29.1 | 30.4 | 32.3 | 41.5 |
| (5) Akweng | 4.1 | 10.9 | 17.2 | 34.9 |
| (6) Abalan | 4.2 | 15.6 | 24.8 | 50.5 |
| (7) Kyoga Lakeside Zone | 12.3 | 24.7 | 35.4 | 65.4 |
| (8) Mpologoma | 327.6 | 322.4 | 325.5 | 365.9 |
| (9) Lumbuye | 6.2 | 8.7 | 11.3 | 20.5 |
| (10) Victoria Nile | 10.7 | 18.8 | 26.4 | 44.8 |
| (11) Sezibwa | 10.3 | 18.4 | 26.1 | 43.1 |
| Total | 435.6 | 513.6 | 590.8 | 844.1 |

 Table 11-8
 Present and Future Water Demand for Sub-basins

| 2008 | | | | | | | | | |
|-------------------------|------------------|-------------------------|-------------------|-----------|--------|-----------|---------------------|-------|--|
| Sub-basin Name | Domestic NWSC | Domestic Small Towns | Domestic Rural | Livestock | Crops | Fisheries | Rural Industries | Total | |
| (1) Okok | 0.00 | 0.49 | 1.25 | 5.82 | 0.01 | 0.09 | 0.06 | 7.7 | |
| (2) Okere | 0.00 | 0.49 | 2.08 | 4.77 | 0.01 | 0.33 | 0.05 | 7.7 | |
| (3) Awoja | 0.57 | 0.92 | 5.92 | 7.47 | 0.03 | 0.79 | 0.08 | 15.8 | |
| (4) Lwere | 0.00 | 0.47 | 1.97 | 1.12 | 25.01 | 0.26 | 0.26 | 29.1 | |
| (5) Akweng | 0.00 | 0.13 | 1.91 | 1.17 | 0.02 | 0.81 | 0.02 | 4.1 | |
| (6)Abalan | 0.00 | 0.21 | 1.97 | 1.31 | 0.10 | 0.56 | 0.02 | 4.2 | |
| (7) Kyoga Lakeside Zone | 0.00 | 0.26 | 3.45 | 3.89 | 3.51 | 1.15 | 0.09 | 12.3 | |
| (8) Mpologoma | 3.33 | 3.98 | 13.77 | 5.33 | 295.34 | 2.85 | 3.04 | 327.6 | |
| (9) Lumbuye | 0.00 | 0.00 | 2.42 | 0.79 | 2.45 | 0.47 | 0.04 | 6.2 | |
| (10) Victoria Nile | 0.00 | 0.48 | 4.44 | 3.10 | 0.31 | 2.28 | 0.06 | 10.7 | |
| (11) Sezibwa | 0.00 | 0.79 | 3.76 | 3.05 | 0.16 | 2.43 | 0.06 | 10.3 | |
| | - | | | | | | | 435.6 | |

| Sub-basin Name | Domestic NWSC | Domestic Small Towns | Domestic Rural | Livestock | Crops | Fisheries | Rural Industries | Total |
|-------------------------|------------------|-------------------------|-------------------|-----------|--------|-----------|---------------------|-------|
| (1) Okok | 0.00 | 0.88 | 2.17 | 6.82 | 2.07 | 0.17 | 0.27 | 12.4 |
| (2) Okere | 0.00 | 0.84 | 3.65 | 6.09 | 4.62 | 0.66 | 0.34 | 16.2 |
| (3) Awoja | 0.67 | 1.32 | 10.13 | 9.27 | 11.57 | 1.58 | 0.67 | 35.2 |
| (4) Lwere | 0.00 | 0.73 | 3.38 | 1.28 | 23.72 | 0.51 | 0.77 | 30.4 |
| (5) Akweng | 0.00 | 0.21 | 3.34 | 1.73 | 3.75 | 1.61 | 0.21 | 10.9 |
| (6)Abalan | 0.00 | 0.30 | 3.32 | 3.37 | 7.13 | 1.12 | 0.35 | 15.6 |
| (7) Kyoga Lakeside Zone | 0.00 | 0.36 | 5.73 | 5.30 | 10.50 | 2.29 | 0.54 | 24.7 |
| (8) Mpologoma | 4.45 | 5.70 | 22.93 | 6.18 | 268.97 | 5.70 | 8.43 | 322.4 |
| (9) Lumbuye | 0.00 | 0.00 | 4.07 | 0.93 | 2.59 | 0.94 | 0.13 | 8.7 |
| (10) Victoria Nile | 0.00 | 0.67 | 7.22 | 3.81 | 2.22 | 4.56 | 0.32 | 18.8 |
| (11) Sezibwa | 0.00 | 1.08 | 5.97 | 3.78 | 2.41 | 4.86 | 0.33 | 18.4 |
| | | | | | | | | 513.6 |

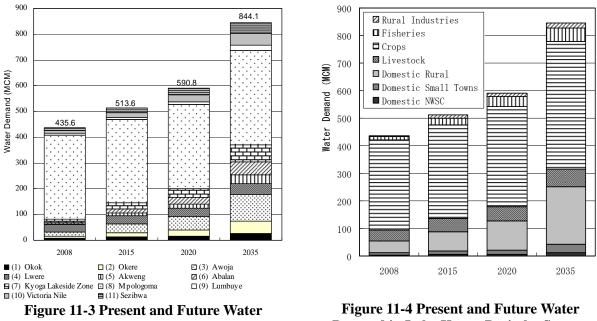
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|---|---|---|----|---|
| | | | | |
| | | | | |

| (1) Okok (2) Okere (3) Awoja (4) Lwere (5) Akweng | 0.00 0.00 0.76 0.00 | 1.25 1.75 1.01 | 3.29 5.55 15.15 5.05 | 6.76 9.71 | 21.49 | 0.26 0.99 2.37 | | 16.1 23.7 52.2 |
|---|------------------------------|----------------------|-------------------------------|--------------|--------|----------------------|------|----------------------|
| (3) Awoja (4) Lwere | 0.76 0.00 | 1.75 1.01 | 15.15 | 9.71 | 21.49 | | | |
| (4) Lwere | 0.00 | 1.01 | | | | 2.37 | 1.01 | 52.3 |
| () | | | 5.05 | 1 20 | | | | 52.2 |
| (5) Akweng | 0.00 | | | 1.29 | 23.43 | 0.77 | 0.76 | 32.3 |
| (•) | 0.00 | 0.30 | 5.07 | 2.02 | 7.00 | 2.42 | 0.34 | 17.2 |
| (6)Abalan | 0.00 | 0.40 | 4.89 | 3.93 | 13.31 | 1.68 | 0.57 | 24.8 |
| (7) Kyoga Lakeside Zone | 0.00 | 0.46 | 8.39 | 5.63 | 16.71 | 3.44 | 0.77 | 35.4 |
| (8) Mpologoma | 5.57 | 7.54 | 33.61 | 6.32 | 255.78 | 8.56 | 8.12 | 325.5 |
| (9) Lumbuye | 0.00 | 0.00 | 6.01 | 0.94 | 2.78 | 1.41 | 0.15 | 11.3 |
| (10) Victoria Nile | 0.00 | 0.86 | 10.40 | 3.93 | 3.89 | 6.84 | 0.44 | 26.4 |
| (11) Sezibwa | 0.00 | 1.37 | 8.44 | 4.04 | 4.46 | 7.29 | 0.47 | 26. |

| | | | 2035 | 5 | | | | |
|----------------------------------|------------------|-------------------------|-------------------|-----------|--------|-----------|---------------------|-------|
| Sub-basin Name | Domestic NWSC | Domestic Small Towns | Domestic Rural | Livestock | Crops | Fisheries | Rural Industries | Total |
| (1) Okok | 0.00 | 2.29 | 7.03 | 7.52 | 8.97 | 0.34 | 0.50 | 26.7 |
| (2) Okere | 0.00 | 3.97 | 11.99 | 9.21 | 20.05 | 1.32 | 0.92 | 47.5 |
| (3) Awoja | 1.08 | 3.87 | 31.32 | 11.80 | 50.15 | 3.16 | 1.95 | 103.3 |
| (4) Lwere | 0.00 | 2.51 | 10.41 | 1.41 | 25.35 | 1.02 | 0.83 | 41.5 |
| (5) Akweng | 0.00 | 0.86 | 10.92 | 2.88 | 16.28 | 3.23 | 0.67 | 34.9 |
| (6)Abalan | 0.00 | 0.89 | 9.66 | 5.62 | 30.97 | 2.23 | 1.16 | 50.5 |
| (7) Kyoga Lakeside Zone | 0.00 | 0.89 | 16.28 | 7.08 | 35.12 | 4.59 | 1.40 | 65.4 |
| (8) Mpologoma | 10.34 | 11.88 | 65.27 | 6.95 | 251.92 | 11.41 | 8.11 | 365.9 |
| (9) Lumbuye | 0.00 | 0.00 | 11.90 | 1.27 | 5.18 | 1.89 | 0.25 | 20.5 |
| (10) Victoria Nile | 0.00 | 1.72 | 19.17 | 5.34 | 8.79 | 9.12 | 0.70 | 44.8 |
| (11) Sezibwa | 0.00 | 2.65 | 14.75 | 4.84 | 10.44 | 9.72 | 0.75 | 43.1 |
| Strategic Investment Plan for th | e Water and | Sanitation St | ub Sector, 20 |)09 | | | | 844 1 |

As shown in Figure 11-3, the water demand of the Mpologoma sub-basin is the largest in the Lake Kyoga Basin sharing about 75 % of the demand of whole Kyoga basin, but its increase is not so sharp The demand of the Mpologoma sub-basin increases to 365.9 MCM as the other sub-basins. equivalent to about 12 % of increase, and remains only at about 43 % of the whole basin, though the demand of the whole basin gains from 435.6 MCM to 844.1 MCM equivalent to about 94 % of increase.



Demand in Lake Kyoga Basin by Sub-basin

Demand in Lake Kyoga Basin by Sectors

(Unit:MCM)

As for the water demand for each sector shown in Figure 11-4 and Table 11-10, the demand of irrigation for crops is considered to be the largest throughout the project period. It shares about 55% only in 2035 though about 75% in 2008. Its increase from 2008 to 2035 is calculated to be 42% which is considered low comparing with the increase of the whole demand of the basin of about 94%.

| | | | | | | | | (Unit.WiCWI) |
|------|------------------|----------------------------|-------------------|-----------|--------|-----------|---------------------|--------------|
| Year | Domestic NWSC | Domestic Small Towns | Domestic Rural | Livestock | Crops | Fisheries | Rural Industries | Total |
| 2008 | 3.9 | 8.22 | 42.94 | 37.82 | 326.95 | 12.02 | 3.78 | 435.7 |
| 2015 | 5.12 | 12.09 | 71.91 | 48.56 | 339.55 | 24 | 12.36 | 513.7 |
| 2020 | 6.33 | 16.31 | 105.85 | 51.54 | 361.31 | 36.03 | 13.45 | 591 |
| 2035 | 11.42 | 31.53 | 208.7 | 63.92 | 463.22 | 48.03 | 17.24 | 844.1 |

 Table 11-10
 Present and Future Water Demand for Sectors

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

11.2.1 Drinking Water

The future demand of the drinking water supply is estimated based on the future population increase discussed in the previous section and the targets of coverage of water service and the consumption per capita as summarized below.

| | | Target | | | | | |
|------------------------------------|---------|--------|------|------|--|--|--|
| Description | Present | 2015 | 2020 | 2035 | | | |
| 1. Urban Water Supply | · | | | | | | |
| 1.1 Coverage (%) | | | | | | | |
| Large Towns | 70 | 80 | - | 100 | | | |
| Small Towns | 41 | 65 | 74 | 100 | | | |
| 1.2 Consumption (liter/day/capita) | 35 | 30 | 45 | 60 | | | |
| 2. Rural Water Supply | | | | | | | |
| 2.1 Coverage (%) | 63 | 77 | 82 | 100 | | | |
| 2.2 Consumption (liter/day/capita) | 15 | 20 | 25 | 30 | | | |

Table 11-11 Targets of Urban and Rural Water Supply

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

11.2.2 Other Water Demands

The water demands for production such as livestock, crops (irrigation), fisheries and rural industries are estimated on the following conditions.

1) Water for Crops (Irrigation)

The water demand for irrigation is estimated based on the present crop mix according to UBOS statistics on cultivated areas and water demands for crop irrigation based on the CROPWAT model that provides data for the major crops in the Basin. As shown in Table 11-12, the cultivated areas are increased and in 2035 all the areas in the arable lands will be utilized. The irrigation facilities will be constructed in both Areas A and B, and 25% and 5% of cultivated lands will be irrigated in 2035.

| Description | 2008 | 2015 | 2020 | 2035 |
|--|----------------|------|------|------|
| Cultivated Area in Arable Land | | 75% | 100% | 100% |
| Area Irrigated in Irrigable Land | | | | |
| Area A | | 5% | 10% | 25% |
| Area B | | 1% | 2% | 5% |
| Techinoloogy Mix of Irrigation Method fo | r Water Saving | | | |
| Area A | | | | |
| Drip | 1% | 2% | 3% | 5% |
| Sprinkler | 3% | 10% | 20% | 30% |
| Surface | 81% | 63% | 57% | 50% |
| Low cost | 15% | 25% | 20% | 15% |
| Irrigation Efficiency | 45% | 50% | 54% | 58% |
| Area B | | | | |
| Drip | 5% | 5% | 18% | 25% |
| Sprinkler | 40% | 40% | 50% | 50% |
| Surface | 30% | 30% | 12% | 10% |
| Low cost | 25% | 25% | 20% | 15% |
| Irrigation Efficiency | 64% | 64% | 73% | 76% |

 Table 11-12
 Target Indices for Irrigation Requirement

Note: The irrigation efficiencies vary depending on the irrigation methods applied as shown below. - Drip: 90%, - Sprinkler: 80%, - Surface: 40%, - Low cost: 60%

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

Saving water is one of the important aspect in SIP, especially for the irrigation it is important because it shares substantial part of the whole demand. In SIP, some advanced method in water application in fields are considered; drip, sprinkler and surface methods as presented in the above table. The irrigation efficiencies are planned to be increased from the present 45% and 64% to 58% and 76% in Areas A and B, respectively in the plan.

2) Water for Livestock

The volume of water required for livestock feeding is estimated based on the future numbers of livestock expressed as Tropical Livestock Units (TLUs), which are estimated according to the rangeland capacity worked out from the rangeland areas and carrying capacities in the various agricultural zones on the UBoS statistics.

The following table shows the various indices of the water supplies for feeding livestock.

| Description | 2015 | 2020 | 2035 |
|------------------------|------|------|------|
| Rangeland Utilized | | | |
| Cattle Corridor | 60% | 70% | 100% |
| Non Cattle Corridor | 30% | 35% | 50% |
| Cattles Fed with Water | | | |
| Cattle Corridor | 30% | 40% | 70% |
| Non Cattle Corridor | 10% | 15% | 30% |

 Table 11-13
 Target Indices for Livestock Requirement

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

3) Water for Fisheries

The water volume necessary for fisheries is estimated based on the annual targets for production of fish from fishponds. The targets are set in accordance with the plans from the Fisheries Department as percentage increase of the present fish production as shown in the following table.

 Table 11-14
 Target Indices for Fish Production

| Description | 2015 | 2020 | 2035 |
|---|------|------|------|
| Fish production (% of 2006 fish production from ponds) | 200% | 300% | 400% |

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

4) Water for Rural Industries

The water volume required for rural industries is estimated as a proportion of those in the above three (3) productive sub-sectors. Presently there is limited use of water for processing of agricultural produce; dairies and abattoirs are located in urban areas. However, the water use by rural industries is expected to increase with the emphasis on development of agricultural industries and food processing close to the production areas.

11.2.3 Water Saving

Since the total water demand of domestic, livestock, agriculture, fisheries and rural industries will be increased from the present 435.6 MCM to 844.1 MCM in 2035 resulting in the severe water shortage unless any measures are taken to reduce such huge increase of demand to meet the available water resources, it is essential to be prepared to shift from the present mass consumption to the water-saving society.

