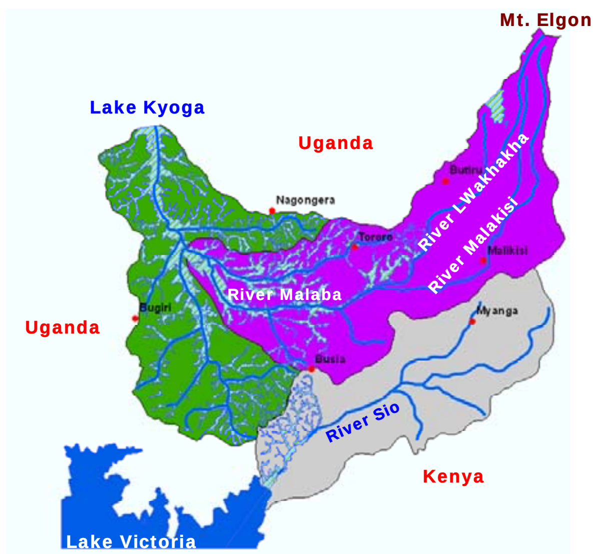
# Nile Basin Initiative
# Nile Equatorial Lakes Subsidiary Action Program

**Sio-Malaba-Malakisi (SMM) Transboundary Integrated Water Resources Management and Development Project**
(NBI/NELSAP/SMM-TIWRMDP/RFP02/2006)

# SMM River Basin Monograph

## Final Report




## Water Resources and Energy Management (WREM) International Inc.

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WREM International

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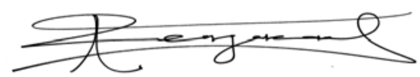
We also wish to thank the staff of the Sio-Malaba-Malakisi districts for their cooperation and project contributions. The SMM Uganda districts comprise Bududa, Bugiri, Busia, Butaleja, Manafwa, Namutumba, Pallisa, and Tororo, while the SMM Kenya districts comprise Bungoma (North, South, West, and East), Busia, Mt. Elgon, and Teso. The way in which all district officers welcomed and embraced the project and worked closely with each other, WREM, and the PMU to contribute their best possible input was no less than inspiring. This team effort sent a hopeful message that the problems the two countries face can indeed be solved with good faith and constructive cooperation.

Atlanta, July 2008



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# LIST OF ABBREVIATIONS AND ACRONYMS

| | |
|---|---|
| AIDS | Acquired Immune Deficiency Syndrome |
| ASAL | Arid and Semi –Arid Lands |
| BAT | British American Tobacco |
| BOD | Biological Oxygen Demand |
| CAAC | Constituency Aids Advisory Committee |
| CBO | Community Based Organizations |
| CIDA | Canadian International Development Agency |
| COM | Council of Ministers |
| COMESA | Common Market for Eastern and Southern Africa |
| CPI | Consumer Price Index |
| CSD | Commission for Sustainable Development |
| CWP | Country Water Partnership |
| DACC | District AIDS Control Committees |
| DANIDA | Danish International Development Agency |
| DEO | District Environmental Officer |
| DEAP | District Environmental Action Plan |
| DfID | Department for International Development – U.K |
| DWO | District Water Officer |
| EAC | East African Community |
| EIA | Environmental Impact Assessment |
| ENSAP | Eastern Nile Subsidiary Action Program |
| FAO | Food and Agricultural Organization |

| | |
|---|---|
| GDP | Gross Domestic Product |
| GEF | Global Environmental Fund |
| GIS | Geographical Information System |
| GoK | Government of Kenya |
| GoU | Government of Uganda |
| HDI | Human Development Index |
| HEP | Hydroelectric Power |
| IDA | International Development Agency |
| IGAD | Inter-Governmental Authority on Development |
| IUCN | International Union for the Conservation of Nature |
| IWRM | Integrated Water Resources Management |
| KIHBS | Kenya Integrated Household Budget Survey |
| KMD | Kenya Meteorological Department |
| KDHS | Kenya Demographic and Health Survey |
| LG | Local Government |
| LATF | Local Authority Transfer Fund |
| LGDP | Local Government Development Program |
| LVDP | Lake Victoria Development Program |
| LVEMP | Lake Victoria Environmental Management Programme |
| MDG | Millennium Development Goals |
| MOLG | Ministry of Local Government |
| MoH | Ministry of Health |
| MSE | Medium Scale Enterprises |
| MTEF | Medium Term Expenditure Framework |
| MWI | Ministry of Water and Irrigation |

| | |
|---|---|
| NASCOP | National AIDS/ Control Programme |
| NBD | Nile Basin Discourse |
| NBI | Nile Basin Initiative |
| NCPD | National Council for Population and Development |
| NEL | Nile Equatorial Lakes |
| NELSAP | Nile Equatorial Lakes Subsidiary Action Program |
| NEL-CU | Coordination Unit |
| NEL-TAC | Technical Advisory Committee |
| NEL-COM | Council of Ministers responsible for Water Affairs |
| NEMA | National Environment Management Authority |
| NGO | Non-Government Organization |
| PER | Public Expenditure Review |
| QA | Quality Assurance |
| RGC | Rural Growth Center |
| RWSD | Rural Water Supply Department |
| RWSS | Rural Water Supply and Sanitation |
| SAP | Subsidiary Action Program |
| SIDA | Swedish International Development Agency |
| SIP | Strategic Investment Plan |
| SMM | Sio-Malaba-Malakisi |
| STD | Sexually Transmitted Diseases |
| SVP | Shared Vision Program |
| TAC | Technical Advisory Committee |
| TC | Technical Committee |

| | |
|---|---|
| TECCONILE | Technical Committee for the Promotion of the Development and Environmental Protection of the Nile Basin |
| ToR | Terms of Reference |
| UMA | Uganda Meteorological Authority |
| UNDP | United Nations Development Programme |
| UNESCO | United Nations Education, Science and Cultural Organization |
| USD | United States dollar |
| VCT | Voluntary Counseling and Testing |
| WRM | Water Resources Management |
| WRMA | Water Resources Management Authority |

# Executive Summary

The Sio-Malaba-Malakisi (SMM) River Basins are shared by Kenya and Uganda. The Sio River originates from Mt. Elgon at an elevation of 1400 meters above sea level (asl), flows along the common Kenya-Uganda border, and discharges into Lake Victoria at 1134 meters asl. The Sio has a catchment area of 1450 square kilometers ($km^2$). Mt. Elgon is also the source of the Lwakhakha and Malakisi Rivers, the two tributaries of the Malaba River which eventually discharges into Lake Kyoga at an elevation of 950 meters asl. The Malaba-Malakisi catchment has an area of 1790 $km^2$. The SMM catchments are part of the Lake Victoria and Lake Kyoga catchments which, in turn, are part of the Nile River Basin.