As for the irrigation water demand, which shares largest at present and in the future (75% in 2008 and 55% in 2035) and of which effect of water saving is expected to be remarkable, it is necessary to adopt positively water-saving irrigation methods. The water saving methods such as drip and sprinkler irrigation, etc. are required to be introduced for upland cultivation in order to improve irrigation

efficiency. In fact as shown in Table 11-12, these water saving methods are considered in the estimation of future irrigation water demand. In the case of the paddy cultivation in wet lands, to reduce the losses by evaporation from water surfaces and seepage from bottoms of canals, it is required to be applied concrete-lined canals or piped conveyance systems instead of the ordinary earthen canals.

The domestic water demand shares 18 % (the second largest after irrigation) of the whole demand in 2008, and will share 38 % (also the second largest after irrigation but twice of that in 2008) in 2035. The domestic water supply will be given the first priority from the viewpoint of BHN (Basic Human Needs) though it is important to provide necessary water volume for the people reducing the volume of unnecessarily wasted water. For instance, as shown in Table 11-15, the Unaccounted for Water (UFW) widely varies from 5 % to 71 %, and if these unaccounted water volumes are reduced to 15 % about 430,000 m³/year of water is saved in the basin.

| | Water | | | | Water | | |
|--------------|-----------------------|-----------------------|-----|------------|-----------------------|-----------------------|-----|
| | Supplied | Water Sold | UFW | | Supplied | Water Sold | UFW |
| Area | (m ³ /day) | (m ³ /day) | (%) | Area | (m ³ /day) | (m ³ /day) | (%) |
| | Large Tov | vns | | Bugiri | 26,973 | 23,829 | 12 |
| Jinja/Lugazi | 4,452 | 3,349 | 25 | Kachumbala | 1,304 | 1,216 | 7 |
| Tororo | 909 | 804 | 12 | Busia | 187,453 | 141,711 | 24 |
| Mbale | 1,221 | 1,109 | 9 | Bulolwe | 17,209 | 14,681 | 15 |
| Lira | 934 | 816 | 13 | Busembatya | 44,026 | 39,392 | 11 |
| Soroti | 749 | 499 | 33 | Buwenge | 38,560 | 30,413 | 21 |
| Total | 8,265 | 6,577 | 20 | Kaliro | 20,573 | 18,884 | 8 |
| | Small Tov | vns | | Kamuli | 56,484 | 46,530 | 18 |
| Kangulumira | 18,618 | 17,052 | 8 | Kapachorwa | 145,521 | 41,954 | 71 |
| Kayunga | 37,036 | 22,164 | 40 | Katakwi | 18,641 | 16,993 | 9 |
| Bombo | 40,742 | 16,975 | 58 | Kumi | 19,658 | 17,684 | 10 |
| Luwero | 107,735 | 89,565 | 17 | Ngora | 56,599 | 33,920 | 40 |
| Semuto | 14,480 | 10,978 | 24 | Lwakhakha | 20,336 | 14,154 | 30 |
| Wobulenz | 82,069 | 57,941 | 29 | Pallisa | 25,596 | 17,235 | 33 |
| Nkokonjeru | 13,174 | 7,387 | 44 | Budadiri | 38,238 | 13,094 | 66 |
| Aduku | 27,673 | 22,988 | 17 | Sironko | 5,909 | 5,615 | 5 |
| Apac | 20,287 | 7,372 | 64 | Serere | 7,457 | 4,876 | 35 |
| Nakasongola | 17,661 | 15,835 | 10 | Dokolo | 22,937 | 17,949 | 22 |
| Kakiri | 12,834 | 9,933 | 23 | Kotido | 33,857 | 27,044 | 20 |
| Wakiso | 60,799 | 42,421 | 30 | Total | 1,256,447 | 857,410 | 32 |
| Budaka | 16,008 | 9,625 | 40 | | | | |

Table 11-15 Unaccounted for Water of Water Supply System in Large and Small Towns

Source: Strategic Investment Plan for the Water and Sanitation Sub Sector, 2009

The other water demands for rural industries, fishery and cattle feeding are small and their shares are also limited, but a certain level of water saving has to be considered in these uses of water. However, only in some areas where the cattle feeding is important in the people's lives full water supply is planned to be achieved, and in the other areas sufficient volume of water to feed all cattle is not assured. Then, it is rather difficult to control the demand of cattle feeding. In addition, the rural industries expected to be grown in the Lake Kyoga Basin are those processing the agricultural and fishery products on cottage industry levels. It is desirable to introduce a recycling system of used water in these industries, only few industries will be able to spare the cost for such recycling system. Consequently, in order to control the water use of these industries number of cattle fed and production of fishes have to be controlled in the allowable levels by the administrative initiative.

CHAPTER 12 WATER RESOURCES POTENTIAL EVALUATION

12.1 Water Balance Analysis for Water Resource Evaluation

A water balance is a numeric accounting of inputs, outputs, and storages of water and it can be used to manage water resources, to monitor and predict water shortage, to prevent flooding, and so on. The water balance of study area is expressed simply by the following equation.

$$P = E + R + I \tag{12.1}$$

Where; *P* is precipitation; *E* is evapotranspiration: *R* is runoff; and *I* is infiltration.

In this study, the water balance analysis was implemented for understanding the characteristic of water balance and evaluating the groundwater storage in the whole study area. In the water balance

analysis, the meteorological data and hydrological data are utilized as the existing monitoring data. The list of used monitoring data is shown in Table 12-1. In the northern part of study are, the monitoring data is not sufficient for an estimation of meteorological data covering the whole study area even by an interpolation method. To compensate the lack of monitoring data, the additional meteorological data observed in Kenya were utilized for the interpolation of some items.

Table12-1 List of Used Monitoring Data

| Observation Items | Frequency of | Number of Stations | | |
|---------------------|----------------------|--------------------|-------|--|
| Observation items | Observation | Uganda | Kenya | |
| Precipitation | Daily and Monthly | 271 | 4* | |
| Maximum Temperature | Daily | 36 | 3* | |
| Minimum Temperature | Daily | 36 | 3* | |
| Average Temperature | Monthly | 1* | 1* | |
| Sunshine Hours | Daily | 6 | 2* | |
| Evaporation | Daily | 9 | - | |
| River Water Flow | Daily | 11 | - | |
| | | | | |

12.1.1 Estimation of Precipitation

The annual and monthly precipitation maps of the study area and its surroundings were created by the precipitation data of meteorological stations. The precipitation values of unmeasured area (unmeasured grid) were estimated by Kriging method as an interpolation using measured precipitation values. The estimated annual precipitation map is shown in Figure 12-1. The study area belongs to "semiarid climate region" and the annual precipitation varies from approximately 700 to over 2,000 mm depending on topography of the area. The annual precipitation of the plain and gently hilly terrain, where the most of study area belong to, is 1,000 to 1,300 mm. However, the annual precipitation

Source: Department of Meteorology, DWRM and WMO*

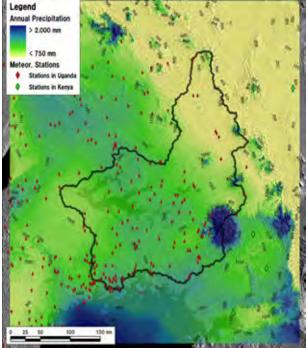


Figure 12-1 Estimated Annual Precipitation Map

in the plain of northern part, Kaabong, Kotido and Moroto Districts, is less than 1,000 mm. On the other hand, the annual precipitation of mountainous area is estimated to be over 2,000 mm.

12.1.2 Estimation of Evapotranspiration

The evapotranspiration of study area was estimated by Makkink equation in consideration with Albedo (Nagai, 1993). The equation is defined as follows:

$$ET_{mak} = \alpha \left((a + 0.06 - A) \frac{\Delta}{\Delta + \gamma} \frac{Rs}{\lambda} + b \right) (12.2)$$

Where; ET_{mak} (mm/day) is evapotranspiration; α is conversion value from potential to actual evapotranspiration value: Δ (hPa/°C) is slope of saturation vapor pressure curve; γ (hPa/°C) is psychrometric constant; *Rs* (MJ/m²/day) is total solar radiation; λ (MJ/kg) is latent heat; *a* and *b* are regional constant values; *A* is albedo value of each land cover class. The annual evapotranspiration map is shown in Figure 12-2.

The annual evapotranspiration values of the study area vary from 200 to 1,000 mm. Generally, the annual evapotranspiration of northern part with low precipitation is less than the central and western parts; estimated to be 300 to 600 mm for a year in the northern part and 600 to 1,000 mm in central and western parts. The annul values of high altitude area were estimated to be less than 300 mm, the lowest value in the study area, because the annual mean temperature of these area is less than 15 degrees Celsius. On the other hand, the highest values of 900 to 1,000 mm were obtained from the area with surface of lakes, wetland and dense tropical rain forests in the western and southwestern parts with very low albedo value (0.06 to 0.11).

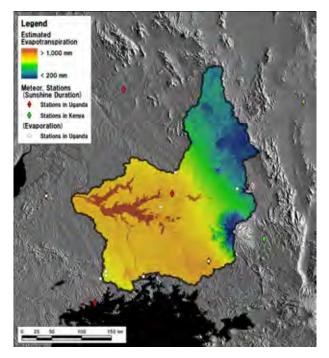


Figure 12-2 Estimated Evapotranspiration Map

12.1.3 Estimation of Runoff

The ratio of runoff, or river discharge was estimated by the techniques of geomorphometry and statistical analysis (Principle Component Analysis; PCA). The "Runoff Index" was defined as the original indicator of surface river discharge on the basis of PCA result, and the indices of each sub-catchment and catchment with gauging station in the study area were calculated. The correlation between the actual runoff ratio and the runoff indices of the sub-catchment with gauging station are shown in Table 12-2 and Figure 12-3.

| | | | | | ounging such |
|--------------------|--|---|--|---|--|
| Station ID | Gra | de of PC Sc | core | Runoff | Actual |
| Station ID | PC 1 | PC 2 | PC 3 | Index | Runoff Ratio |
| 82212 | 6 | 4 | 3 | 5.065 | 0.313 |
| 82213 | 6 | 4 | 5 | 5.521 | 0.418 |
| 82218 | 4 | 6 | 3 | 3.521 | 0.195 |
| 82220 | 2 | 4 | 2 | 2.751 | 0.084 |
| 82228 | 7 | 4 | 1 | 5.130 | 0.232 |
| 82231 | 5 | 3 | 5 | 5.250 | 0.101 |
| 82240 | 6 | 4 | 5 | 5.521 | 0.280 |
| 82241 | 7 | 5 | 4 | 5.564 | 0.312 |
| 82243 | 7 | 7 | 5 | 5.292 | 0.318 |
| 82245 | 2 | 5 | 5 | 3.185 | 0.009 |
| 82252 | 2 | 3 | 3 | 3.230 | 0.012 |
| 0.450 0.400 V = | 0.0997x - 0.2200 R ² = 0.78 | 6 | | | • |
| | 82213 82218 82220 82220 82221 82221 82221 82221 82240 82241 82243 82245 82252 9450 | Station ID PC 1 82212 6 82213 6 82218 4 82220 2 82228 7 82231 5 82240 6 82241 7 82243 7 82245 2 82252 2 0450 $\chi^2 = 0.0997 x - 0.220$ $R^2 = 0.78$ R^2 | PC 1 PC 2 82212 6 4 82213 6 4 82213 6 4 82213 6 4 82213 6 4 82218 4 6 82220 2 4 82220 2 4 82220 2 4 82220 2 4 82220 2 4 82213 5 3 82240 6 4 82241 7 5 82243 7 7 82245 2 5 82252 2 3 0450 $\chi^2 = 0.78$ $\chi^2 = 0.78$ | PC 1 PC 2 PC 3 82212 6 4 3 82213 6 4 5 82218 4 6 3 82210 2 4 2 82220 2 4 1 82213 5 3 5 82220 2 4 2 82228 7 4 1 82231 5 3 5 82240 6 4 5 82241 7 5 4 82243 7 7 5 82245 2 5 5 82252 2 3 3 0450 $y = 0.0997x - 0.2206$ $R^2 = 0.78$ | PC 1 PC 2 PC 3 Index 82212 6 4 3 5.065 82213 6 4 5 5.521 82218 4 6 3 3.521 82200 2 4 2 2.751 82228 7 4 1 5.130 82231 5 3 5 5.250 82240 6 4 5 5.521 82241 7 5 4 5.564 82243 7 7 5 5.292 82245 2 5 5 3.185 82252 2 3 3 3.230 |

Table 12-2 Actual Runoff Ratio and Runoff Index of Gauging Stations

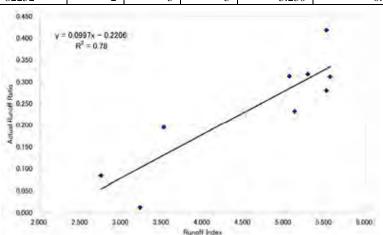


Figure 12-3 Scatter Diagram showing the Actual Runoff Ratio and Runoff Index

As shown in Figure 12-3, the correlation of the both is quite good ($R^2 = 0.78$), and the runoff index of ungauged sub-catchment can be calculated from the runoff ratio by the following equation of the linear regression.

 $R_{ratio} = 0.0997 \times RI - 0.2206 \quad (12.3)$

Where; R_{ratio} is estimated runoff ratio of sub-catchment; *RI* is estimated runoff index. The estimated runoff ratio map is shown in Figure 12-4.

The highest runoff ratio (red colored catchment in Figure 12-4) is obtained from the sub-catchments, located in the slope of mountainous and hilly terrain and showing rounded shape. On the other hand, as shown in dark blue color, the lowest runoff ratio is obtained from the sub-catchments, located in plain area and showing narrow sharp.

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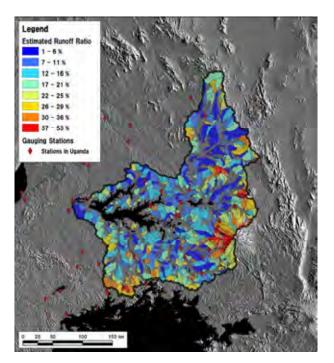


Figure 12-4 Estimated Runoff Ratio Map

12.1.4 Estimation of Infiltration (Groundwater Recharge)

On the basis of the estimated precipitation, evapotranspiration and runoff ratio, the infiltration, reflecting the ground water recharge and storage, can be expressed by the following equation.

 $I_{est} = P_{est} - AET_{mak} - P_{est} \times R_{ratio}$ (12.4) Where; I_{est} (mm) is estimated amount of infiltration; P_{est} (mm) is estimated precipitation; AET_{mak} (mm) is estimated evapotranspiration value; R_{ratio} is estimated runoff ratio from the runoff index.

The annual infiltration map of the study area on a grid basis is shown in Figure 12-5. High estimated values were generally obtained for mountainous area in the eastern part, because precipitation is higher in the high altitude area than in the plain area. The infiltration of plain area with low precipitation, especially the northern part and the outlet area of Lake Kyoga are very low. As for the plain of western part, the infiltration varies widely depending on its surface conditions.

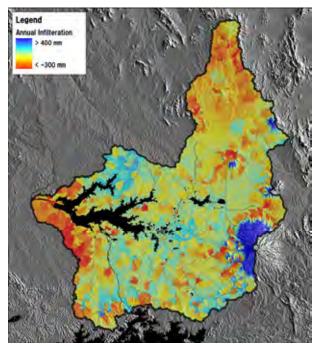


Figure 12-5 Estimated Annual Infiltration

12.2 Surface Water Resources Potential and Water Allocation Analysis

Estimation of surface water resources potential was done using Mile Basin (simulation software, made by Danish Hydraulic Institute) and the knowledge of various study results obtained in the course of the study. Then, water allocation analysis was done using the simulation model.

Simulation was carried out in two steps as follows

1) Build up a simulation model

- Data preparation (rainfall, evapotranspiration, river discharge and water usage.
- Setup catchment parameter (catchment rainfall, evapotranspiration, run-off ratio and so on)
- Calibration (adjusts run-off analysis and observed river discharge)
- Simulate initial condition

2) Simulate future condition by future water demand using drought rainfall, and analyze water allocation

- Prepare future water demand projection (2035)
- Prepare drought rainfall
- Simulate future water demand with drought rainfall
- Evaluate future water resources condition and consider water allocation

Detail simulation process is described in this part.