## Objective of the SMM River Basin Monograph

The objective of the SMM River Basin Monograph is to compile existing data and information on all water resources related sectors, characterize water resources challenges and issues along with their causes and impacts, and identify potential development and investment opportunities. Cross-cutting and transboundary issues are particularly relevant, as they can only be addressed through an integrated water resources planning and management approach.

## SMM Issues and Challenges

The SMM River Basins are home for nearly 4 million people. Most parts of the catchment have high population densities ranging from 150 to 500 persons per $km^2$ and high population growth rates from 2% to 5%. This rapidly rising population also suffers high poverty levels ranging from 30% to 66%. As many of the rural people struggle to meet their basic needs (shelter, food, water, health, and education), they inexorably over-exploit the catchment land, water, and environmental resources.

More than 80% of the SMM people are engaged in agriculture. Pressure for expanding the already scarce agricultural lands is mounting. Farming systems are largely traditional in highly fragmented small size farms cultivated intensively throughout the year. Agriculture is largely rain fed, using low yielding seed varieties prone to diseases and vulnerable to droughts. Furthermore, the use of fertilizers is inadequate and improper. Excessive cultivation breaks the soil structure resulting in increased run off and soil erosion. At the slopes of Mt. Elgon, agriculture is encroaching on forest resources which are also depended upon heavily for firewood, ropes, pole wood, vegetables, bamboo shoots, fruits, medicines, and for livestock feed. Gazetting of the national parks and forest reserves has only served to create resentment by rural communities who used to rely on these land resources. At the lower river reaches, the pressure for agricultural land is changing wetlands into rice fields.

The local population has little understanding and awareness of the interrelationship between land deforestation, soil erosion, catchment runoff, waste management, and river water quality. As a result, land stewardship and management practices are poor, leading to declining land productivity and diminishing water resources. Land slides are common in the mountainous areas of the catchment. Poor farming practices and the systematic cultivation of the natural riparian buffer zones have contributed to increased sediment load, excessive river turbidity, riverbank erosion, and deteriorating water quality.

The percentage of the population without access to clean safe water and sanitation facilities remains distressfully low (far behind the Millennium Development Goals). In Uganda, access to safe water facilities is estimated to be 57% and 80% in rural and urban areas respectively, while access to improved sanitation services is 56% for both rural and urban areas. Similarly, in Kenya, 46% of the rural population and about 70% of the urban population have access to safe water. The lack of adequate sewerage facilities and toilets combined with the high urban population growth has resulted in serious environmental pollution by urban and human wastes. Poor solid waste management exacerbates the environmental crisis.

Water related diseases are widespread. Diarrheal diseases (cholera and dysentery) are among the major killers of young children, accounting for about 20% of all infant deaths. In addition to water related diseases, HIV/AIDS continues to pose a very serious public health challenge contributing significantly to morbidity and mortality and straining the public health budgets of both countries. About 75% of all AIDS cases occur among people in the most economically productive age group, 20 to 45 years. This has an adverse impact on productivity and further aggravates the poverty situation. Women are particularly vulnerable to HIV infection than men. HIV prevalence in women aged 15-49 years is nearly 9% compared to less than 5% for men in the same age bracket.

Conflicts over equitable access to land and water resources are also being reported within each country and across the border. Enforcement of national environmental laws is lax, and laws addressing transboundary issues are lacking. Water institutions lack the human, technical, and financial capacity to effectively address the magnitude and complexity of water related issues. Decision making processes are not sufficiently inclusive, especially with respect to women and other under-represented groups.

## SMM Development Potential

The SMM catchment is well endowed with significant natural resources which, if managed and developed sustainably, can become the key for social and economic development of the catchment. Key development opportunities are outlined next:

### *High Potential for Increased Agricultural Productivity*

Most of the agricultural production in the SMM catchment is rain fed with very little irrigation being practiced. The only large-scale irrigation activities are in the Kibimba and Doho rice schemes in Bugiri and Butaleja districts respectively. Limited and informal small-scale irrigation is also practiced in the fringes of wetlands in the lower SMM catchment (e.g., in the districts of Tororo and Bugiri) most commonly for rice and vegetable production.

There is significant potential for increased agricultural productivity through investments in modern agricultural practices, use of high yielding and disease resistant varieties, development of irrigation infrastructure, reduction of post harvest losses, agro-processing facilities, and marketing of agricultural products.

***High Tourism Potential***

The SMM catchment has a wide array of ecosystems including lakes, rivers, forests, game reserves, and national parks that are home to various forms of bio-diversity. Major tourist sites include the Mt. Elgon National Park and Forest Reserve, Kakamega indigenous forest, and Lake Victoria and its many islands. These sites are part of the Eastern African High Altitude Biodiversity hotspots where endemic, endangered, and threatened flora and fauna are found. Wildlife includes the three big five (buffalo, leopard, elephants), mammals, rare and endangered primates (blue debrazza monkey), bushbuck, butterflies, reptiles, and amphibians. This area also represents an Important Bird Area (IBA) with over 300 bird species including the *Papyrus Yellow Warbler Chrolopeta gracillostris* and the *Papyrus Gonolek Laniarius mufumbiri*. The catchment also includes very scenic features such as cliffs with panoramic views, mountains with hiking trails and easy to climb peaks, hills and valleys, a caldera, hot springs, gorges, and spectacular caves with natural salt licks and bird nesting sites.

There is thus high tourism development potential in the catchment that can be realized through investment in tourism infrastructure, protection of the existing tourist attractions and ecological biodiversity, and diversification of existing tourism activities.

***High Demand for Water Supply and Sanitation Services***

The highest consumptive use of water in the SMM catchment is rural and urban water supplies and, to a lesser extent, irrigation. Though water supply and sanitation is one of the priority sectors in both Kenya and Uganda, a large percentage of the population still has no access to safe water and improved sanitation facilities. Only about 2 million urban residents are connected to reticulated sewerage systems with the rest of the population relying on on-site sanitation, mainly pit latrines.

Inadequate access to safe water and poor sanitation and hygiene continue to be major predisposing factors to the burden of disease in the catchment. Disease prevalence in the Uganda SMM districts increased from 35.9% to 48.7% between the years 2002/2003 and 2005/2006 (Uganda National Household Survey 2005/2006). The same survey also identified Malaria to be the dominant cause of sickness accounting for about 51.4% of the sickness reported. In the Kenya SMM districts, Malaria and Respiratory Infections are the major causes of morbidity accounting for over 55% of the total morbidity causes (Ministry of Health, 2003).

There is, thus, urgent need for investment in water supply and sanitation facilities to reduce water related diseases and deaths and improve the quality of life.

*Significant Mineral Resources*

Mining is one of the lucrative socio-economic activities in the SMM catchment. Gold reserves are known to exist in the Sio-Busia-Tororo area. Artisanal gold mining is going on in Busia district (Uganda) and Kakamega district (Kenya). Extensive limestone reserves exist in the catchment, especially in Tororo district, Uganda, where the Tororo cement factory is located. Phosphates also exist and used to be mined (in Tororo) but this industry has collapsed. There is also widespread extraction of building material, such as granite, clay, sand, and murram. Quarrying for building materials is currently extensively exploited in the Mt. Elgon area and on rock outcrops in the catchment. Sand mining is a very common economic activity in the lower catchment reaches.