12.2.1 Build up Simulation Model

(1) Preparation Work

Work flow of the preparation work is shown in Figure 12-6.

i) Selection of Calibration Period

The rainfall data and river gauging station data are dramatically decreased since civil war had started at 1981. After the civil war, many of the stations are broken and observation has not been held until now. These data are stored in Hydata which is a database of hydrological information. For the calibration, both of rainfall data and river gauging data in the same period are necessary. Therefore, calibration period shall be selected according to the data availability and coverage in each sub-catchment. For the calibration, data which were observed in 1950 to 1979 shall be selected because of following two reasons.

- Data availability in Hydata
- Less water demand than the present

Lists of rainfall station and river gauging station which are useful for analysis in Lake Kyoga basin is shown in Table 12-3 and 12-4, and data coverage of observed data are shown in Figure A12-1 and A12-2 of Appendix 12.

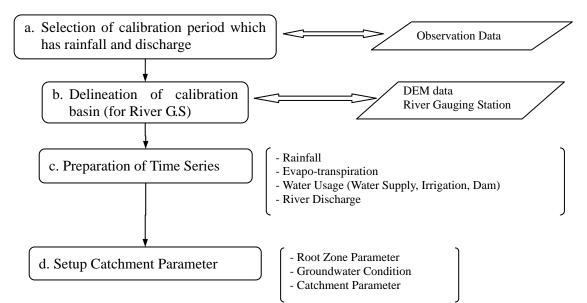


Figure 12-6 Flow Chart of Preparation Work

| Table | 12-3 | List | of | Rainfall | Stations | in | Lake | Kvoga | Basin | for | Simulation |
|-------|------|------|-----|----------|----------|----|------|-------|-------|-----|------------|
| | | | ~ - | | | | | | | | |

| Best Best <th< th=""><th>Iu</th><th>ble 12 5 Libt of</th><th>Runnun</th><th>otations</th><th>III Luke K</th><th>yogu Dushi iti k</th><th>Jimululioi</th><th></th></th<> | Iu | ble 12 5 Libt of | Runnun | otations | III Luke K | yogu Dushi iti k | Jimululioi | |
|---|-------------|------------------|---------|----------|-------------|------------------|------------|--------|
| 86340020 Kotido 34.1000 3.0170 88340040 Kachumbala KU 34.1000 1.22 86340030 Loyoro [Count 34.2170 3.3670 88340150 Bukedea Expt 34.0500 1.33 87320020 Ngetta Farm 32.9330 2.3170 88340260 Bugusege Coff 34.2670 1.15 87320020 Bardyang Fore 32.9500 2.5170 88340300 Sipi CM 34.3830 1.33 87320200 Bardyang Fore 32.9500 2.0170 88340470 Namalu WDD 34.6170 1.84 87330050 Ocacia Boys 33.4500 2.0330 88340490 Bukwa Catholi 34.7500 1.30 87340040 Nabilatuk 34.5170 2.1000 89310050 Kiogga 31.7670 0.91 87340040 Iriri Variety 34.230 2.1000 8932000 Kings College 32.4830 0.25 87340060 Iriri Variety 34.2570 1.4630 89320130 Moniko Estate 32.9000 0.36 | Station No. | Location Name | Long. | Lat. | Station No. | Location Name | Long. | Lat. |
| 86340030 Loyoro [Count 34.2170 3.3670 88340150 Bukedea Expt 34.0500 1.33 87320020 Ngetta Farm 32.9330 2.3170 88340260 Bugusege Coff 34.2670 1.15 87320080 Minakulu Vero 32.3670 2.5170 88340300 Sipi CM 34.3830 1.33 87320200 Bardyang Fore 32.9500 2.0170 88340370 Namalu WDD 34.6170 1.81 87330050 Ocacia Boys 33.4500 2.0330 88340470 Kapchorwa Dis 34.4500 1.40 87330070 Morulem 33.7670 2.6170 88340490 Bukwa Catholi 34.7500 1.30 87340040 Nabilatuk 34.5170 2.1000 89310050 Kings College 32.4830 0.25 87340060 Iriri Variety 34.2330 2.1000 89320130 Moniko Estate 32.9000 0.38 88310030 Masindi Met S 31.7170 1.6830 89320130 Moniko Estate 32.9330 0.35 <tr< td=""><td>86340010</td><td>Kaabong</td><td>34.1000</td><td>3.5500</td><td>88340020</td><td>Mbale</td><td>34.1830</td><td>1.0830</td></tr<> | 86340010 | Kaabong | 34.1000 | 3.5500 | 88340020 | Mbale | 34.1830 | 1.0830 |
| 87320020Ngetta Farm32.93302.317088340260Bugusege Coff34.26701.1587320080Minakulu Vero32.36702.517088340300Sipi CM34.38301.3387320200Bardyang Fore32.95002.017088340370Namalu WDD34.61701.8187330050Ocacia Boys33.45002.033088340470Kapchorwa Dis34.45001.4087330070Morulem33.76702.617088340490Bukwa Catholi34.75001.3087340040Nabilatuk34.51702.100089310050Kiboga31.76700.9187340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320130Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.93000.3688310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089330130Nawanzu33.50000.5688320130Kidera32.98301.30089330240Mamaganda KUR33.21700.8888320130Kidera32.98301.90089330270Mutai Forest33.23300.5688330010Katakwi Dispe33.96701.917089330280Butaleja Pris33.96700.9188330030Ngora Church <td>86340020</td> <td>Kotido</td> <td>34.1000</td> <td>3.0170</td> <td>88340040</td> <td>Kachumbala KU</td> <td>34.1000</td> <td>1.2330</td> | 86340020 | Kotido | 34.1000 | 3.0170 | 88340040 | Kachumbala KU | 34.1000 | 1.2330 |
| 87320080Minakulu Vero32.36702.517088340300Sipi CM34.38301.3387320200Bardyang Fore32.95002.017088340370Namalu WDD34.61701.8187330050Ocacia Boys33.45002.033088340470Kapchorwa Dis34.45001.4087330070Morulem33.76702.617088340490Bukwa Catholi34.75001.3087340040Nabilatuk34.51702.100089310050Kiboga31.76700.9187340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3688310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330140Vukula33.58300.9588320130Kidera32.98301.350089330200Mbulamuti KUR33.21700.8888320150Ibuje32.38301.900089330250Budumba KUR33.21700.8688330030Ngora Church33.80001.467089330260Butaleja Pris33.96700.9188330040Serer Agric | 86340030 | Loyoro [Count | 34.2170 | 3.3670 | 88340150 | Bukedea Expt | 34.0500 | 1.3330 |
| 87320200Bardyang Fore32.95002.017088340370Namalu WDD34.61701.8187330050Ocacia Boys33.45002.033088340470Kapchorwa Dis34.45001.4087330070Morulem33.76702.617088340490Bukwa Catholi34.75001.3087340040Nabilatuk34.51702.100089310050Kiboga31.76700.9187340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3688310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320100Bale Gombolol32.88301.100089330200Mbulamuti KUR33.21700.8688320130Kidera32.98301.350089330200Mbulamuti KUR33.21700.8688320150Ibuje32.38301.900089330250Budumba KUR33.21700.8688330010Katakwi Dispe33.96701.917089330280Butaleja Pris33.96700.9188330040Serere Agric | 87320020 | Ngetta Farm | 32.9330 | 2.3170 | 88340260 | Bugusege Coff | 34.2670 | 1.1500 |
| 87330050 Ocacia Boys 33.4500 2.0330 88340470 Kapchorwa Dis 34.4500 1.40 87330070 Morulem 33.7670 2.6170 88340490 Bukwa Catholi 34.7500 1.30 87340040 Nabilatuk 34.5170 2.1000 89310050 Kiboga 31.7670 0.91 87340050 Kangole 34.4500 2.4670 89320000 Kings College 32.4830 0.25 87340060 Iriri Variety 34.2330 2.1000 89320030 Gayaza High S 32.6170 0.44 88310030 Masindi Met S 31.7170 1.6830 89320130 Moniko Estate 32.9000 0.38 88310060 Bulindi Farm 31.4670 1.4830 89320180 Ntenga Estate 32.9330 0.35 88310210 Nalweyo Gombo 31.2670 1.1170 89320570 Nakifuma 32.7830 0.56 88320020 Nakasongola T 32.4670 1.3170 89330130 Nawanzu 33.5000 0.56 <td< td=""><td>87320080</td><td>Minakulu Vero</td><td>32.3670</td><td>2.5170</td><td>88340300</td><td>Sipi CM</td><td>34.3830</td><td>1.3330</td></td<> | 87320080 | Minakulu Vero | 32.3670 | 2.5170 | 88340300 | Sipi CM | 34.3830 | 1.3330 |
| 87330070Morulem33.76702.617088340490Bukwa Catholi34.75001.3087340040Nabilatuk34.51702.100089310050Kiboga31.76700.9187340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3888310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320100Bale Gombolol32.88301.100089330200Mbulamuti KUR33.80000.8388320130Kidera32.98301.350089330200Mbulamuti KUR33.21700.8688320150Ibuje32.38301.900089330270Mutai Forest33.23300.5688330030Ngora Church33.80001.467089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 87320200 | Bardyang Fore | 32.9500 | 2.0170 | 88340370 | Namalu WDD | 34.6170 | 1.8170 |
| 87340040Nabilatuk34.51702.100089310050Kiboga31.76700.9187340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3888310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320110Aduku Variety32.71701.983089330200Mbulamuti KUR33.80000.8388320130Kidera32.98301.350089330240Namaganda KUR33.21700.8488320150Ibuje32.38301.900089330270Mutai Forest33.23300.5688330010Katakwi Dispe33.96701.917089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 87330050 | Ocacia Boys | 33.4500 | 2.0330 | 88340470 | Kapchorwa Dis | 34.4500 | 1.4000 |
| 87340050Kangole34.45002.467089320000Kings College32.48300.2587340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3888310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320100Bale Gombolol32.88301.100089330140Vukula33.58300.9588320110Aduku Variety32.71701.983089330200Mbulamuti KUR33.21700.8888320130Kidera32.98301.350089330240Namaganda KUR33.21700.8688330010Katakwi Dispe33.96701.917089330270Mutai Forest33.23300.5688330030Ngora Church33.80001.467089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 87330070 | Morulem | 33.7670 | 2.6170 | 88340490 | Bukwa Catholi | 34.7500 | 1.3000 |
| 87340060Iriri Variety34.23302.100089320030Gayaza High S32.61700.4588310030Masindi Met S31.71701.683089320130Moniko Estate32.90000.3888310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320100Bale Gombolol32.88301.100089330140Vukula33.58300.9588320110Aduku Variety32.71701.983089330200Mbulamuti KUR33.21700.8888320130Kidera32.98301.350089330240Namaganda KUR33.21700.8488330010Katakwi Dispe33.96701.917089330270Mutai Forest33.23300.5688330030Ngora Church33.80001.467089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 87340040 | Nabilatuk | 34.5170 | 2.1000 | 89310050 | Kiboga | 31.7670 | 0.9170 |
| 88310030 Masindi Met S 31.7170 1.6830 89320130 Moniko Estate 32.9000 0.38 88310060 Bulindi Farm 31.4670 1.4830 89320180 Ntenga Estate 32.9330 0.35 88310210 Nalweyo Gombo 31.2670 1.1170 89320570 Nakifuma 32.7830 0.56 88320020 Nakasongola T 32.4670 1.3170 89330130 Nawanzu 33.5000 0.56 88320090 Bale Gombolol 32.8830 1.1000 89330140 Vukula 33.5830 0.95 88320110 Aduku Variety 32.7170 1.9830 89330200 Mbulamuti KUR 33.8000 0.83 88320130 Kidera 32.9830 1.3500 89330240 Namaganda KUR 33.2170 0.84 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.8000 1.4670 89330280 Butaleja Pris 33.9670 0.91 | 87340050 | Kangole | 34.4500 | 2.4670 | 89320000 | Kings College | 32.4830 | 0.2500 |
| 88310060Bulindi Farm31.46701.483089320180Ntenga Estate32.93300.3588310210Nalweyo Gombo31.26701.117089320570Nakifuma32.78300.5688320020Nakasongola T32.46701.317089330130Nawanzu33.50000.5688320090Bale Gombolol32.88301.100089330140Vukula33.58300.9588320110Aduku Variety32.71701.983089330200Mbulamuti KUR33.80000.8388320130Kidera32.98301.350089330240Namaganda KUR33.21700.8688320150Ibuje32.38301.900089330250Budumba KUR33.21700.8188330010Katakwi Dispe33.96701.917089330270Mutai Forest33.23300.5688330030Ngora Church33.80001.467089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 87340060 | Iriri Variety | 34.2330 | 2.1000 | 89320030 | Gayaza High S | 32.6170 | 0.4500 |
| 88310210 Nalweyo Gombo 31.2670 1.1170 89320570 Nakifuma 32.7830 0.56 88320020 Nakasongola T 32.4670 1.3170 89330130 Nawanzu 33.5000 0.56 88320090 Bale Gombolol 32.8830 1.1000 89330140 Vukula 33.5830 0.95 88320110 Aduku Variety 32.7170 1.9830 89330200 Mbulamuti KUR 33.8000 0.83 88320130 Kidera 32.9830 1.3500 89330240 Namaganda KUR 33.2170 0.88 88320150 Ibuje 32.3830 1.9000 89330250 Budumba KUR 33.2170 0.84 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.4500 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88310030 | Masindi Met S | 31.7170 | 1.6830 | 89320130 | Moniko Estate | 32.9000 | 0.3830 |
| 88320020 Nakasongola T 32.4670 1.3170 89330130 Nawanzu 33.5000 0.56 88320090 Bale Gombolol 32.8830 1.1000 89330140 Vukula 33.5830 0.95 88320110 Aduku Variety 32.7170 1.9830 89330200 Mbulamuti KUR 33.8000 0.83 88320130 Kidera 32.9830 1.3500 89330240 Namaganda KUR 33.2170 0.86 88320150 Ibuje 32.3830 1.9000 89330250 Budumba KUR 33.2170 0.81 88330010 Katakwi Dispe 33.9670 1.9170 89330280 Butaleja Pris 33.9670 0.91 88330030 Ngora Church 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88310060 | Bulindi Farm | 31.4670 | 1.4830 | 89320180 | Ntenga Estate | 32.9330 | 0.3500 |
| 88320090 Bale Gombolol 32.8830 1.1000 89330140 Vukula 33.5830 0.95 88320110 Aduku Variety 32.7170 1.9830 89330200 Mbulamuti KUR 33.8000 0.83 88320130 Kidera 32.9830 1.3500 89330240 Namaganda KUR 33.2170 0.88 88320150 Ibuje 32.3830 1.9000 89330250 Budumba KUR 33.2170 0.81 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.4500 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88310210 | Nalweyo Gombo | 31.2670 | 1.1170 | 89320570 | Nakifuma | 32.7830 | 0.5670 |
| 88320110 Aduku Variety 32.7170 1.9830 89330200 Mbulamuti KUR 33.8000 0.83 88320130 Kidera 32.9830 1.3500 89330240 Namaganda KUR 33.2170 0.83 88320150 Ibuje 32.3830 1.9000 89330250 Budumba KUR 33.2170 0.81 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.8000 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88320020 | Nakasongola T | 32.4670 | 1.3170 | 89330130 | Nawanzu | 33.5000 | 0.5670 |
| 88320130Kidera32.98301.350089330240Namaganda KUR33.21700.8888320150Ibuje32.38301.900089330250Budumba KUR33.21700.8188330010Katakwi Dispe33.96701.917089330270Mutai Forest33.23300.5688330030Ngora Church33.80001.467089330280Butaleja Pris33.96700.9188330040Serere Agric33.45001.517089330360Bugiri33.75000.56 | 88320090 | Bale Gombolol | 32.8830 | 1.1000 | 89330140 | Vukula | 33.5830 | 0.9500 |
| 88320150 Ibuje 32.3830 1.9000 89330250 Budumba KUR 33.2170 0.81 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.8000 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88320110 | Aduku Variety | 32.7170 | 1.9830 | 89330200 | Mbulamuti KUR | 33.8000 | 0.8330 |
| 88330010 Katakwi Dispe 33.9670 1.9170 89330270 Mutai Forest 33.2330 0.56 88330030 Ngora Church 33.8000 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88320130 | Kidera | 32.9830 | 1.3500 | 89330240 | Namaganda KUR | 33.2170 | 0.8830 |
| 88330030 Ngora Church 33.8000 1.4670 89330280 Butaleja Pris 33.9670 0.91 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88320150 | Ibuje | 32.3830 | 1.9000 | 89330250 | Budumba KUR | 33.2170 | 0.8170 |
| 88330040 Serere Agric 33.4500 1.5170 89330360 Bugiri 33.7500 0.56 | 88330010 | Katakwi Dispe | 33.9670 | 1.9170 | 89330270 | Mutai Forest | 33.2330 | 0.5670 |
| | 88330030 | Ngora Church | 33.8000 | 1.4670 | 89330280 | Butaleja Pris | 33.9670 | 0.9170 |
| 88330060 Soroti Met St 33.6170 1.7170 89330390 Ikulwe Farm I 33.4830 0.43 | 88330040 | Serere Agric | 33.4500 | 1.5170 | 89330360 | Bugiri | 33.7500 | 0.5670 |
| | 88330060 | Soroti Met St | 33.6170 | 1.7170 | 89330390 | Ikulwe Farm I | 33.4830 | 0.4330 |
| 88330070 Kibale VTC St 33.7830 1.2000 89340270 Dabani Cathol 34.0500 0.43 | 88330070 | Kibale VTC St | 33.7830 | 1.2000 | 89340270 | Dabani Cathol | 34.0500 | 0.4330 |
| 88330130 Kaberamaido A 33.1670 1.7830 89340470 Nagongera KUR 34.0500 0.78 | 88330130 | Kaberamaido A | 33.1670 | 1.7830 | 89340470 | Nagongera KUR | 34.0500 | 0.7830 |
| 88330260 Mukongoro 33.8830 1.3330 89340490 Magodesi KUR 34.1500 0.83 | 88330260 | Mukongoro | 33.8830 | 1.3330 | 89340490 | Magodesi KUR | 34.1500 | 0.8330 |
| 88330290 Kagaya/Ochero 33.0170 1.6670 89340520 Nagongera Cat 34.0170 0.78 | 88330290 | Kagaya/Ochero | 33.0170 | 1.6670 | 89340520 | Nagongera Cat | 34.0170 | 0.7830 |
| 88330330 Kagulu 33.2500 1.1000 89341220 Magale Girls 34.3670 0.88 | 88330330 | Kagulu | 33.2500 | 1.1000 | 89341220 | Magale Girls | 34.3670 | 0.8830 |
| 88330500 Ongino Lepros 33.9670 1.5170 | 88330500 | Ongino Lepros | 33.9670 | 1.5170 | | | | |

The Development Study on Water Resources Development and Management for Lake Kyoga Basin Final Report -Supporting- Chapter 12 Water Resources Potential Evaluation

| | E 12-4 LIST OF KIVE | Gauging | s Statio | | ake Kyoga Dasili lui | Sinnuia | |
|-------|----------------------|---------|----------|-------|-------------------------|---------|--------|
| No. | Name | Long. | Lat. | No. | Name | Long. | Lat. |
| 81202 | Jinja Lake Victoria | 33.2075 | 0.4144 | 82228 | Namalu at Mbale – Mo | 34.5927 | 1.7862 |
| 82203 | Victoria Nile at Mbu | 33.0000 | 0.8667 | 82229 | Amaler at Mbale – Mo | 34.6000 | 1.7833 |
| 82204 | Victoria Nile at Nam | 32.9333 | 1.0167 | 82231 | Kelim (Greek) at Mba | 34.5377 | 1.5922 |
| 82212 | Manafwa at Mbale - T | 34.1545 | 0.9355 | 82240 | Sironko at Mbale – M | 34.2542 | 1.2350 |
| 82213 | Namatala at Mbale – | 34.1702 | 1.1052 | 82241 | Simu at Mbale – Moro | 34.2857 | 1.2923 |
| 82217 | Mpologoma at Budumba | 33.7873 | 0.8228 | 82242 | Muyembe at Mbale – M | 34.3000 | 1.3333 |
| 82218 | Malaba at Jinja – To | 34.0500 | 0.5833 | 82243 | Sipi at Mbale – Moro | 34.3085 | 1.3762 |
| 82219 | Omunyal Upper at Sor | 33.4408 | 1.9000 | 82244 | Atari at Mbale – Mor | 34.4500 | 1.5000 |
| 82220 | Enget at Bata – Doko | 33.1833 | 2.0000 | 82245 | Akokorio at Soroti – | 33.8525 | 1.8583 |
| 82221 | Agu at Kumi – Serere | 33.6953 | 1.4677 | 82246 | Omunyal Lower at Sor | 33.4333 | 1.8333 |
| 82222 | Abuket at Kumi – Ser | 33.6520 | 1.4520 | 82247 | Namatsyo at Busamaga | 33.7333 | 0.9667 |
| 82223 | Kapiri I at Railway | 33.8000 | 1.6667 | 82248 | Nabiyonga at Busamag | 34.2167 | 1.0833 |
| 82225 | Sezibwa at Falls | 32.8667 | 0.3667 | 82252 | R. Kyoga Nile at Masind | 32.1000 | 1.7000 |
| 82226 | Kami at Tororo – Bus | 34.1000 | 0.5167 | 83203 | R. Kafu at Kampala – Gu | 32.0500 | 1.5500 |
| 82227 | Kapiri at Kumi – Sor | 33.7355 | 1.6669 | 83213 | | | |

Table 12-4 List of River Gauging Stations in Lake Kyoga Basin for Simulation

ii) Delineation of the Calibration Catchment

Calibration Catchment was selected based on the river gauging stations. List of the river gauging stations for the calibration were shown in Table 13-4.

The area which has few or no river gauging stations, was divided by considering topographical condition, geological condition, precipitation and distribution of evapotranspiration. Division is based on the sub-basin. Delineated catchments (Small-Catchment) are shown in Figure 13-7.

iii) Time Series

Following time series are prepared before construction of the model. Time series data shall be covered from January 1st, 1950 to December 31st 1979.

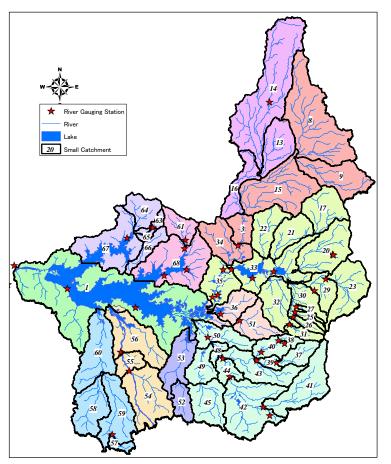


Figure 12-7 Delineated Catchments (Small-Catchments) for Simulation

1) Rainfall time series (each catchment or rainfall station which cover a target area)

- 2) Evapo-transpiration (each catchment or rainfall station which cover a target area)
- 3) River discharge (all observed discharge at gauging station, which are for calibration purposes)
- 4) Water Usage (Water Supply System, Irrigation)

a) Rainfall Time Series

Regarding the rainfall time series data, the data for daily rainfall time series of each small-catchment is created by weighting the monitoring point data of each small-catchment, which is based on the data of each monitoring station acquired by the Thiessen method.

b) Evapotranspiration Time Series

The measurement data of the evapotranspiration is extremely insufficient, and is not recommended to utilize as-is. Therefore, the result of satellite image analysis mentioned in the section 13.1.2 was used. The annual and monthly range of evapotranspiration is smaller compared to those of rainfall or river discharge, therefore monthly time series data of a year is converted to the analysis period of 30 years. The evapotranspiration per small-catchment was created from the basin information and by the satellite image analysis.

c) River Discharge Time Series

The river discharge time series is used for the comparison of the difference between the runoff analysis results by the simulation and observation results. The measured data was used as the time series data of the discharge measurement point.

d) Water Usage Time Series

Water supply facilities or irrigation facilities can be deemed not to have existed from 1950 to 1979 which was the calibration period of the simulation. Therefore, simulation for calibration is conducted excluding water usage.

iv) Setup Catchment Parameters

For the every small-catchment, parameters of (1) Surface-Rootzone, (2) Groundwater and (3) Initial Conditions, shall be prepared as shown Table 13-5. Default values are used for the beginning of calibration work. Then simulations are conducted adjusting each parameter variously and comparing observation values to simulation results about runoff volume or hydrograph. Simulation and calibration of each parameter are continued until observation values and simulation results become closely correlated. Table 13-5 shows final calibrated values of each parameter as well.

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| | Table 12-5 Param | | | | G |
|------------------|--|-----------------|---------|-------------|-----------------------------------|
| | Items | | Default | Final Value | Common Range |
| | Max. water content in surface storage (mm) | UMax | 1.0 | 10 | 10 ~ 20 |
| | Max. water content in root zone storage (mm) | LMax | 100 | 300 | 50 ~ 300 |
| sone | Overland flow runoff coefficient (%) | CQOF | 0.5 | 0.07 ~ 0.3 | 0 ~ 1.0 |
| Rootz | Time constant for interflow (hours) | CKIF | 1000 | 200 | 500 ~ 1000 |
| Surface Rootzone | Time constants for routing overland flow (hours) | CK1 | 10 | 48 | 3~48 |
| Ñ | Root zone threshold value for overland flow (%) | TOF | 0 | 0.5 | 0 ~70 |
| | Root zone threshold value for inter flow | TIF | 0 | 0 | |
| | Root zone threshold value for groundwater recharge (%) | TG | 0 | 0 | 0 ~0.70 |
| | Time constant for routing base flow (hour) | CKBF | 2000 | 750 | |
| L | Ratio of groundwater catchment to topographical catchment area | Carea | 1 | 1 | Less than 1.0 |
| Groundawter | Specific yield for the groundwater storage | Sy | 0.1 | 0.1 | 0.01~0.1 (clay) 0.1~0.3 (sand) |
| rour | Max. groundwater depth causing baseflow (m) | CWLBF0 | Null | Null | |
| 6 | Depth for unit capillary flux (m) | CWLBF1 | Null | Null | |
| | Lower base flow. Recharge to lower reservoir (%) | Cqlow | 0 | 0 | |
| | Time constant for routing lower baseflow (hour) | Cklow | 10000 | 10000 | More than CLBF |
| | Relative water contents in the surface storage | U_UMax | 0 | 0 | 0 ~ 1 |
| | Relative water content in root zoon storage | L_LMax | 0 | 0 | 0 ~ 1 |
| ondition | Overland flow | QOF | 0 | 0 | From the hydrograph |
| Cont | Interflow | QIF | 0 | 0 | rom the hydrograph |
| Initial C | Baseflow | BF | 0 | 0 | rom the hydrograph |
| In | Lower Baseflow | BF_low | 0 | 0 | rom the hydrograph |
| | Snow Storage (mm) | SnowStorag e | 0 | 0 | Initial snow depth |

(2) Rainfall-Runoff Analysis (NAM Analysis) of Each Small-Catchment

Each parameter of each small-catchment is calibrated according to the comparison of the results of runoff analyses conducted adjusting parameters' values and the discharge measurement time series data. The flow of calibration is shown in Figure 13-8. In addition, the small-catchments and river gauging stations used for the comparison are shown in the table below.

Table 12-6 Target Small-Catchments for the Calibration Work

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| Small-Catchment | 41 | 42 | 57 | 37 | 38 | 31 | 26 | 23 |
|-------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| River Gauging St. | 82218 | 82217 | 82225 | 82212 | 82213 | 82240 | 82241 | 82231 |

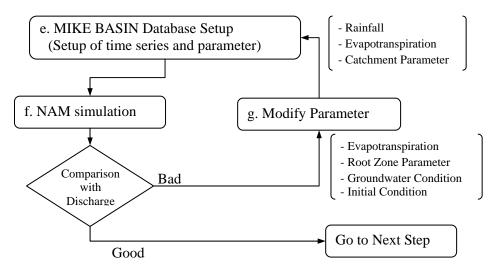


Figure 12-8 Flow Chart of Calibration Work

i) Evapotranspiration

The potential evapotranspiration is used for evapotranspiration in general. However, the measured value of the evapotranspiration is not the actual measured evapotranspiration value. For this reason, it is more likely to be deemed as an estimate value compared to the amount of rainfall or river discharge. Upon calibration, the total annual runoff must be firstly adjusted by adjusting the evapo-transpiration.

The evapotranspiration is adjusted based on the value (potential evapotranspiration) from the satellite image analysis mentioned before. Table 12-7 shows the adjustment coefficient of the evapotranspiration.

| Small-Catchment No. | 41 | 42 | 57 | 37 | 38 | 31 | 26 | 23 |
|------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|
| River Gauging Station | 82218 | 82217 | 82225 | 82212 | 82213 | 82240 | 82241 | 82231 |
| ET Coefficient (%) | 67 | 90 | 67 | 55 | 67 | 67 | 55 | 90 |
| Ratio of NAM / Observed | 0.78 | 0.84 | 0.95 | 0.82 | 0.95 | 1.16 | 0.82 | 0.92 |

Table 12-7 Adjustment Coefficient of Evapotranspiration (%)

*1: The Ratio of NAM/observed is a value which divide long-term average of simulation result (runoff) to apply ET coefficient to potential evapo-transpiration by long-term average of observed river discharge.

*2: Since small-catchment 42 is located in the downstream of small-catchment 41, the simulated value including the runoff amount of 41 is compared with observed value of 82217.

The evapotranspiration of the each small-catchment was setup based on the result of Table 12-7 referencing distribution of runoff coefficient described below. The ET coefficient is applied from four (4) values of 55%, 67%, 90% and 95%.

2) Runoff Coefficient

Likewise the evapotranspiration, the average runoff coefficient of each small-catchment was obtained by using the result of satellite image analysis mentioned in the section 12.1.3. The runoff coefficient by small-catchment is shown in Figure 12-9. Additionally, the runoff coefficient by district used in the report of SIP is shown in Table 12-8. Figure 12-9 is also including the distribution map of the runoff coefficient by SIP. Relatively large values are provided for the runoff coefficient in general for SIP. In particular, as for Kapchorwa, where the maximum value was marked is 0.7. However, low runoff coefficients such as from 0.1 to 0.2 are marked for areas around Lake Kyoga and the northern area, while higher in the southern area and the highest in Mt. Elgon area, which proves that similar patterns can be observed.

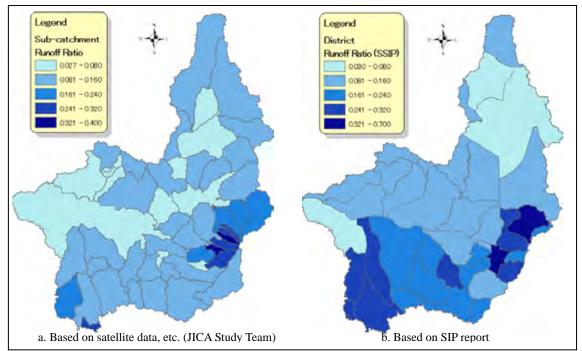


Figure 12-9 Distribution Map of Runoff Coefficient

| District Name | Runoff Coefficient | District Name | Runoff Coefficient | District Name | Runoff Coefficient |
|---------------|-----------------------|---------------|-----------------------|---------------|-----------------------|
| Kampala | 0.28 | Kumi* | 0.11 | Butaleja | 0.24 |
| Luweero* | 0.28 | Mbale* | 0.43 | Kaliro | 0.24 |
| Mukono | 0.28 | Pallisa* | 0.11 | Manafwa | 0.31 |
| Nakasongola | 0.03 | Soroti | 0.11 | Namutumba | 0.31 |
| Kayunga | 0.28 | Tororo | 0.11 | Apac* | 0.09 |
| Wakiso | 0.28 | Kaberamaido | 0.11 | Kotido* | 0.03 |
| Bugiri* | 0.24 | Mayuge | 0.24 | Lira* | 0.11 |
| Busia | 0.24 | Sironko | 0.26 | Moroto | 0.03 |
| lganga* | 0.24 | Amuria | 0.11 | Nakapipirit | 0.15 |
| Jinja | 0.24 | Budaka | 0.24 | Abim | 0.11 |
| Kamuli | 0.24 | Bududa | 0.24 | Amolatar | 0.11 |
| Kapchorwa* | 0.70 | Bukedea | 0.11 | Dokolo | 0.11 |
| Katakwi* | 0.11 | Bukwa | 0.24 | Kaabong | 0.11 |

Table 12-8 Runoff Coefficient by District by SIP

Figure 12-10 Runoff Coefficient of Small-Catchment and Classification

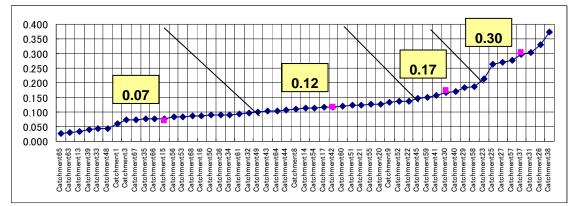


Figure 12-10 Runoff Coefficient of Small-Catchment and Classification

Figure 12-10 shows trend of when runoff coefficients obtained from the satellite image analysis are sequenced from low values to higher values. This simulation classifies runoff coefficients into four types (flat land, hill, slope, steep slope) for simplification, and is used as a characteristic value (Surface Rootzone) of the catchment.