The mining industry has thus the potential to grow through private investment aiming to develop the existing mineral resources in an environmentally sustainable manner.

*Significant Energy Demand and Development Potential*

Energy supply in the catchment is inadequate in quantity as well as diversity. The lack of diversity in energy provision is a strong indicator of lacking economic diversity. The area is largely a rural subsistence economy. Fuel wood in form of charcoal and firewood is the dominant energy source in the catchment. Sources of fuel wood include on-farm exotic trees, indigenous trees in non-protected areas, and the protected forest reserve. Investments are needed to develop diverse energy sources to spur economic growth, improve the livelihood of the communities, and protect the environment.

Electric power coverage is very low, although the demand for it is growing. There is need to provide electricity access to more households and rural growth centers to reduce pressure on the forest resources and support small-scale industries and agro-processing activities. The Sio, Malaba, and Malakisi Rivers have potential for mini and micro-electric hydro-power generation at several waterfall sites. Furthermore, the steep topography of the Malaba and Malakisi Rivers in the upper reaches is conducive for development of small-scale/mini hydropower schemes. Mini-hydropower generation potential exists on Terem Falls of the Terem/Kuywa River, a major tributary of Nzoia River. On the Uganda side of SMM, there is one mini-hydropower site in the project area known as Ririma (1.2 MW), being developed by the Mt. Elgon Power Company. In addition to this potential, there is also potential for extending the existing transmission grid lines to other areas of the catchment. This is already being undertaken as part of the rural electrification programs in both countries. Other renewable energy sources such as solar, wind, and biogas can also be developed.

*High Fisheries Development Potential*

Fishing is a major socio-economic activity and source of food and livelihood for communities living close to the SMM rivers and lakes. Over the years, fish resources in the lakes and rivers have declined as a result of the use of destructive fishing methods, destruction of breeding grounds along the shores and wetland drainage, water pollution, and over-fishing. However, with the formation of Beach Management Units and the involvement of local communities in the management of the fishery resources, the situation has started to improve.

Aquaculture is slowly being embraced in many parts of the catchment as an alternative source of food and revenue. There are also high prospects for commercial trout farming in the Mt. Elgon districts both in Kenya and Uganda where there are rivers flowing from Mt. Elgon with suitable temperatures and unimpaired water. Trout is on very high demand in the hotel and tourism industry in the region.

### *High Demand for Forestry Products and Services*

The SMM catchment is endowed with significant forest resources, especially in the Mt. Elgon area. Forests contribute significantly to the socio economy of many communities by providing wood and other forest products for commercial and domestic use. They also support the pulp and paper industries, sawmills, building and construction industry, charcoal production, firewood, transmission posts for electric and telephone lines, woodcarving for tourism, as well as other income-generating activities such as beekeeping. Forests are important as they act as a sanctuary for wildlife, birds and insects. Many plants are also used as medicine and food for local communities.

However, increased and uncontrolled encroachment of the forests in search of additional agricultural land, illegal and unsustainable harvesting of forest products, and poor agricultural practices exacerbated by inadequate extension services have resulted in extensive catchment degradation, soil erosion, and sedimentation of water bodies.

There is, therefore, need for and opportunities in afforestation of degraded forest areas and promotion of sustainable forestry management practices, including agro-forestry, eco-tourism, and apiary.

### *Strong Cross Border Trade*

A heavy volume of goods is exchanged along the SMM Kenya-Uganda border in the form of cross border trade. Major goods exchanged between the two countries include petroleum products, plastic articles, medicinal products, agricultural products, livestock products, fisheries products, non-agricultural household goods, farm inputs, wood and timber products, clothes and textiles, and construction materials. For example, in 2005, Kenya exported goods worth 42.5 billion KShs.

The potential to strengthen and broaden the cross border trade between the two countries by expanding the volume and range of the currently traded goods is excellent.

### *High Potential for Industrial Growth*

There are a number of industries and factories operating in the catchment. The major industries include PanPaper Mills and the Nzoia Sugar Company in Bungoma, a Cement Industry in Tororo, the British American Tobacco (BAT) and the Mastermind Processing Tobacco centers in Teso district, the Teso Sugar Company (jaggery), small coffee pulping factories, jaggeries, bakeries, and quarries (mainly excavating murram) for road construction. There are also various small and medium scale enterprises (MSE) scattered in the districts including furniture workshops, metal workshops, tailoring, and brick making by individual entrepreneurs.

Investments in agro-processing industries and in processing minerals would add value to agricultural and mining products.

## Linkage with the SMM DSS, Cooperative Framework, and Investment Strategy

The SMM River Basin Monograph is one of the SMM TIWRD Project outputs, the other being the SMM DSS, Cooperative Framework, and Investment Strategy.

The SMM DSS is a technical decision support tool based on modern computer technology to enable SMM stakeholders to develop factual insights of various development options and trade-offs essential for the sustainable management and development of the SMM water resources. The SMM DSS consists of four main components including a database, data analysis tools, a river basin planning tool, and a user-data-model interface. The database is the depository of all water resources and socio-economic data collected through the existing monitoring systems and all data generated by the data analysis tools and application programs. The data analysis tools provide user-friendly means to visualize and analyze data and their interrelationships. The purpose of the river basin planning tool is to analyze alternative basin development scenarios and quantify their tradeoffs, and relative benefits and impacts. The SMM DSS has been transferred to the SMM stakeholder agencies through extensive training.

A major SMM challenge is the lack of a Cooperative Policy, Legal, and Institutional Framework that can enable SMM stakeholders in Kenya and Uganda to come together and develop shared vision strategies and solutions for current and emerging SMM issues. The development of the Cooperative Framework has been undertaken by WREM International Inc. under a separate project and is reported elsewhere. The cooperative framework provides recommendations for the harmonization of the legal systems in Kenya and Uganda; the development of a Cooperative Framework; a stakeholder participation plan; a gender mainstreaming plan; and a capacity building plan. The outputs of the SMM Cooperative Framework project are designed to address the specific resource issues identified and quantified in the SMM River Basin Monograph.

Lastly, following the identification of issues and potential development opportunities, a comprehensive investment strategy was developed and summarized in Chapter 12 of the Monograph and as a separate report. The investment strategy emphasizes the development of transboundary projects that will enhance collaboration between local communities across the border and strengthen inter-state cooperation in the joint management and development of the shared SMM water resources. A number of specific local projects are proposed to motivate local communities to embrace integrated water resources management and to show tangible benefits of transboundary cooperation. These projects were prioritized by the SMM stakeholders in a series of regional and national workshops.