(3) Calibration based on Discharge from Lake Victoria and Discharge from Lake Kyoga

Lake Kyoga Basin is characterized by the fact that River Nile flows through the Basin. Therefore, after completion of calibration of NAM analysis condition of each small-catchment, conditions regarding entire Lake Kyoga Basin are set or calibrated based on discharge from Lake Victoria and outflow from Lake Kyoga. Concretely, the discharge from Lake Victoria is set as a boundary condition of the model, and evaporation on Lake Kyoga and inflow from tributaries to Lake Kyoga are calibrated aiming at adjusting the simulated outflow from Lake Kyoga to fit reference values. For the calibration, the discharge from Lake Victoria (Inflow from River Victoria Nile to Lake Kyoga) and the height-volume curve of Lake Kyoga, which are used in a model being prepared by DHI on a parallel with this Study, are also applied in this simulation model in order to ensure consistency with the DHI model as per DWRM's request. Besides, the outflow from Lake Kyoga, which is an indicator of calibration, are adjusted referencing value of the DHI model, results of past studies of Hydromet and COWI-DHI that is a base of present DHI analysis.

Calibration result and reference values are shown in the table below. Since the calibration result proved out, it was deemed to complete buildup of the model of an initial condition.

| | | | | Unit: m ³ /s |
|--|-----------------------|-----------------------|--|------------------------------------|
| Item | Hydromet ¹ | COWI-DHI ² | DHI Model | Simulation Result on this Study |
| Average Inflow from River Victoria Nile to Lake Kyoga | 914 | 1074.2 | (1056.8) (Discharge from Lake Victoria) | 1069.5 |
| Average Inflow from Tributaries to Lake Kyoga | 92 | 118.2 | _ | 93.3 |
| Average Loss in Lake Kyoga (Direct Rainfall on Lake Kyoga | -66 | -91.7 | | -90.1 |

 Table 12-9 Comparison of Condition of Runoff Analysis

3,

TT ...

¹ Hydrometeorological Survey of the Catchments of Lakes Victoria, Kyoga and Albert (1974)

² Study on the planned restoration of Lake Kyoga; Sub-report 1: Modelling of Lake Kyoga Flows (2007), COWI Uganda/MoWE, Kampala, Uganda

| — Lake Evaporation) | | | | |
|------------------------------------|-----------|-----------|-----------|-----------|
| Average Outflow from Lake Kyoga | 930 | 1097.6 | 1056.7 | 1073.1 |
| Reference Period | 1948-1970 | 1950-2004 | 1950-1979 | 1950-1979 |

*1 Inflow from tributaries to Lake Kyoga is adjusted by applying flow loss factor to tributaries' reach in consideration of characteristic of Lake Kyoga Basin. Final applied flow loss factor is basically 0.3.

12.2.2 Setup of Simulation Condition and Implementation of Simulation

Simulation for grasping basic runoff characteristic of each sub-basin and simulation on future water demand in 2035 in drought rainfall condition are carried out using the completed model.

Figure 12-11 shows the work flow.

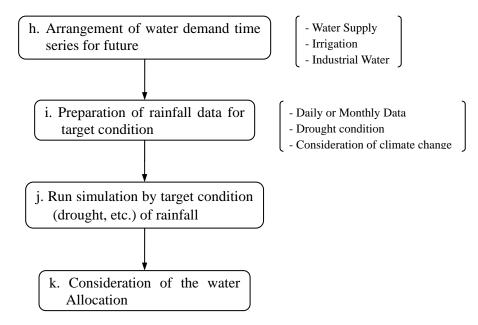


Figure 12-11 Flow Chart for Setup of Simulation Condition and Implementation of Simulation

(1) Simulation for Grasping Runoff Characteristic of Each Sub-Basin and Surface Water **Resources Potential**

Simulation is conducted in the following conditions to grasp basic runoff characteristic like low water and drought water discharge.

- 1. Simulation Period: From 1950 to 1979
- 2. Water Demand: Nothing
- 3. Rainfall Condition: Same rainfall time series as using in calibration work

Table 12-10 shows average, low water and drought water discharge of each sub-basin, which are calculated as basic runoff characteristic of each sub-basin and surface water potential.