## Monograph Development Approach and Methodology

The general approach adopted in the development of the SMM River Basin Monograph was based on active and sustained stakeholder engagement through out the duration of the project. This approach coupled with the significant local expertise in the Consultant's team (>50%) enabled the Consultant to leverage the existing knowledge and understanding of local issues, challenges, and opportunities by the riparians themselves. This helped ensure relevance and ownership of the Consultant's final recommendations and proposals.

Upon commencement of the assignment, the Consultant undertook a detailed review of the available relevant documents and reports to gain a thorough understanding of the key issues in the basin and ongoing and planned efforts to address them. The review mainly focused on understanding the critical water resources issues and challenges in the catchment and the ongoing and planned intervention measures to address them at local, national, and regional levels. Other documents reviewed were acquired from the SMM PMU, national and local government agencies, NBI Secretariat, EAC Secretariat, and from the public domain. A list of the documents reviewed is contained in the Bibliography to this and the other project reports.

Besides literature review, the Consultant's team spent significant time visiting and consulting with local government officials, NGOs, CBOs, and local communities in all catchment districts. Additional consultative meetings and discussions were held with officials from national and regional agencies including EAC, LVBC, NBI, NELSAP, and LVFO, among others.

Several national and regional stakeholder workshops were also conducted to solicit input from different stakeholders and seek guidance on some of the issues identified, proposed intervention measures, and recommended actions. Stakeholders were particularly instrumental in the identification and prioritization of potential intervention measures and specific projects. The measures were prioritized and jointly agreed upon by stakeholders from the two countries during a regional workshop held in September 2007 at Mt. Elgon Hotel in Mbale, Uganda. During the workshop, stakeholders developed objective criteria that were used to rank all potential intervention measures.

This and the other reports generated by this Consultancy address the tasks outlined in the project ToRs, and they also include several key suggestions and inputs made by different stakeholders during the course of the project. Specific attention was given to addressing the comments made by the Regional Project Steering Committee (RSPC) members, the NEL-CU officials, and the SMM Project Management Unit (PMU), as well as the comments made in the course of the national and regional stakeholder workshops.

## Outline of the Report

The Monograph is organized in 12 chapters and several appendices. Chapter 1 provides an overview of the SMM catchment and critical issues. The subsequent chapters elaborate on detailed sector by sector findings: hydro-climatology (Chapter 2); water supply and sanitation (Chapter 3); agriculture (Chapter 4); fisheries and aquaculture (Chapter 5); environment, ecosystems, and tourism (Chapter 6); energy and hydropower development (Chapter 7); land, water, and air transport (Chapter 8); integrated water resources management cooperative framework (Chapter 9); population and social development (Chapter 10); trade, industry, and macro-economic development (Chapter 11), and basin development and investment strategy (Chapter 12). The appendices include additional supporting data and other useful information.

# Table of Contents

**APPENDICES**

# List of Tables

# List of Figures

# List of Plates

# 1.0 Overview of the Sio-Malaba-Malakisi Catchment

This chapter provides an introduction to the Sio-Malaba-Malakisi (SMM) catchment and an overview of its main water resources issues, causes, and impacts. These aspects are discussed more comprehensively in subsequent chapters.

## 1.1 The Sio-Malaba-Malakisi (SMM) catchment

The Sio and the Malaba-Malakisi river catchments are located along the Kenya–Uganda border and drain two adjacent areas on the southern slopes of Mt. Elgon (Figure 1.1). The Malaba and Malakisi Rivers originate from the slopes of Mt. Elgon. The Sio River originates from wetlands to the west of Bungoma Town. The geographical area drained by the two rivers lies between latitude 1.133$^{o}$ N to 0.193$^{o}$ S and longitude 33.673$^{o}$ to 34.571$^{o}$ E. The Sio River catchment occupies an area of 1450 Km$^2$ and the Malaba-Malakisi catchment an area of 1790 Km$^2$. The rivers are transboundary with some of their reaches forming the boundary of the two countries. The Sio River discharges into Lake Victoria while the Malaba River flows westwards into Lake Kyoga after it is joined by the Malakisi River. Thus, the SMM catchments are part of the Lake Victoria and Lake Kyoga catchments, which in turn are part of the Nile River basin.

On the Kenyan portion, the catchments comprise the Sio-Malakisi-Malaba Management Unit which is part of the Lake Victoria North Catchment Area. The Lake Victoria North Catchment Area is managed by the Kenyan Water Resources Management Authority (WRMA). The SMM River Basin is shared by the Bududa, Bugiri, Busia, Butaleja, Manafwa, Namutumba, Pallisa, and Tororo districts in Uganda, and Bungoma (North, South, East, and West), Busia, Mt. Elgon, and Teso districts in Kenya.

The landscape of the SMM catchment is dominated by Mt. Elgon which is the fourth highest mountain in East Africa. Catchment elevation is highest at the summit of Mt. Elgon (4,320 m) and lowest at the Sio River mouth (1134 meters; Lake Victoria) and the Mpologoma wetlands where the Malaba River enters Lake Kyoga (950 meters). Permanent water courses have cut steep-sided valleys that radiate from the caldera of Mt. Elgon. Afro-alpine heath and moorland occupy a small area around Mt. Elgon. Beyond the moorland, the area in the immediate vicinity of the mountain comprises national parks (in both Uganda and Kenya), several forest reserves, and the Chepkitale national reserve in Kenya (17,200 ha). However, large areas of forest cover surrounding the mountain in both countries have been lost to human settlements over the past 50 years, and the southern forest edge of Mt Elgon has been receding. Woodlands of different types occur in the areas forests have receded. These are interspersed with large tracts of small-scale farmland and grasslands. The low lying areas are dominated by large expanses of wetlands.

The Malaba River originates from the southwest slopes of Mt. Elgon where it is known as Lwakhakha and flows along the common border between Kenya and Uganda. Upstream of Malaba town, the Lwakhakha becomes Malaba. The Malakisi River which is wholly in Kenya rises from the southern slopes of Mt. Elgon. The river discharges into the Malaba River along the Kenya/Uganda border to the south of Tororo town. The Malaba River then turns west and flows into Lake Kyoga.

The Sio River originates from a marshy land to the south-west of Bungoma town. A Sio tributary, the Walatsi, originates from the south of Malakisi market. The two rivers join near Nambale market and flow southwest toward the Uganda border. Subsequently, the river flows along the Kenya-Uganda border for a considerable distance and eventually discharges into Lake Victoria. The majority of the Sio River catchment is in Kenya and consists of rolling plains.

**Figure 1.1: A schematic view of the Sio-Malaba-Malakisi catchment**

## 1.2 Soils

The SMM catchment has a wide range of soil types. The soils show considerable variation in fertility and drainage properties. Soils of moderate to high fertility are confined largely to the mountainous parts. The soils of the region are volcanic in origin, young, fertile and rich in minerals. On the upper parts of Mt. Elgon, the soils are developed on ashes and other rocks of recent volcanoes. These soils are clay loam, well-drained, shallow to moderately deep, dark reddish brown, friable, humic, and rocky and stony.

The soils in the middle of the catchment are comprised of well drained, moderately deep to very deep, reddish brown to yellow brown, friable clay. On the undulating lower slopes of Mt. Elgon, the soils are formed on granite and they are well-drained, extremely deep, dark reddish brown to dark brown, friable clays with acidic humic topsoil. Along the river valleys, the soils consist of a complex of imperfectly drained to poorly drained, very deep, very dark grey to brown, mottled, friable to firm, sandy clay to clay, often underlying a topsoil of friable sandy clay loam.

**Figure 1.2: Geology and soils in the Sio-Malaba-Malakisi catchment in Uganda**

## 1.3 Vegetation

The natural vegetation cover from the mountain top to the lowlands consists of:

- High altitude moorland and heath
- High altitude forest
- Moist savannas
- Dry savannas
- Farmlands

## 1.4 Land use

The main land use in the Sio-Malaba-Malakisi catchment area is rain-fed subsistence agriculture. However, the agricultural practices in the region have not been sustainable and cultivation on steep slopes has exacerbated the soil erosion phenomenon. In addition, large areas of forest cover, including river riparian zones, have been lost to agriculture due to population increase. This has led to further degradation of the catchment areas and the increase of soil erosion and sedimentation.

On the lowlands, small-scale irrigation is being practiced. However, due to the undulating terrain, some areas which are suitable for irrigation are located at higher elevations than the river level and this together with lack of funds to procure water pumping systems restrict irrigation to small plots.

Mt. Elgon itself is a watershed of unique importance to the region and is one of the regional water towers that feeds the rivers in the catchment. The watershed maintains water quality, quantity, and flow distribution into the Sio-Malaba-Malakisi system. This area also comprises the forest and national park protected areas of the catchment. Figures 1.3 and 1.4 show the land use categorisation of the Sio-Malaba-Malakisi catchment in Uganda and Kenya.

**Figure 1.3: SMM land use (Uganda)**

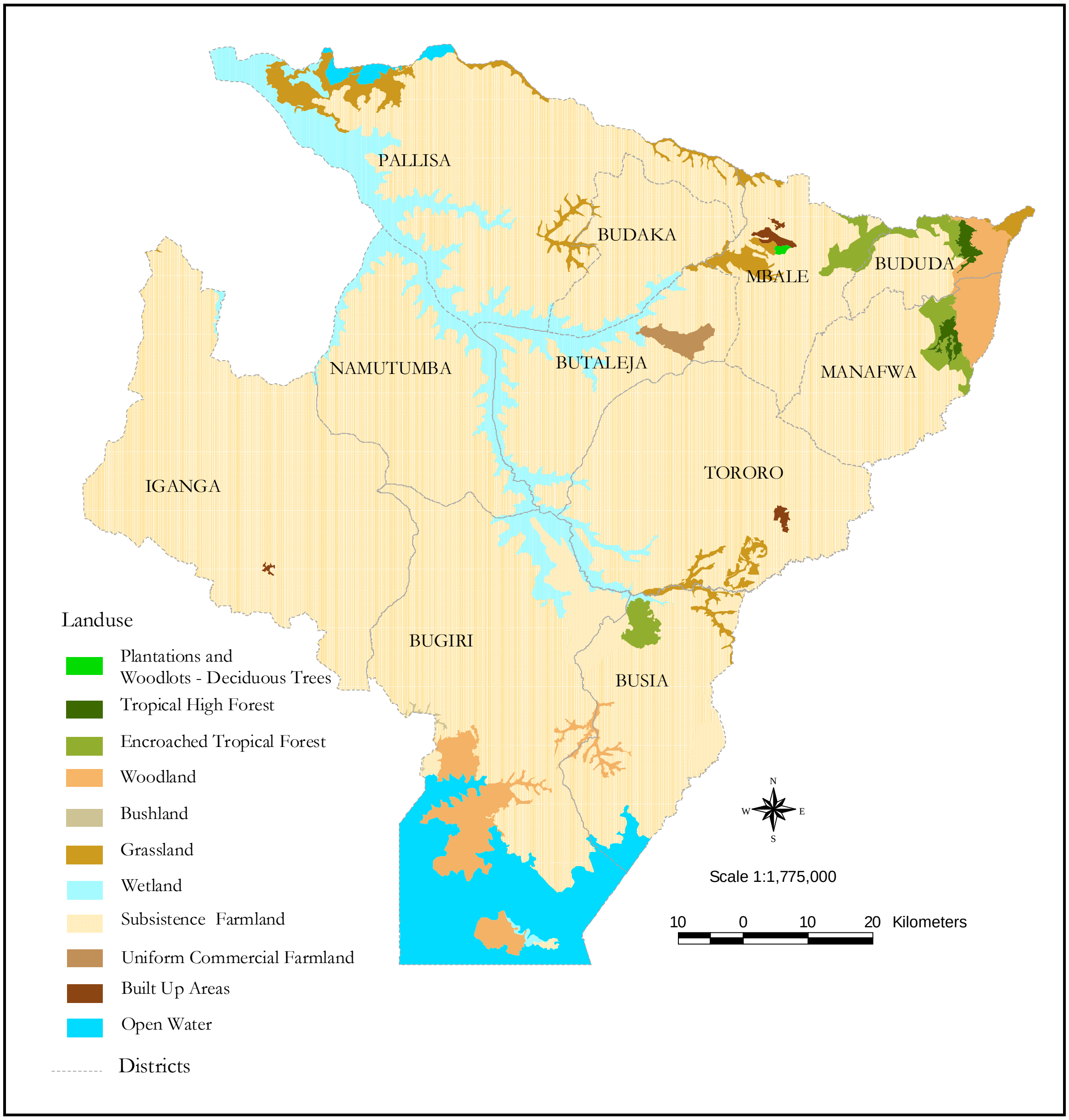
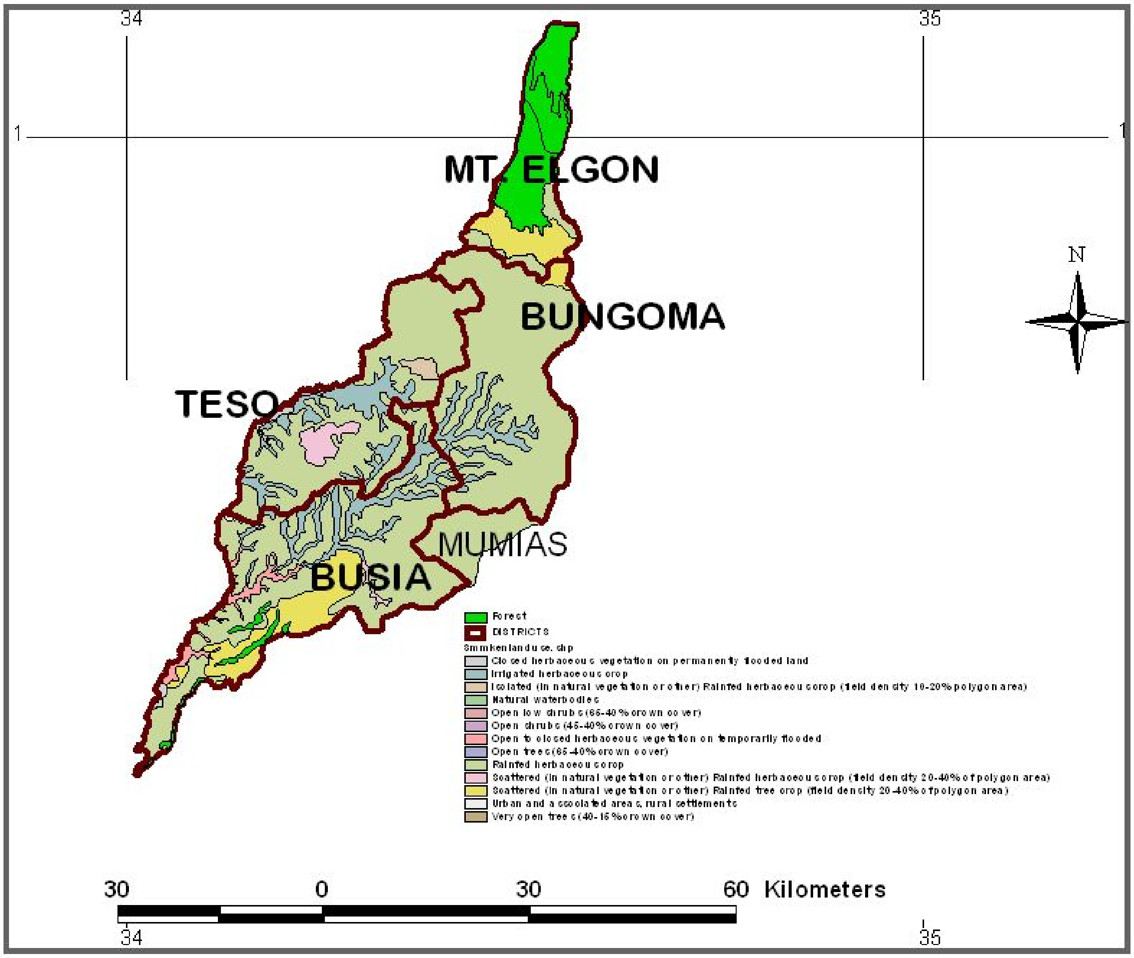