| | | | | | | | | | | | | | | U | Jnit: (m ³ /s) | - | | |
|--|---|---|---|---|--|---|---|--|--|---|---|--|---|--|--|---|---|--|
| | | (1) Okok | - | | (2) Okere | | | (3) Awoja | | | (4) Lwere | | | (5) Ak weng | | | | |
| | Average Water | Low Water | Drought Water | Average Water | Low Water | Drought Water | Average Water | Low Water | Drought Water | Average Water | Low Water | Drought Water | Average Water | Low Water | Drought Water | | | |
| 1950 | 0.857 3.333 | 0.000 | 0.000 | 5.519 7.786 | 0.417 2.003 | 0.000 | 16.663 20.953 | 0.936 | 0.000 | 6.307 8.366 | 0.244 2.817 | 0.000 | 13.349 11.370 | 1.363 4.087 | 0.000 | | | |
| 1951 | 2.899 | 0.689 | 0.000 | 5.838 | 1.378 | 0.122 | 18.773 | 6.557 | 2.036 | 6.968 | 2.982 | 0.689 | 8.410 | 3.912 | 1.467 | | | |
| 1953 | 4.495 | 0.245 | 0.024 | 5.238 | 0.634 | 0.050 | 12.698 | 1.779 | 0.578 | 3.541 | 0.418 | 0.050 | 7.453 | 1.463 | 0.163 | | | |
| 1954 | 7.343 | 0.386 | 0.044 | 11.875 | 1.168 | 0.227 | 21.893 | 2.513 | 0.863 | 5.542 | 0.441 | 0.121 | 6.075 | 1.568 | 0.379 | | | |
| 1955 | 5.684 2.202 | 0.482 | 0.079 | 7.243 5.379 | 1.312 0.716 | 0.185 | 12.235 16.591 | 5.360 6.243 | 1.590 | 4.073 3.816 | 1.418 | 0.192 0.585 | 7.812 8.641 | 0.572 2.757 | 0.051 0.947 | | | |
| 1950 | 3.739 | 0.291 | 0.044 | 3.293 | 0.580 | 0.235 | 16.528 | 4.146 | 1.735 | 4.848 | 0.561 | 0.182 | 8.653 | 2.129 | 0.868 | | | |
| 1958 | 4.954 | 0.270 | 0.050 | 5.554 | 0.765 | 0.070 | 13.461 | 4.028 | 0.921 | 4.686 | 0.888 | 0.128 | 8.935 | 0.982 | 0.334 | | | |
| 1959 1960 | 3.165 | 0.557 0.578 | 0.071 0.165 | 4.764 5.674 | 0.356 | 0.046 | 10.683 | 6.489 4.953 | 3.137 2.617 | 4.116 5.907 | 1.127 | 0.487 | 8.766 8.053 | 3.982 3.507 | 1.346 0.855 | | | |
| 1960 | 11.049 | 0.378 | 0.165 | 11.917 | 0.395 | 0.070 | 35.903 | 4.955 | 0.648 | 10.633 | 1.130 | 0.364 | 15.548 | 3.307 | 0.833 | | | |
| 1962 | 7.917 | 1.200 | 0.461 | 6.792 | 2.416 | 0.543 | 25.581 | 13.874 | 6.509 | 7.783 | 4.253 | 1.772 | 13.955 | 6.035 | 2.256 | | | |
| 1963 | 1.885 | 0.399 | 0.181 | 6.887 | 1.097 | 0.234 | 27.310 | 7.890 | 3.473 | 9.184 | 2.158 | 0.778 | 9.595 | 3.021 | 0.794 | | | |
| 1964 1965 | 0.685 | 0.160 | 0.059 | 6.236 1.951 | 2.056 | 0.413 | 18.227 10.319 | 7.577 4.761 | 3.784 0.824 | 5.265 3.334 | 2.274 | 1.134 0.185 | 6.628 6.420 | 2.901 1.609 | 0.982 | | | |
| 1966 | 2.203 | 0.435 | 0.055 | 5.941 | 1.040 | 0.084 | 16.616 | 8.181 | 3.915 | 6.919 | 2.946 | 0.607 | 10.873 | 4.028 | 1.892 | | | |
| 1967 | 2.129 | 0.197 | 0.033 | 10.795 | 1.926 | 0.188 | 24.308 | 5.002 | 1.342 | 6.247 | 1.537 | 0.223 | 15.563 | 1.598 | 0.387 | | | |
| 1968 1969 | 1.918 1.358 | 0.483 | 0.075 | 6.249 3.144 | 1.589 0.928 | 0.760 | 23.054 19.019 | 9.024 10.644 | 3.971 | 8.291 6.836 | 3.154 3.565 | 1.811 1.709 | 15.499 10.136 | 5.163 4.017 | 3.017 | | | |
| 1969 | 3.167 | 0.426 | 0.016 | 5.245 | 1.421 | 0.099 | 27.218 | 10.644 | 3.468 | 0.850 | 3.565 | 1.709 | 16.570 | 6.649 | 3.101 | | | |
| 1971 | 2.836 | 0.302 | 0.034 | 2.869 | 0.551 | 0.084 | 16.591 | 4.661 | 1.233 | 3.836 | 0.897 | 0.091 | 10.449 | 1.784 | 0.184 | | | |
| 1972 | 2.672 | 0.331 | 0.053 | 3.012 | 0.805 | 0.147 | 13.236 | 3.454 | 1.471 | 5.129 | 0.968 | 0.375 | 11.299 | 3.596 | 0.767 | | | |
| 1973 | 0.913 | 0.135 0.214 | 0.035 | 0.462 | 0.136 | 0.000 | 10.717 14.732 | 3.924 3.148 | 0.837 | 4.737 3.680 | 1.850 0.424 | 0.424 0.145 | 7.755 8.119 | 2.182 2.427 | 0.368 | | | |
| 1974 | 5.190 | 0.214 | 0.029 | 8.028 | 1.224 | 0.006 | 31.724 | 5.325 | 0.806 | 9.222 | 1.350 | 0.025 | 18.077 | 2.427 | 0.321 | | | |
| 1976 | 2.630 | 0.385 | 0.076 | 2.796 | 0.443 | 0.086 | 16.844 | 3.163 | 0.746 | 4.257 | 0.958 | 0.130 | 8.581 | 1.550 | 0.275 | | | |
| 1977 | 2.628 | 0.459 | 0.028 | 3.235 | 0.550 | 0.066 | 25.308 | 10.574 | 2.679 | 7.756 | 2.613 | 0.373 | 12.288 | 3.566 | 0.823 | | | |
| 1978 | 7.125 | 1.130 0.183 | 0.368 0.051 | 5.137 0.764 | 0.825 0.193 | 0.070 | 47.864 7.549 | 11.777 4.285 | 4.156 2.041 | 8.024 2.074 | 2.353 0.589 | 0.633 0.175 | 10.245 7.481 | 4.994 3.649 | 1.911 1.828 | | | |
| Average | 3.373 | | | | | | | | | | | | | | | | | |
| | | 0.420 | 0.087 | 5.385 | 0.982 | 0.185 | 19.591 | 6.073 | 2.089 | 6.081 | 1.742 | 0.505 | 10.420 | 3.036 | 0.962 | | | |
| | | 0.420 | | | | | 19.591 | | | | | 0.505 | 10.420 | | | | 11) 6 . 9 | |
| | | (6) Abalanş | | (7) Kyo | ga Lakesi | de Zone | (8 |) Mpologor | na | (| 9) Lumbuy | e | (10 |) Victoria ! | Nile | | 11) Sezibw | |
| | | | | | | | | | | | | | | | | (Average Water | 11) Sezibw Low Water | a Drought Water |
| 1950 | Average Water 14.01 | (6) Abalang Low Water 1.53 | Drought Water 0.00 | (7) Kyo Average Water 8.36 | ga Lakesio Low Water 0.69 | de Zone Drought Water 0.00 | (8 Average Water 19.91 |) Mpologor Low Water 4.54 | na Drought Water 0.00 | (Average Water 1.49 | 9) Lumbuy Low Water 0.25 | e Drought Water 0.00 | (10 Average Water 10.76 |) Victoria I Low Water 2.83 | Nile Drought Water 0.00 | Average Water 4.79 | Low Water 1.45 | Drought Water 0.00 |
| 1950 1951 | Average Water 14.01 13.42 | (6) Abalang Low Water 1.53 4.42 | Drought Water 0.00 0.53 | (7) Kyo Average Water 8.36 15.42 | ga Lakesi Low Water 0.69 2.37 | de Zone Drought Water 0.00 0.07 | (8 Average Water 19.91 32.75 |) Mpologor Low Water 4.54 12.22 | na Drought Water 0.00 2.18 | Average Water 1.49 6.82 | 9) Lumbuy Low Water 0.25 2.22 | e Drought Water 0.00 0.11 | (10 Average Water 10.76 19.22 |) Victoria l Low Water 2.83 6.00 | Nile Drought Water 0.00 0.79 | Average Water 4.79 11.77 | Low Water 1.45 2.87 | Drought Water 0.00 0.93 |
| 1950 | Average Water 14.01 | (6) Abalang Low Water 1.53 | Drought Water 0.00 | (7) Kyo Average Water 8.36 | ga Lakesio Low Water 0.69 | de Zone Drought Water 0.00 | (8 Average Water 19.91 |) Mpologor Low Water 4.54 | na Drought Water 0.00 | (Average Water 1.49 | 9) Lumbuy Low Water 0.25 | e Drought Water 0.00 | (10 Average Water 10.76 |) Victoria I Low Water 2.83 | Nile Drought Water 0.00 | Average Water 4.79 | Low Water 1.45 | Drought Water 0.00 |
| 1950 1951 1952 1953 1954 | Average Water 14.01 13.42 7.14 6.91 7.86 | (6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 | g Drought Water 0.00 0.53 1.61 0.24 0.51 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 | (8) Average Water 19.91 32.75 27.49 10.25 19.61 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 | na Drought Water 0.00 2.18 3.07 0.42 0.99 | (Average Water 1.49 6.82 3.89 1.02 2.26 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 | e Drought Water 0.00 0.11 0.17 0.04 0.23 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 |) Victoria I Low Water 2.83 6.00 4.14 2.31 4.13 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 | Average Water 4.79 11.77 12.16 7.29 9.65 | Low Water 1.45 2.87 5.52 3.06 6.04 | Drought Water 0.00 0.93 2.89 0.51 3.39 |
| 1950 1951 1952 1953 1954 1955 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 | (6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 | g Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 | (8) Average Water 19.91 32.75 27.49 10.25 19.61 16.23 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 | na Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 |) Victoria I Low Water 2.83 6.00 4.14 2.31 4.13 4.85 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 |
| 1950 1951 1952 1953 1954 1955 1956 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 | (6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 | ga Lakesio Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 |) Victoria I Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 |
| 1950 1951 1952 1953 1954 1955 1956 1957 1958 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 | (6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 | ga Lakesio Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 0.02 0.00 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 0.22 0.28 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 | Victoria I Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 |
| 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 2.78 2.78 2.78 1.76 2.60 1.81 4.70 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 0.92 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 | ga Lakesie Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 0.02 0.00 0.24 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 | na Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.43 0.39 0.22 0.28 0.47 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 2.89 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 |
| 1950 1951 1952 1953 1954 1955 1956 1957 1957 1958 1959 1960 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.80 1.81 4.70 4.13 | 2 Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 0.92 1.47 | (7) Kyo Average Water 8.36 15.42 6.40 0.107 1.91 3.46 4.36 5.32 2.93 4.19 3.88 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.25 1.23 | te Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 0.02 0.000 0.024 0.34 | (8) Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 22.46 | Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 | na Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 0.1.81 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 3.13 4.29 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.27 0.19 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 |) Victoria 1 Low Water 2.83 6.00 4.14 4.231 4.13 4.85 4.35 4.35 4.25 2.39 2.89 2.89 4.66 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 1.93 |
| 1950 1951 1952 1953 1954 1955 1956 1957 1958 1959 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 2.78 2.78 2.78 2.78 2.78 2.78 2.7 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 0.92 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 | ga Lakesie Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 0.02 0.00 0.24 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 | na Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.43 0.22 0.28 0.47 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 2.89 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 |
| 1950 1952 1953 1954 1955 1956 1957 1958 1959 1959 1950 1960 1961 1962 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 18.93 17.66 14.75 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.60 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.40 | g Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 | ga Lakesia Low Water 0.69 2.37 1.32 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 | te Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.03 0.02 0.00 0.024 0.34 0.34 0.08 2.34 1.80 | (8) Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 22.46 52.97 30.43 51.05 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.67 17.13 17.50 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.43 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 0.148 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.83 14.03 8.54 6.37 15.86 24.72 19.13 22.09 |) Victorial Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 2.89 2.89 4.66 6.46 9.43 7.74 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.66 1.17 0.58 3.64 3.13 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.835 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 1.14 2.60 1.14 4.78 4.77 |
| 1950 1951 1952 1953 1955 1955 1955 1955 1955 1959 1960 1961 1962 1963 1964 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.999 7.51 11.34 10.47 18.93 17.66 14.75 16.77 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.400 | 5 Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.20 0.20 0.20 1.23 1.17 5.75 4.60 7.40 | k Zone Drought Water 0.00 0.07 0.34 0.05 0.03 0.08 0.02 0.00 0.24 0.34 0.08 2.34 1.80 3.51 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.05 18.07 16.05 18.05 22.46 52.97 30.43 51.05 31.92 |) Mpologor Low Water 4,54 12,22 14,50 2,46 4,17 8,90 8,63 4,23 3,52 9,57 6,64 17,67 17,13 17,50 18,97 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 1.129 8.43 | (Average Water 1.49 6.82 3.899 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.600 7.74 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 1.48 1.57 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 |) Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 2.89 2.89 4.66 6.46 6.46 9.43 7.74 12.85 | Nile Drought Water 0.00 0.79 1.45 0.45 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.75 16.45 16.98 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.355 9.77 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 1.93 0.67 4.78 4.77 6.76 |
| 1950 1952 1953 1954 1955 1956 1957 1958 1959 1959 1950 1960 1961 1962 | Average 4.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.40 7.68 | B Drought Water 0.00 0.53 1.61 0.24 0.51 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 | (7) Kyoo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 | ga Lakesia Low Water 0.69 2.37 0.132 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 7.40 0.669 | k Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.18 0.02 0.00 0.24 0.34 0.34 0.34 1.80 3.51 0.10 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.07 16.05 18.07 30.43 51.05 31.05 31.02 19.02 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.67 17.13 17.50 18.75 8.35 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.24 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.43 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 0.148 | (10 Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 22.56 8.816 |) Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 4.66 6.46 9.43 7.74 12.85 3.80 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.82 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.35 9.977 3.04 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 4.08 1.60 1.14 2.60 1.13 0.67 4.78 4.77 6.766 6.766 |
| 1950 1951 1952 1953 1954 1955 1956 1956 1957 1958 1959 1950 1960 1961 1962 1965 1966 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 9.7.51 11.34 10.64 19.59 11.34 10.47 11.34 10.47 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.67 11.34 10.57 10.57 11.34 10.57 1 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.831 6.40 7.68 2.52 6.07 | 2 Drought Water 0.00 0.53 1.61 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 0.53 3.29 0.78 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.346 4.36 5.32 2.93 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 | ga Lakesii Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 7.40 0.60 2.73 0.92 | de Zone Drought Water 0.00 0.07 0.34 0.05 0.03 0.18 0.02 0.00 0.24 0.34 0.03 0.24 0.34 0.08 2.34 1.80 3.51 0.10 1.53 | (8 Average Water 19.91 32.75 19.61 16.23 17.75 18.05 18.05 18.05 18.05 18.05 18.05 31.92 19.02 19.02 19.02 19.02 26.55 27.56 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.67 17.13 17.50 18.97 8.835 11.76 12.62 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 1.82 9.843 1.129 8.43 1.47 7.47 3.67 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 3.61 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.94 3.25 1.41 1.58 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.43 0.43 0.43 0.22 0.28 0.47 0.19 0.05 0.79 1.48 1.57 0.41 0.78 0.41 | (10) Average Water 10.76 19.22 12.855 8.877 9.83 14.03 8.633 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.16 12.26 19.05 |) Victoria 1 Low Water 2.83 6.000 4.114 2.31 4.13 4.85 4.25 2.39 2.89 2.89 2.89 4.66 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 | Nile Drought Water 0.00 0.79 1.45 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.82 | Average Water 4,79 11,77 12,16 7,29 9,65 9,40 12,64 13,88 9,05 8,81 16,39 17,18 18,77 16,45 16,98 11,82 9,9,11,135 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.355 9.77 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.14 2.60 1.93 0.67 4.78 4.77 6.76 1.17 2.52 0.51 |
| 1950 1951 1952 1953 1955 1955 1956 1957 1959 1959 1950 1960 1960 1966 1966 1966 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.68 1.76 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 | 2 Drought Water 0.00 0.53 1.61 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 3.53 3.29 0.78 3.51 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 11.10 5.72 10.77 | ga Lakesi Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.13 1.17 5.75 4.60 7.40 0.692 2.73 0.92 | de Zone Drought Water 0.00 0.07 0.34 0.03 0.18 0.02 0.03 0.18 0.02 0.00 0.24 0.34 0.08 2.34 1.80 3.51 0.16 0.46 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 22.46 52.97 30.43 51.05 31.92 26.95 27.56 41.21 |) Mpologor Low Water 4,54 12,22 14,50 2,46 4,17 8,90 8,63 4,23 3,52 9,57 6,64 17,67 17,13 17,50 18,97 17,13 17,50 18,97 8,35 11,76 12,62 21,978 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 5 11.46 11.29 8.43 1.47 7.47 7.47 7.3.67 9.55 | () Average Water 1.49 6.82 3.89 1.02 2.26 2.26 2.25 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 5.61 3.09 | 9) Lumbuyy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.06 | e Drought Water 0.00 0.111 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 1.48 1.57 0.41 1.57 0.41 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.803 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.816 12.26 19.05 15.91 |) Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 2.89 2.89 4.66 6.46 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.68 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.82 1.87 3.46 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.35 17.18 16.35 | Low Water 1.45 2.87 5.52 3.06 6.04 5.42 7.56 3.76 3.76 3.76 2.75 3.94 5.79 4.58 10.66 8.35 9.77 3.04 5.06 4.33 7.68 | Drought Water 0.000 0.933 2.899 0.511 3.399 3.088 4.080 1.600 1.144 2.600 1.139 0.677 4.778 4.777 6.766 1.117 2.552 0.511 2.855 |
| 1950 1951 1952 1953 1954 1955 1956 1959 1960 1961 1960 1966 1966 1966 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.67 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 | G) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 4.59 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 0.53 3.29 0.78 3.51 2.19 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 7.40 0.60 7.40 0.273 0.273 0.215 | de Zone Drought Water 0.00 0.07 0.34 0.05 0.03 0.03 0.03 0.03 0.02 0.000 0.24 0.04 0.04 0.05 0.03 0.02 0.000 0.24 0.04 0.05 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.0200 0.0200 0.0200 0.0200000000 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 22.46 52.97 30.43 51.05 31.92 19.02 26.95 27.56 41.21 28.58 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.67 17.13 17.50 18.97 18.97 8.35 11.76 12.62 19.78 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 1.81 1.81 1.82 1.84 3.05 1.129 8.84 3.147 7.47 7.47 7.55 11.91 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 5.61 5.61 3.09 3.00 | 9) Lumbay Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 2.94 3.25 1.49 2.37 2.94 3.25 1.41 1.58 1.06 1.06 1.06 | e Drought Water 0.00 0.11 0.17 0.04 0.23 0.43 0.43 0.43 0.22 0.28 0.43 0.43 0.22 0.28 0.47 0.05 0.05 0.79 1.48 1.57 0.41 0.78 0.40 0.05 0.67 0.41 0.59 0.65 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.16 12.26 19.05 15.91 12.39 |) Victorial Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 2.89 2.89 4.66 6.46 6.46 6.46 6.44 12.85 3.80 5.12 4.25 6.04 6.64 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.87 3.46 3.30 | Average 4.79 4.71 11.77 12.16 7.29 9.66 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.35 2.51 11.35 21.16 | Low Water 1.45 2.87 5.52 3.06 6.04 5.52 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.35 9.77 3.04 4.33 7.68 9.78 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 4.08 4.08 1.14 2.60 1.93 0.67 4.78 4.77 6.76 6.76 1.17 2.52 0.51 2.85 3.71 |
| 1950 1951 1952 1953 1955 1955 1956 1957 1959 1959 1950 1960 1960 1966 1966 1966 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 10.80 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.68 1.76 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 | Drought Water 0.000 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 8.329 0.78 3.29 0.78 3.51 2.19 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 2.10.77 5.83 3.14 | ga Lakesia Low Water 0.69 2.37 1.32 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 7.40 0.60 2.73 0.60 2.73 0.92 1.20 2.15 0.39 | de Zone Drought Water 0.000 0.07 0.34 0.04 0.05 0.03 0.08 0.02 0.000 0.24 0.03 0.03 0.02 0.03 0.02 0.03 0.03 0.04 0.03 0.02 0.03 0.02 0.00 0.07 0.01 0.01 0.01 0.01 0.01 0.01 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 18.05 22.46 52.97 30.43 51.05 31.92 26.95 27.56 41.21 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 3.52 9.57 6.64 17.67 17.13 17.50 18.97 8.35 11.76 12.62 19.78 19.78 19.69 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.843 1.47 7.47 7.47 7.3.67 9.55 11.91 6.63 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 5.61 3.61 3.09 3.09 3.305 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.06 1.53 1.53 | e Drought Water 0.00 0.111 0.17 0.04 0.23 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 1.48 1.57 0.41 1.57 0.41 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.803 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.16 12.26 8.16 12.26 19.05 15.91 12.39 21.75 |) Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 4.25 2.39 2.89 2.89 4.66 6.46 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 | Nile Drought Water 0.070 1.45 0.422 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.82 1.82 1.82 1.82 3.46 3.30 2.63 | Average Water 4.797 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.82 9.53 21.16 19.05 21.16 11.35 21.16 11.35 21.16 11.55 11.55 | Low Water 1.45 2.87 5.52 3.06 6.04 5.52 7.56 2.75 2.75 2.75 3.94 5.79 4.58 10.66 5.835 9.77 3.04 5.06 4.33 7.68 9.72 | Drought Water 0.000 0.93 2.89 0.51 3.39 3.08 4.08 4.08 4.08 4.00 1.14 2.60 1.93 0.67 4.78 4.77 6.76 6.76 1.17 2.52 2.0.51 2.85 3.711 2.85 |