**Figure 1.4: SMM land use (Kenya)**




## 1.5 Socio-economic situation in the SMM catchment

The unifying administrative units in the SMM catchment are districts. Selected socio-economic indicators for the SMM districts in Kenya and Uganda are summarized in Table 1.1.

**Table 1.1: Socio-economic indicators in the SMM districts**

| District | Total Area | Population (2002) | Population density (Persons/km$^2$) | Literacy rate | Infant Mortality Rate /1000 live births | Poverty incidence |
|---|---|---|---|---|---|---|
| Bungoma | 2,068 | 997.175 | 482 | 89.5 | 78 | 56 |
| Busia | 1261 | 405,388 | 321 | 66 | 75 | 66 |
| Mt. Elgon | 937 | 144,679 | 154 | 57 | 64 | 56 |
| Teso | 558 | 197,395 | 354 | 67.4 | 75 | 56 |
| Total/Average (**Kenya**) | **4,824** | **1,744,637** | **328** | | | |
| | | | | | | |
| Bududa | 274 | 123,102 | 450 | 63% | | 30 – 40% |
| Manafwa | 451 | 262,566 | 493 | 67% | 59 | 30 – 40% |
| Tororo | 1,600 | 381,259 | 313 | 57% | | 40 – 50% |
| Busia | 743 | 225,008 | 325 | 63% | | 50 – 60 % |
| Butaleja | 644 | 157,489 | 245 | 78% | | 40 – 50% |
| Bugiri | 5,701 | 412,395 | 284 | 59% | 104 | 50 – 60 % |
| Namutumba | 802 | 167,691 | 242 | 34% | | 40 – 50% |
| Pallisa | 2,051 | 384,118 | 328 | 54% | | 50 – 60% |
| Total/Average (**Uganda**) | **12,266** | **2,250,103** | **335** | | | |

*Source: District Development Plans, Bungoma, Busia, Mt. Elgon, and Teso: 2002-2008 (Kenya)*

Approximately 4 million people (based on 2002 census data) live within the SMM catchment, with 80% of the population engaged in subsistence farming. This high population density is putting enormous pressure on scarce agricultural land resources. Heavy dependence on forest resources is common in the Districts near Mt. Elgon, i.e., Mt. Elgon in Kenya, and Bududa and Manafwa in Uganda. The forests are utilized by the communities for firewood, ropes, pole wood, vegetables, bamboo shoots, fruits, medicines, and livestock grazing (IUCN 2005). Because of their importance for rural communities, forested lands have been encroached upon by new human settlements, while gazetting of national parks and forest reserves has created significant resentment and social unrest. The total protected area in the Uganda SMM districts was 37,045 hectares in 2002 (National Biomass Study, 2002-Uganda).

In Kenya, the gazetted forest reserves in the catchment area extend over 50,866 hectares all of which is in Mt. Elgon District.

The SMM catchment is a socially, economically, and politically diverse area, fraught with problems stemming from poor land use practices and water resources management. Water resources are still abundant and the catchment development potential remains unexploited, as evidenced by the very few water use permit applications. An analysis of the permit applications established that as of 2006 less than 60 water use permits had been issued from all three rivers and their tributaries in Kenya for domestic water supplies, general and minor irrigation, and hydropower generation.

## 1.6 Water supply and sanitation

The utilization of water resources in the SMM catchment has focused on the provision of rural and urban water supplies and minor irrigation. The main water sources in the catchment are the rivers, small dams, lakes, ponds, boreholes, shallow wells, protected and unprotected springs, and roof catchment.

Sanitation facilities mainly consist of pit latrines. Other facilities include septic tanks, cess pools, bucket latrines, and the bush. However, there are major problems in informal settlements where there is insufficient coverage of pit latrines.

Sewerage facilities exist for some urban areas but are in need of repair and upgrading. The lack of adequate sewerage facilities and toilets combined with the high urban population growth has resulted serious environmental pollution by urban and human wastes.

## 1.7 Environment and tourism

The Sio-Malaba-Malakisi catchment area has a wide array of ecosystems including lakes, rivers, forests, and game reserves and national parks which are home to a widely diverse flora and fauna. These are important environmental and economic resources for the communities in both countries.

The catchment is endowed with ecosystems which have high tourist potential. However, this potential is largely undeveloped. Tourist sites include the Kakamega indigenous forest; Lake Victoria and its many islands; Mt. Elgon Forest Reserve with 50,886 hectares in Mt. Elgon District; and the Chepkitale Game Reserve of some 17,200 ha. These sites are part of the Eastern African High Altitude Biodiversity attractions where endemic, endangered, and threatened flora and fauna can be seen.