| 1950 1951 1952 1953 1954 1955 1956 1956 1956 1960 1960 1960 1960 1960 1960 1960 196 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 19.82 16.08 19.82 16.08 10.80 14.68 11.60 | 6) Abalang Low Water 1.53 4.42 2.22 2.62 2.78 1.76 2.60 1.81 4.47 8.31 6.40 7.68 2.52 6.07 7.2.62 5.92 4.53 5.24 2.30 4.09 | Drought Water 0.00 0.53 1.61 0.24 0.51 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 0.53 3.29 0.78 3.51 2.19 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.20 0.20 0.20 0.20 0.20 0.20 | de Zone Drought Water 0.00 0.07 0.34 0.05 0.03 0.03 0.03 0.03 0.02 0.000 0.24 0.04 0.04 0.05 0.03 0.02 0.000 0.24 0.04 0.05 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.010 0.0200 0.020 0.020 0.020 0.020 0.020 0.020 0.020 0.020 0.020 0.020 0.020 0.0200 0.0200 0.0200 0.0200 0.0200 0.0200 0.02000 0.0200000000 | (8) Average Water 19.911 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 22.46 52.97 30.43 51.05 31.92 26.95 21.902 26.95 27.56 41.21 28.58 33.09 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.67 17.13 17.50 18.97 18.97 8.35 11.76 12.62 19.78 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 1.81 1.81 1.82 1.84 3.05 1.129 8.84 3.147 7.47 7.47 7.55 11.91 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 5.61 5.61 3.09 3.00 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.58 0.89 | e Drought Water 0.000 0.011 0.014 0.23 0.45 0.47 0.05 0.45 0. | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.16 12.26 19.05 15.91 12.39 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.25 4.35 4.25 2.39 2.89 2.89 4.66 6.46 6.46 6.46 6.46 6.42 5.12 4.25 6.04 6.82 8.53 5.07 4.44 | Nile Drought Water 0.000 0.79 1.45 0.42 1.73 2.88 1.67 1.06 1.06 1.07 2.21 0.58 3.64 3.13 6.87 2.09 1.87 3.46 3.00 2.63 3.00 2.63 0.48 1.67 3.48 3.46 3.00 2.63 3.00 2.63 0.48 1.67 3.00 2.63 3.00 2.63 0.48 1.67 3.00 2.63 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.00 2.63 3.04 3.00 2.63 3.00 3 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.82 9.51 11.35 21.16 19.06 39.53 31.303 | Low Water 1.45 2.87 5.52 3.06 6.04 5.52 7.56 3.76 2.75 3.94 5.79 4.58 10.66 8.35 9.77 3.04 4.33 7.68 9.78 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 4.08 4.08 1.14 2.60 1.93 0.67 4.78 4.77 6.76 6.76 1.17 2.52 0.51 2.85 3.71 |
| 1950 1951 1952 1953 1955 1956 1956 1957 1957 1957 1950 1960 1960 1960 1960 1960 1960 1965 1966 1967 1968 1969 1970 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 10.80 11.68 11.65 13.17 12.85 | 6) Abalang Low Water 1.53 4.42 2.22 2.60 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.40 7.68 2.59 2.60 1.81 4.70 4.13 4.47 8.31 6.40 7.68 2.59 2.60 4.13 5.54 4.42 3.55 3.52 4.42 3.55 3.52 4.42 3.55 3.52 4.42 3.55 3.52 4.42 3.55 3.52 4.42 3.55 3.55 3.55 3.55 3.55 3.55 3.55 3.5 | Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 4.20 3.04 8.351 2.19 1.83 3.29 0.78 3.51 2.19 0.77 0.89 0.40 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 5.32 2.93 4.19 3.88 15.01 26.92 19.43 15.01 26.92 19.43 11.10 5.72 10.77 5.83 3.14 1.04 1.04 1.04 1.04 1.04 1.04 1.04 1 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.85 1.23 1.17 5.75 4.60 7.40 0.69 2.37 0.47 0.79 0.30 0.47 1.23 1.24 1.20 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.08 2.34 0.08 2.34 0.08 2.34 0.08 2.34 0.08 0.351 0.16 0.01 0.53 0.01 0.01 0.01 0.01 0.01 0.01 0.01 0.0 | (8 Average Water 19.91 32.75 27.49 10.25 19.61 16.23 17.75 18.07 16.05 22.46 52.27.6 31.92 21.96 31.92 21.96 41.21 28.58 33.09 19.70 27.26 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.13 17.50 18.35 11.76 17.67 17.13 17.50 18.35 11.76 12.62 19.78 19.66 19.25 19.58 | na Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.433 1.47 7.47 3.67 9.55 11.91 6.63 1.51 4.85 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 9.60 7.74 2.46 3.61 3.61 3.61 3.09 3.05 3.30 4.64 2.45 1.58 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 0.92 1.69 1.36 0.92 1.37 2.94 3.25 1.41 1.58 1.06 1.06 1.53 1.56 0.58 0.58 0.689 0.64 | e Drought Water 0.00 0.11 0.04 0.23 0.43 0.39 0.22 0.28 0.47 0.19 0.05 0.79 1.48 1.57 0.41 0.79 1.48 1.57 0.64 0.53 0.67 0.53 0.67 0.53 0.04 0.05 0.05 0.05 0.01 0.01 0.01 0.01 0.01 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.816 12.26 8.816 12.26 19.05 15.91 12.39 21.75 14.38 13.59 4.41 | Victorial Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 4.66 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 6.82 8.53 5.07 4.44 2.34 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.82 1.82 1.82 1.87 3.46 3.00 2.63 3.00 3.00 2.63 3.00 2.63 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3 | Average Water 4.79 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.82 9.51 11.35 21.16 19.06 39.53 13.03 13.03 13.21 2.57 | Low Water 1.455 2.87 5.52 3.306 6.04 5.42 7.56 2.75 3.94 4.58 10.66 8.35 9.77 3.04 4.53 9.77 3.04 4.53 9.77 3.04 5.06 8.35 9.77 3.04 4.33 7.68 9.72 12.59 6.86 7.58 1.259 | Drought Water 0.000 0.933 2.89 0.511 3.399 3.08 4.08 4.08 4.08 4.00 1.14 4.260 0.677 4.78 4.77 6.766 1.17 2.52 0.511 2.85 3.711 4.299 3.338 4.57 0.666 |
| 1950 1951 1952 1953 1954 1955 1956 1959 1959 1960 1961 1966 1966 1966 1966 1966 196 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 18.93 17.66 16.77 7.98 15.65 16.77 7.98 15.65 19.82 16.080 14.68 10.80 14.68 11.65 13.17 12.85 10.16 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.62 2.78 1.76 2.60 1.81 4.470 4.81 6.400 7.68 2.52 6.07 2.62 5.923 5.24 2.300 4.09 3.54 4.33 | Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 4.20 3.04 9.78 3.51 2.19 1.83 0.27 0.78 3.51 2.19 1.83 0.27 0.78 3.51 2.19 1.239 1.239 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 4.36 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 3.14 1.213 8.08 4.07 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 7.40 0.20 0.85 1.23 1.17 5.75 5.4.60 2.73 0.92 1.20 0.215 0.39 0.39 0.14 0.09 2.15 0.39 0.12 0.39 0.12 0.39 0.14 0.39 0.39 0.39 0.39 0.39 0.39 0.39 0.39 | de Zone Drought Water 0.00 0.07 0.34 0.04 0.05 0.03 0.03 0.03 0.03 0.02 0.00 0.24 0.04 0.34 1.80 0.23 4 0.00 0.24 1.80 0.351 0.16 0.153 0.16 0.07 0.03 0.07 0.03 0.00 0.04 0.04 0.04 0.04 0.04 0.05 0.04 0.04 | (8) Average Water 1991) 10.25 27,49 10.25 19,61 16.05 18.05 18.05 18.05 18.05 18.05 18.05 18.05 18.05 18.05 22.46 51.97 30.43 31.92 19.02 26.95 27.56 41.21 28.58 33.09 19.70 27.26 17.67 16.05 27.56 41.21 28.58 33.09 19.70 27.26 17.67 16.05 27.56 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 17.13 17.50 18.97 18.35 11.76 12.62 19.78 19.66 16.92 5.68 12.25 9.58 5.37 | ma Drought Water 0.00 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.43 1.47 7.47 3.67 9.55 11.91 6.63 1.51 1.51 1.52 1.191 6.63 1.51 1.52 | (Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 5.04 5.04 5.01 5.61 3.09 3.05 3.30 4.64 4.245 1.58 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.58 8 0.89 0.64 0.64 0.64 | e Drought Water 0.000 0.111 0.17 0.044 0.23 0.439 0.22 0.28 0.477 0.19 0.05 0.79 1.48 0.411 0.79 1.48 0.410 0.59 0.653 0.041 0.53 0.041 0.58 0.05 0 | (10) Average Water 10.76 19,22 12.85 8.77 9.83 12.28 8.03 14.03 14.03 8.54 4.637 15.86 24.72 19.13 22.09 25.56 8.16 12.26 19.05 15.91 12.23 19.05 15.91 12.23 14.38 13.59 4.41 5.25 | Victorial Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.35 2.39 2.89 4.66 9.43 6.44 9.43 6.44 9.43 6.64 9.43 5.12 4.25 6.04 6.82 8.53 5.07 4.44 2.34 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.313 6.87 2.09 1.82 1.87 3.46 3.00 2.63 0.263 0.263 0.059 0.19 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.82 21.16 19.06 39.53 31.321 13.21 2.57 3.334 | Low Water 1.45 2.87 5.52 3.306 6.04 5.42 7.56 3.76 3.76 3.75 3.94 5.79 4.58 10.66 8.35 5.9.77 3.04 4.58 9.77 3.04 4.33 7.68 4.33 7.68 4.33 7.66 5.42 7.56 7.56 7.56 7.56 7.56 7.56 7.56 7.56 | Drought Water 0.00 0.93 2.89 0.51 3.39 3.08 4.08 1.60 1.93 0.67 4.78 4.77 6.76 1.17 2.52 0.51 2.85 3.71 4.29 3.38 4.57 0.66 0.33 |
| 1950 1951 1952 1953 1955 1956 1956 1957 1957 1957 1950 1960 1960 1960 1960 1960 1960 1965 1966 1967 1968 1969 1970 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.08 10.80 14.68 10.80 14.68 11.65 13.17 12.85 10.16 | 6) Abalang Low Water 1.53 4.42 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.13 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 4.53 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.30 5.24 2.52 5.25 5.24 2.30 5.24 1.33 5.24 1.33 5.24 1.33 5.24 1.33 5.24 1.33 5.24 1.33 5.24 1.33 5.24 1.34 | Drought Water 0.000 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 0.97 0.97 0.97 0.97 0.97 0.97 0.9 | (7) Kyo Average Water 8.36 15.42 6.40 1.07 1.91 3.46 5.32 2.93 4.19 3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 3.14 1.04 12.13 8.08 8.08 4.07 0.57 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 0.60 2.73 0.92 1.20 0.60 2.15 0.39 0.14 0.06 2.39 0.14 | de Zone Drought Water 0.000 0.07 0.34 0.04 0.005 0.003 0.018 0.02 0.000 0.24 0.000 0.24 0.351 0.10 1.53 0.16 0.41 0.62 0.007 0.003 0.015 | (8) Average Water 19.91 10.25 27.49 10.25 19.61 16.23 17.75 18.07 16.05 22.46 52.97 30.43 51.05 31.92 27.56 41.21 28.58 33.09 19.70 27.26 17.67 16.05 23.57 |) Mpologon Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 17.66 4.17 17.13 17.50 18.97 8.35 11.76 18.87 12.65 19.78 19.66 16.92 5.68 19.25 5.958 5.37 7.21 | ma Drought Water 0.000 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.43 1.47 7.47 7.47 7.55 1.67 9.55 11.91 1.663 1.51 4.85 2.54 2.54 2.38 0.88 | (Average Water 1.49 6.82 2.26 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 3.61 3.61 3.09 3.00 3.00 3.30 4.64 2.45 5.158 1.55 3.38 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.58 0.89 0.64 0.05 | e Drought Water 0.000 0.011 0.17 0.044 0.23 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.43 0.45 0.79 0.44 0.41 0.75 0.41 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.45 0.47 0.41 0.47 0.47 0.41 0.47 0.47 0.41 0.47 0.47 0.47 0.41 0.47 0. | (10) Average Water 10.66 19.22 12.85 8.77 9.83 14.03 14.03 8.54 6.37 15.86 24.72 19.13 22.09 25.56 8.16 19.05 15.91 12.39 21.75 14.38 13.59 4.41 5.25 5 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 4.66 6.46 6.46 6.46 6.46 6.46 6.42 5.12 4.25 5.22 8.53 5.07 4.44 4.23 4.23 4.23 4.21 | Nile Drought Water 0.000 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 6.87 2.09 1.82 1.82 1.82 1.82 1.82 1.82 1.82 1.82 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 18.77 16.45 16.98 11.35 21.16 19.06 39.53 13.21 2.57 3.34 | Low Water 1.455 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 5.79 4.58 10.666 8.35 9.77 3.04 4.58 10.666 8.35 9.77 2.12,59 6.866 9.725 12,59 6.866 1.466 0.888 1.466 | Drought Water 0.000 0.93 2.89 0.51 3.39 3.08 4.08 4.08 4.08 4.00 1.14 4.260 1.193 0.67 4.78 4.77 6.76 6 1.17 2.522 0.51 1.285 3.371 4.299 3.38 4.577 0.666 0.33 0.23 |
| 1950 1951 1952 1953 1954 1955 1956 1956 1957 1958 1959 1960 1961 1960 1963 1964 1966 1966 1967 1972 1973 1974 1977 1977 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.68 10.80 14.68 13.17 12.85 10.16 21.85 10.16 21.85 10.16 21.85 | 6) Abalang Low Water 1.53 4.42 2.22 2.62 2.78 1.76 2.60 4.60 4.13 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 4.53 5.24 2.30 4.09 3.54 4.34 1.71 2.05 1.71 1.71 2.62 1.76 1.75 1 | Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 0.53 3.29 0.78 3.51 2.19 1.83 0.27 0.87 0.87 0.87 0.87 0.87 0.87 0.87 0.8 | (7) Kyo Average Water 8.36 15.42 6.40 1.077 1.91 3.46 5.32 2.93 4.19 3.88 15.01 26.92 19.43 5.43 15.01 26.92 19.43 5.72 10.77 5.83 3.3.14 1.00 5.72 10.77 5.83 3.3.14 1.00 5.72 10.77 5.83 3.3.14 1.00 5.72 10.77 5.83 3.3.14 1.00 5.72 1.077 5.83 3.3.14 1.077 5.83 3.3.14 1.077 5.83 3.3.14 1.077 5.83 3.3.14 1.077 5.83 3.314 1.077 5.72 5.73 3.314 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.20 0.20 0.20 0.20 0.20 0.20 | de Zone Drought Water 0.000 0.007 0.34 0.004 0.005 0.003 0.015 0.000 0.024 0.000 0.24 0.34 0.34 0.34 0.08 0.34 0.00 0.024 0.03 0.01 0.005 0.01 0.005 | (8) Average Water 1991) 10.25 27,49 10.25 19,61 16,05 18,05 18,05 18,05 22,46 52,97 30,43 51,05 21,55 22,46 52,97 30,43 51,05 22,46 52,97 30,43 51,05 22,56 41,21 26,95 27,56 41,21 28,588 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,26 41,21 28,558 33,09 19,700 27,266 41,21 28,558 33,09 19,700 27,56 41,21 28,558 33,09 19,700 27,56 41,21 28,558 33,09 27,56 41,21 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 28,558 33,09 27,56 41,21 22,55 41,21 22,55 41,21 22,55 41,21 22,55 5 22,556 41,21 22,556 23,557 24,556 24,5577 24,5577 24,55777 24,5577777777777777777777777777777777777 |) Mpologon Low Water 4.54 12.22 14.50 2.466 4.17 8.90 2.466 4.17 8.90 3.52 9.57 6.64 17.67 17.13 17.50 18.97 17.70 18.97 11.766 12.62 19.78 19.766 12.62 19.78 19.766 12.62 19.78 19.76 12.55 9.558 5.377 7.21 3.74 6.48 | ma Drought Water 0.000 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.43 1.47 7.47 3.67 9.55 1.51 1.51 4.85 2.54 2.54 2.54 2.54 1.65 1.65 1.45 | () Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.313 3.13 4.29 90.60 7.74 2.46 3.61 5.61 5.61 3.09 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.01 1.58 1.58 1.58 1.58 1.58 1.58 1.58 1.58 1.58 1.58 | 9) Lumbuy Low Water 0.25 0.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.88 0.89 0.64 0.058 0.89 0.64 0.058 | e Drought Water 0.000 0.011 0.017 0.044 0.23 0.45 0.47 0.41 0.59 0.65 0.67 0.65 0.65 0.65 0.65 0.65 0.67 0.65 0.65 0.65 0.65 0.67 0.65 0.65 0.65 0.67 0.65 0.65 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.67 0.65 0.67 0.67 0.67 0.65 0.67 0 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 14.03 14.03 14.03 14.03 19.13 22.09 24.72 19.13 22.09 24.72 19.13 22.09 24.75 19.05 15.91 12.26 19.05 15.91 12.26 19.05 15.91 12.25 21.25 14.25 15.91 12.25 21.25 14.25 15.91 12.25 21.25 14.25 15.91 12.25 21.25 12.85 13.59 14.25 15.91 12.25 12.85 13.59 14.59 15.91 12.25 12.85 13.59 14 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.13 4.25 2.39 2.89 2.89 2.89 2.89 4.66 6.46 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 6.85 3.80 5.12 4.25 6.04 6.85 3.80 5.17 4.44 1.23 4.17 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.24 1.24 1.24 1.24 1.24 1.24 1.24 1.24 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.107 2.21 0.58 3.64 3.13 6.87 2.09 1.82 2.09 1.82 2.09 1.82 2.09 1.82 2.09 1.87 2.09 2.63 0.048 0.263 0.059 0.059 0.059 0.059 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 16.45 16.45 11.35 21.16 19.06 39.53 13.03 13.21 2.57 3.344 7.95 10.37 9.19 | Low Water 1.45 2.87 5.52 3.306 6.04 5.42 7.56 3.76 2.75 3.94 4.58 10.66 4.33 9.77 3.04 4.58 9.77 3.04 4.53 9.77 3.04 4.33 7.66 7.75 5.75 7.75 7.75 7.75 7.75 7.75 | Drought Water 0.000 0.933 2.899 0.511 3.39 3.088 4.08 4.08 1.14 2.600 1.93 0.67 4.77 4.78 4.777 6.76 1.17 2.552 0.511 2.85 3.711 4.29 3.388 4.577 0.666 0.333 0.233 0.233 0.239 0.977 |
| 1950 1950 1951 1952 1953 1955 1956 1956 1956 1957 1957 1960 1961 1962 1963 1964 1965 1966 1967 1977 1977 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 16.77 7.98 15.65 19.82 16.08 10.68 11.65 13.17 12.285 10.16 21.855 12.42 21.545 | 6) Abalang Low Water 1.53 4.42 3.35 2.22 2.62 2.78 1.76 2.60 1.81 4.70 4.71 8.31 6.40 7.68 2.52 6.07 2.62 5.92 4.53 5.24 2.30 4.09 3.54 4.34 1.81 1.71 2.05 6.31 | Drought Water 0.000 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.34 4.20 3.55 3.29 0.77 0.89 9.0.73 3.51 1.21 1.21 1.21 1.21 1.21 1.21 1.21 1 | (7) Kyo Average Water 8.36 15.42 6.40 1.077 1.91 3.46 5.32 2.93 4.19 9.3.88 15.83 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 3.14 1.213 8.08 4.07 0.577 3.16 4.58 4.58 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.85 1.23 1.17 5.75 4.60 2.73 0.92 1.20 2.15 0.39 0.14 0.06 2.39 0.14 0.05 0.15 0.669 0.41 0.15 0.69 | de Zone Drought Water 0.000 0.007 0.34 0.04 0.05 0.03 0.000 0.24 0.000 0.24 0.351 0.16 0.34 1.80 0.34 1.80 0.34 1.80 0.35 0.16 0.01 0.66 0.027 0.007 0 | (8) Average Water 19:11 13:275 27:49 10:25 19:61 16:23 17:75 18:07 16:05 18:05 22:46 52:97 30:43 51:05 31:92 27:56 41:21 28:58 33:09 19:70 27:26 17:67 16:06 17:67 16:06 17:67 12:76 21:53 16:43 |) Mpologor Low Water 4.54 12.22 14.50 2.46 4.17 8.90 8.63 4.23 3.52 9.57 6.64 4.23 3.52 9.57 6.64 17.67 17.13 17.50 18.97 8.35 11.76 12.62 19.78 19.68 19.68 15.68 12.25 9.58 5.37 7.21 3.74 6.48 8.53 | na Drought Water 0.000 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 0.65 11.46 11.29 8.43 1.47 7.47 3.67 9.55 11.91 6.63 1.51 4.85 2.54 2.31 0.88 1.65 | () Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.31 3.13 4.29 10.14 5.04 9.60 7.74 2.46 3.61 5.61 3.30 3.30 4.64 2.45 1.58 1.58 1.58 1.58 1.58 | 9) Lumbuy Low Water 0.25 2.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.58 0.64 0.42 0.53 0.73 | e Drought Water 0.000 0.011 0.17 0.044 0.23 0.45 0.45 0.55 0.25 0. | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 8.54 6.37 15.86 24.72 24.72 24.72 24.72 24.73 22.09 25.56 8.16 12.26 19.05 15.91 12.39 21.75 14.38 13.59 24.71 25.55 5.65 5.65 5.4.17 12.26 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.85 4.25 2.39 2.89 4.66 6.46 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 6.823 5.07 4.44 4.23 4.23 4.23 1.23 4.25 6.04 6.823 5.07 1.423 4.234 1.234 4.234 1.234 4.234 1.235 4.254 1.234 1.235 4.255 1.234 1.234 1.235 1.234 1.234 1.235 1.234 1.234 1.235 1.234 1.234 1.235 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.234 1.237 1.234 1.234 1.234 1.237 1.234 1.234 1.234 1.237 1.234 1.234 1.234 1.234 1.234 1.234 1.237 1.234 1.2444 1.244 1.244 1.2444 1.2444 1.2444 1.24444 1.2444 1.2444 | Nile Drought Water 0.000 1.45 0.422 1.73 2.88 1.67 1.65 1.06 1.17 2.21 0.58 3.64 3.13 3.687 2.09 1.82 1.87 3.46 3.00 2.69 1.82 1.87 3.46 3.00 2.65 9.0.19 0.05 0.059 0.019 0.05 0.019 0.059 0.019 0.059 0.019 0.059 0.019 0.059 0.019 0.059 0.019 0.059 0.020 0.059 0.020 0.059 0.020 0.059 0.020 0.058 0.020 0.059 0.058 0.000 0.059 0.058 0.058 0.058 0.058 0.058 0.058 0.058 0.058 0.055 0.058 0.059 0.058 0.058 0.059 0.058 0.059 0.058 0.058 0.059 0.058 0.059 0.059 0.058 0.059 0.058 0.059 0.059 0.059 0.059 0.059 0.058 0.059 0.05 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 9.65 9.40 12.64 13.88 16.39 17.18 18.77 16.45 16.98 11.35 21.16 19.066 39.53 13.21 2.57 3.34 7.95 10.37 9.19 3.81 | Low Water 1.455 2.87 5.52 3.06 6.04 5.42 7.56 3.76 2.75 3.94 4.58 10.66 8.35 9.77 3.04 4.58 10.66 8.35 9.77 3.04 4.58 10.66 8.35 9.77 2.12,59 6.86 7.58 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.88 1.46 0.45 0.42 0.45 0.45 0.45 0.45 0.45 0.45 0.45 0.45 | Drought Water 0.000 0.93 2.89 0.511 3.39 3.08 4.08 4.08 4.08 4.00 1.14 4.260 1.93 0.67 4.78 4.77 6.76 6 6.76 6.76 6.75 7.11 2.52 0.511 3.711 4.29 0.53 3.711 4.29 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 2.52 0.53 3.71 3.71 3.71 3.71 3.71 3.71 3.71 3.7 |
| 1950 1951 1952 1953 1954 1955 1956 1956 1957 1958 1959 1960 1967 1968 1966 1966 1966 1966 1967 1972 1973 1974 | Average Water 14.01 13.42 7.14 6.91 7.86 10.29 10.64 9.99 7.51 11.34 10.47 18.93 17.66 14.75 16.77 7.98 15.65 19.82 16.68 10.80 14.68 13.17 12.85 10.16 21.85 10.16 21.85 10.16 21.85 | 6) Abalang Low Water 1.53 4.42 2.22 2.62 2.78 1.76 2.60 4.61 4.70 4.13 4.47 8.31 6.40 7.68 2.52 6.07 2.62 5.92 4.53 5.24 2.30 4.09 3.54 4.34 1.71 2.05 1.71 1.71 2.62 1.76 1.71 1 | Drought Water 0.00 0.53 1.61 0.24 0.55 0.42 1.19 0.63 0.92 1.47 0.97 3.84 4.20 3.04 4.20 3.04 0.53 3.29 0.78 3.51 2.19 1.83 0.27 0.87 0.87 0.87 0.87 0.87 0.87 0.87 0.8 | (7) Kyo Average Water 8.36 15.42 6.40 1.077 1.91 3.46 5.32 2.93 4.19 3.88 15.01 26.92 19.43 5.43 15.01 26.92 19.43 5.43 11.10 5.72 10.77 5.83 3.3.14 1.04 7.58 8.64 1.12 1.12 1.12 1.12 1.12 1.12 1.12 1.1 | ga Lakesia Low Water 0.69 2.37 1.32 0.18 0.37 0.47 0.79 0.30 0.20 0.20 0.85 1.23 1.17 5.75 5.75 4.60 0.60 2.73 0.92 1.20 0.215 0.39 0.14 0.04 0.02 0.39 0.14 0.05 0.74 0.15 0.60 | de Zone Drought Water 0.000 0.007 0.34 0.004 0.005 0.003 0.015 0.000 0.024 0.000 0.24 0.351 0.10 0.35 0.16 0.153 0.16 0.41 0.662 0.021 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.004 0.004 0.004 0.005 0.003 0.003 0.004 0.004 0.005 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.004 0.005 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.003 0.004 0.0000 0.0000 0.0000 0.0000 0.000000 | (8) Average Water 1991) 10.25 27,49 10.25 18.07 16.05 18.05 18.05 22.46 52.97 30.43 51.05 21.45 31.92 27.56 41.21 28.58 33.09 19.70 27.26 17.67 16.05 27.56 41.21 28.58 33.09 |) Mpologon Low Water 4.54 12.22 14.50 2.466 4.17 8.90 2.466 4.17 8.90 3.52 9.57 6.64 17.67 17.13 17.50 18.97 17.70 18.97 11.766 12.62 19.78 19.766 12.62 19.78 19.766 12.62 19.78 19.76 12.55 9.558 5.377 7.21 3.74 6.48 | ma Drought Water 0.000 2.18 3.07 0.42 0.99 2.64 3.95 1.77 1.52 1.60 1.81 0.65 11.46 11.29 8.43 1.47 7.47 3.67 9.55 1.51 1.51 4.85 2.54 2.54 2.54 2.54 1.65 1.65 1.45 | () Average Water 1.49 6.82 3.89 1.02 2.26 2.65 1.52 3.67 2.313 3.13 4.29 90.60 7.74 2.46 3.61 5.61 5.61 3.09 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.00 3.30 4.64 2.45 1.58 1.58 1.88 1.88 1.88 | 9) Lumbuy Low Water 0.25 0.22 0.93 0.21 0.73 1.14 0.75 0.89 0.63 1.36 0.92 1.69 2.37 2.94 3.25 1.41 1.58 1.06 1.53 1.56 0.58 0.89 0.64 0.058 0.64 0.058 | e Drought Water 0.000 0.011 0.017 0.044 0.23 0.45 0.47 0.41 0.59 0.65 0.67 0.65 0.65 0.65 0.65 0.65 0.67 0.65 0.65 0.65 0.65 0.65 0.67 0.65 0.65 0.65 0.65 0.65 0.67 0.65 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.65 0.67 0.67 0.65 0.67 0 | (10) Average Water 10.76 19.22 12.85 8.77 9.83 12.28 8.03 14.03 14.03 14.03 14.03 14.03 19.13 22.09 24.72 19.13 22.09 24.72 19.13 22.09 24.75 14.26 19.05 15.91 12.26 19.05 15.91 12.26 9 21.75 14.38 13.59 24.75 12.85 5.65 5.65 | Victoria 1 Low Water 2.83 6.00 4.14 2.31 4.13 4.13 4.25 2.39 2.89 2.89 2.89 4.66 6.46 6.46 6.46 6.46 9.43 7.74 12.85 3.80 5.12 4.25 6.04 6.85 3.80 5.12 4.25 6.04 6.85 3.80 5.17 4.44 1.23 4.17 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.23 4.25 1.24 1.24 1.24 1.24 1.24 1.24 1.24 1.24 | Nile Drought Water 0.00 0.79 1.45 0.42 1.73 2.88 1.67 1.65 1.06 1.107 2.21 0.58 3.64 3.13 6.87 2.09 1.82 2.09 1.82 2.09 1.82 2.09 1.82 2.09 1.87 2.09 2.63 0.048 0.263 0.059 0.059 0.059 0.059 | Average Water 4.79 11.77 12.16 7.29 9.65 9.40 12.64 13.88 9.05 8.81 16.39 17.18 16.45 16.45 11.35 21.16 19.06 39.53 13.03 13.21 2.57 3.344 7.95 10.37 9.19 | Low Water 1.45 2.87 5.52 3.306 6.04 5.42 7.56 3.76 2.75 3.94 4.58 10.66 4.33 9.77 3.04 4.58 9.77 3.04 4.53 9.77 3.04 4.53 9.77 2.55 2.55 2.75 5.79 4.58 10.66 4.33 7.66 7.75 5.75 7.75 7.75 7.75 7.75 7.75 | Drought Water 0.000 0.93 2.89 0.51 1.3.39 3.08 4.08 1.60 1.14 2.60 1.93 0.67 4.77 4.78 4.77 4.77 6.76 1.17 2.52 0.51 2.85 3.371 4.29 3.388 4.57 0.666 0.33 3.023 0.023 0.023 0.023 |