## 1.8 Public health

Good health is essential for social and economic development and a key measure of quality of life. Health trends in the SMM catchment as well as other regions are best described by consolidating data analysed and reported in different health surveys in Kenya and Uganda. For example in Kenya, health information collected in such surveys assist the government and other service providers to identify the population sections with health problems and to measure progress toward achieving health targets (set in the Second National Health Sector Strategic Plan; NHSSP II – 2005-2010) and Millennium Development Goals.

## 1.9 NBI, NELSAP, and the SMM project

The Nile Basin Initiative (NBI) is a transitional institutional arrangement set up in 1999 to promote cooperative management and development of the Nile River Basin resources. NBI oversees the implementation of the Nile River Basin Action Plan pending establishment of a permanent legal and institutional framework for the basin. NBI's shared vision is *"To achieve sustainable socioeconomic development through the equitable utilization of, and benefits from, the common Nile-Basin water resources."* Primary NBI objectives include:

a) To develop the water resources of the Nile Basin in a sustainable and equitable manner to ensure prosperity, security and peace for all its peoples;

b) To ensure efficient water management and optimal use of the resources;

c) To ensure cooperation and joint action between the riparian countries, seeking win-win gains;

d) To target poverty eradication and promote economic integration; and

e) To ensure that the program results in a move from planning to action.

To translate the shared vision into action, NBI developed and launched a Strategic Action Program consisting of two complementally components;

- A Shared Vision Program (SVP): This is a basin-wide program, comprising of seven sectoral and facilitative projects to build confidence, trust, and capacity and to create an enabling environment for sustainable development;
- A Subsidiary Action Program (SAP): This program aims to achieve action on the ground through joint investments in the basin.

Two subsidiary action programs are being implemented, namely;

a) The Nile Equatorial Lakes Program (NELSAP), involving the countries of Burundi, Rwanda, Tanzania, Kenya, Uganda, DRC, Sudan and Egypt, with its coordination unit in Kigali, Rwanda; and

b) The Eastern Nile Subsidiary Action Program (ENSAP), involving Egypt, Ethiopia, and Sudan (and Eritrea as a fourth potential member), with its coordination unit in Addis Ababa, Ethiopia.

NELSAP was established in 1999, in accordance with NBI policies and Guidelines, with the goal of identifying, preparing, and funding cooperative investment projects at sub-basin levels within the framework of the Nile Basin Initiative. The NBI Shared Vision, Strategic Action Plan and Policies and Guidelines provide the overall framework for NELSAP implementation.

The NELSAP objective is *"to contribute to the eradication of poverty, promote economic growth, and reverse environmental degradation."* To achieve this objective, twelve transboundary and multi-country projects have been identified targeting investments in the fields of agriculture, fisheries development, hydropower development and interconnections, transboundary water resources management and development, and water hyacinth control.

The Sio-Malaba-Malakisi River Basin Transboundary Integrated Water Resources Management and Development Project is one of three transboundary water resources management projects, the other two pertaining to rivers Mara and Kagera. The Project Management Unit (PMU) to coordinate the implementation of the SMM project is in Kakamega, Kenya.

## 1.10 Policy, legal, and institutional arrangements

In recent decades, emerging threats and novel management practices challenged the policies, institutional frameworks, and laws Kenya and Uganda had inherited from the colonial era. Their efforts have been directed mainly towards two directions. The first direction has been toward strengthening national policies, institutional frameworks, and laws to meet the emerging challenges. The second has been to intensify interstate cooperation to address transboundary issues.

Within the national frameworks, the two states have adopted policy documents which encompass innovative and up-to-date techniques of managing water resources, water use rights, integrated management of basin systems, decentralization of water management, de-linking resource management from service provision, and involvement of civil society in the management of resources.

In both countries, in addition to the law governing water resources, there has been a spirited effort to improve laws governing complementary sectors such as the environment, forests, wetlands, local government, land use and land tenure, wildlife and protected areas management. These improvements have added value to the framework as the sectors impact seriously on water resources management.

The institutional frameworks in the two countries have evolved in response to emerging needs in the management of water resources. New institutional frameworks have also emerged in the complementing sectors.

At the inter-state level, the Sio-Malaba-Malakisi Rivers form part of the Nile Basin and therefore are subject to the legal arrangements of the Nile Basin. Furthermore, the two states also belong to the East African Community (EAC). The EAC has signed the Lake Victoria Protocol establishing the Lake Victoria Basin Commission (LVBC) to oversee the management and development of the Lake Victoria Basin water resources. (A comprehensive review of the existing policy, legal, and institutional arrangements in Kenya and Uganda is the subject of later Chapter of the Monograph and of a separate report.)

## 1.11 Challenges in the management of transboundary water resources

Notwithstanding ongoing reforms in the water sectors of Kenya and Uganda, the following issues are identified in water resources management:

- Despite the presence of the EAC, there is presently no formal institutional collaboration between the water resources institutions in Kenya and Uganda;
- Because of its drainage into Lake Victoria, the Sio River falls within the Lake Victoria Protocol. However, there is no similar arrangement pertaining to Lake Kyoga, and the Malaba-Malakisi River, which drains into it, does not have a clear legal and institutional framework.
- There is no effective mechanism for harmonizing the national laws of Kenya and Uganda on water resources management or any other natural resource.
- Water resources management in Kenya has been decentralized to local levels, while this process is forthcoming in Uganda.
- The Nile River Basin Cooperative Framework is yet to be concluded to provide the necessary legal and institutional framework for all of the Nile Basin areas.

## 1.12 Summary of challenges, issues, causes, and impacts

### 1.12.1 Challenges

**(1) Poverty** - The poverty levels in the catchment are high ranging from 30% to 66%, with many of the rural population struggling to meet their basic needs (shelter, food, water, health and education). Poverty is adversely impacting the active participation of most people in socio-economic development activities including the planning, management, and implementation of water resources management and development activities.

**(2) High Population Density and Growth Rates –** Most parts of the catchment have high population densities ranging from 150 to 500 persons per km2 with corresponding high population growth rates ranging from 2% to 5%. This has resulted in heavy and increasing pressure on the catchment natural resources rendering their current rate of exploitation unsustainable. There are already reported cases of increasing water and land use conflicts and unprecedented encroachment on gazetted forests and wetlands in pursuit of additional agricultural land. Because the population growth rates in the catchment are much higher than the rate of expansion of infrastructure and social services, it is becoming increasingly difficult for the authorities to meet their development targets in terms of service delivery (e.g., water supply and sanitation coverage) under current investment levels. It is therefore clear that any progress in achieving the national targets and MDGs in the catchment will require a significant increase in investment in service delivery from the current levels to cope with the high population growth rates.