Table 12-10 Runoff Characteristic of Each Sub-Basin

(2) Simulation on Future Water Demand in Drought Rainfall Condition (Surface Water Allocation Analysis)

Simulation is conducted in the following conditions aiming at contributing to water allocation investigation by grasping monthly tendency of entire Lake Kyoga Basin on future water demand and confirming utilization manner of this simulation model.

- 1. Simulation Period: One year (From January to December)
- 2. Water Demand: Future Water Demand in 2035
- 3. Rainfall Condition: Rainfall time series in drought year

Details of setup of simulation condition and simulation result are described below.

i) Setup of Water Demand Condition (Water Demand TS)

Water demand TS of 2035 is prepared in each small-catchment based on SIP. Since SIP

categorizes water use into seven (7) sectors, this simulation for surface water targets five (5) sectors among them, which are deemed to use surface water as a water source. The five (5) sectors are "Domestic NWSC", "Domestic Small Towns", "Livestock", "Crops" and "Fisheries". Calculated future water demand in each small-catchment is shown in Table A12-1.

In general, amount of irrigation water use varies considerably through the year according to the crops pattern, and domestic water as well as irrigation water shall consider return water to the downstream channel/river against amount of intake water. Water demand TS is simply set up not to consider the annual fluctuation of water use and the return water to the downstream, however, because this simulation aims at grasping general tendency of entire Lake Kyoga Basin for discussing the basic plan. It is recommended to conduct more detailed investigation including such conditions in the next step like a master plan study.

ii) Setup of Rainfall Condition

Rainfall condition for simulation is prepared by selecting a drought year from rainfall TS of 1950 to 1979, which are prepared and used for calibration work. Selection procedure is as follows:

- 1. To calculate annual total rainfall amount (annual rainfall multiplied by area) in each small-catchment, to sum the amount for all small-catchment, then to calculate annual total rainfall amount of entire Lake Kyoga Basin in each year.
- 2. To select the drought year (third year from the last year with lowest annual total rainfall amount, which can deem the 10 year return period) from 30 years' data of annual total rainfall amount. Finally, 1974 was selected as the drought year.

iii) Investigation regarding Influence of Climate Change

According to the Fourth Assessment Report (AR4) by IPCC, rainfall tends to increase in the long term in east Africa including Uganda. The trend is the same in not only annual average but also seasonal (every three months) average. Since drought is the major matter regarding water resources management in Lake Kyoga Basin and the target for the simulation of this Study, special condition taking account of climate change is not set up in this simulation model.

iv) Simulation Result

Simulation result is shown in Table 12-11 and Figure 12-12.

In the simulation, calculation of rainfall, runoff and deduction of water demand in each small-catchment, and runoff of surplus water from the upstream to the downstream small-catchment are calculated in a daily basis. The result shown in the table and figure is to sum up daily calculation results in each sub-catchment in a monthly basis. The summed result is calculated by subtracting monthly total amount of deficit water in each sub-catchment (excess or deficiency of runoff against water demand in each small-catchment is calculated in a daily basis, and the deficit amount is summed up in each sub-catchment in a monthly basis) from monthly total runoff amount at the end of each sub-catchment. The negative value in the table and figure

means that total runoff amount is not enough against water demand if water is maximally properly allocated within a corresponding sub-catchment in a corresponding month.

From the simulation result, the following can be cited as a general characteristic of Lake Kyoga Basin although the simulation is conducted in the limited condition such as the simple water demand as described above:

- In case of the condition of drought year with 10 year return period and future water demand, water deficit occurs in almost all sub-catchments.
- Sub-basins where water deficit frequently occurs are Okok, Okere, Lwere, Kyoga Lakeside Zone and Mpologoma. Especially, Okok and Okere sub-basins are severer.
- The months when water deficit frequently occurs are January to April and November to December.

| | | | | | | | | | | Unit: million m ³ | per month |
|----------------------------|-------------|--------------|--------------|--------------|---------------|----------------|-------------------------------|------------------|----------------|------------------------------|-----------------|
| Sub-basin Name Month | (1) Okok | (2) Okere | (3) Awoja | (4) Lwere | (5) Akweng | (6) Abalang | (7) Kyoga Lakeside Zone | (8) Mpologoma | (9) Lumbuye | (10) Victoria Nile | (11) Sezibwa |
| January | -2.17 | -2.75 | 3.43 | 0.10 | 5.87 | 8.70 | -1.54 | 0.11 | 2.47 | 13.30 | 0.82 |
| February | -1.93 | -2.67 | -0.43 | -1.42 | 1.72 | 2.39 | -3.23 | -3.52 | 0.09 | 2.41 | -0.27 |
| March | -0.93 | -2.47 | 4.40 | -0.17 | 3.10 | 8.79 | -3.83 | -4.20 | -0.40 | -0.35 | 0.97 |
| April | 2.07 | -0.21 | 13.02 | 10.31 | 17.51 | 34.38 | 6.69 | 49.71 | 8.07 | 35.10 | 21.31 |
| May | 8.74 | 4.48 | 31.46 | 8.32 | 22.20 | 26.13 | 3.38 | 49.63 | 6.21 | 20.48 | 12.32 |
| June | 2.82 | 1.57 | 49.92 | 13.96 | 20.03 | 26.60 | -1.23 | 52.24 | 2.06 | 18.16 | 10.52 |
| July | 10.90 | 27.19 | 128.61 | 33.51 | 41.72 | 48.05 | 19.51 | 90.62 | 7.23 | 27.66 | 14.99 |
| August | 4.95 | 10.72 | 61.74 | 11.87 | 22.49 | 24.28 | 15.99 | 43.75 | 2.46 | 7.60 | 7.51 |
| September | 4.44 | 2.23 | 75.74 | 13.92 | 38.61 | 30.27 | 26.06 | 44.57 | 5.34 | 10.20 | 10.32 |
| October | 4.55 | 0.08 | 37.27 | 4.48 | 43.62 | 47.34 | 11.89 | 26.04 | 2.77 | 2.25 | 4.16 |
| November | -0.20 | -1.42 | 15.85 | -0.17 | 13.62 | 16.43 | 2.71 | 11.27 | 1.14 | 0.04 | 1.66 |
| December | -1.61 | -2.42 | 4.03 | -1.57 | 3.35 | 2.82 | -3.07 | -2.96 | -0.20 | -1.78 | -0.47 |

 Table 12-11 Simulation Result