**(3) High Disease Prevalence and Morbidity Rates -** Water-related diseases are the most common causes of illness and death among the rural poor communities in the SMM catchment. Diarrhoeal diseases (cholera & dysentery) are among the major killer diseases of young children, accounting for about 20% of all infant deaths in the SMM catchment. For example, data from a health survey conducted in Uganda in 2006 (UDHS, 2006) showed that 26% of the children under the age of five, reported severe diarrhoea. Similarly, in Kenya, water borne and water related diseases are among the top ten causes of outpatient morbidity (MoH, 2006).

Provision of safe drinking water and basic sanitation is crucial to the preservation of human health, especially among children. Households with improved access to safe water and sanitation services suffer less morbidity and mortality from water-related diseases, spend less money on health related issues, and are more productive. More specifically, access of girls and women to improved safe water and sanitation services would improve their chances of having better educational and development opportunities, as this would safeguard their privacy and enrollment in school and relieve the burden of having to walk long distances to fetch water.

**(4) Gender Inequality in Decision-making –** Decision-making based on gender equity is a pre-requisite for good water governance and a key factor in achieving sustainable water resources management and development. However, although women are responsible for household water, sanitation and hygiene issues, they continue to be marginalized in the water resources management and development processes. According to the findings of the Uganda Participatory Poverty Assessment Process/Second Participatory Poverty Assessment (UPPAP/PPA2), gender inequality is one of the main reasons for persistent poverty in Uganda. Women's lack of access to and control over resources adversely impacts their productivity and remains one of the root causes of poverty in the catchment.

There is, therefore, an urgent need to address gender imbalance in the catchment. This can be achieved through the design and implementation of measures that are specifically targeted to alleviate the burden of women to walk long distances to collect water for domestic use, and also measures aimed at empowering women to actively participate in the decision-making processes in their communities.

**(5) Inadequate Capacity to Plan and Implement Intervention Measures -** One of the most difficult challenges to sustainable water resources management and development in the SMM catchment is lack of adequate technical and financial capacity to plan, implement, and monitor water resources management and development activities. Though both countries had made significant efforts to establish fairly elaborate policy, legal, and institutional mechanisms to address water sector challenges, the lack of capacity to implement these policies and enforce the corresponding laws has grossly undermined their effectiveness. It is therefore common practice to find water users polluting water sources, draining wetlands, cutting down trees, and cultivating up to riverbanks with impunity regardless of the laws and regulations prohibiting such activities.

It is thus clear that enacting good policies and laws alone cannot lead to sustainable water resources management and development. For this to occur, commensurate investment in development of human and institutional capacity is necessary to oversee effective implementation of the policies and enforcement of the enacted laws.

**(6) Lack of a Clear Transboundary Cooperative Framework –** A last but by no means least challenge to sustainable and integrated water resources management and development in the SMM catchment is the lack of a comprehensive transboundary cooperative framework for the joint planning and implementation of development activities by the governments and communities in the two countries. Current planning activities have a local or a national focus without considering the catchment as a whole.

Though development activities in the upstream part of the catchment have significant impacts on downstream water users, current planning and management processes do not recognize such crucial dependencies. As a result, downstream water users are experiencing water quantity and quality degradation due to unsustainable water and land use practices. This ominous must be reversed before it sets off destructive social conflicts.

### 1.12.2 Issues, causes, impacts

The key water related issues in the SMM catchment include low safe water and sanitation coverage, inadequate awareness of water resources related issues, water pollution (surface water and groundwater), deforestation, flooding, drainage of wetlands, excessive soil erosion, cultivation of riverbanks, lack of access to adequate and reliable water resources data and information, and over-exploitation of groundwater resources. These issues together with their causes and associated environmental impacts are summarized in Table 1.2 below.

**Table: 1.2 Problem matrix**

| Issues | Causes | Impact |
|---|---|---|
| Low safe water and sanitation coverage | -Inadequate investment in safe water supply and sanitation facilities.<br>-Poor operation and maintenance of installed water supply and sanitation facilities resulting in low operational efficiencies and frequent facility break down. | -High prevalence of water related diseases resulting in high infant mortality rates, reduced productivity and unnecessary health expenses.<br>-Low productivity of women and girls who spend most of their time walking long distances to fetch water.<br>-High drop out rates of female students from school due to poor sanitation facilities. |
| Inadequate awareness of water resources related issues | -Lack of access to reliable water resources data and information.<br>-Inadequate school curriculum that does not make adequate provisions for water resources and hygiene related studies.<br>-Inadequate technical and financial capacity to sensitise local communities on water resources related issues. | -Lack of interest by local communities to participate in water resources related activities.<br>-Catchment degradation and pollution of water resources.<br>-Unsustainable and inefficient domestic, industrial and irrigation water use. |
| Water pollution | -Inadequate sanitation facilities especially in public areas (schools, markets, etc.).<br>-Poor planning and location of sanitation facilities (e.g., pit latrines near water sources).<br>-Improper discharge of effluent from industries, abattoirs, and toilets into rivers.<br>-Improper use of agro-chemicals.<br>-Watering of livestock in rivers.<br>-Bathing, and washing of clothes, utensils, and chemical containers in rivers.<br>-Lack of/and or poor solid waste disposal facilities.<br>-Laxity in enforcement of environmental rules and | -Poor water quality for human consumption and ecological functions.<br>-Water borne diseases.<br>-Loss of aesthetic value.<br>-Ecological damage in rivers and wetlands. |

| Issues | Causes | Impact |
|---|---|---|
| | regulations. | |
| Deforestation | -Cutting down of trees to create more agricultural land due to population pressure.<br>-Charcoal burning and timber logging as alternative sources of income.<br>-Poaching of forest products.<br>-Forest excision. | - Increased soil erosion and sediment loads in rivers and lakes. due to loss of vegetation cover.<br>-Drying up of streams and rivers due to increased flush floods and hence reduction in base flow.<br>-Destruction of ecological biodiversity due to loss of habitat for flora and fauna. |
| Flooding | -Catchment destruction especially cutting down of trees and cultivation of hill slopes. | - Loss of soil fertility and increased sediment loads rivers due to soil erosion.<br>-Destruction of infrastructure, crops, farmland, and displacement of downstream communities.<br>-Waterborne diseases. |
| Drainage of wetlands | -Conversion of wetlands into agricultural land due to shortage of arable land.<br>-Unsustainable harvesting of wetland products.<br>-Disposal of excessive toxic wastes into wetlands<br>-Brick making.<br>-Lack of awareness/wrong perception on importance of wetlands. | -Loss of wetland ecosystem (biodiversity, water supply, etc.).<br>-Loss of wetland functions (flood control, erosion control, water filtration, water storage, etc.). |
| River bank cultivation | -Shortage of agricultural land due to population pressure.<br>-Weak enforcement of river bank protection regulations and guidelines | -Soil loss.<br>-Increased sediment loads in rivers.<br>-River bank failures and interference with natural river morphology. |
| Soil erosion | -Deforestation and vegetation removal.<br>-Inappropriate land use practices.<br>-Cultivation on steep slopes.<br>-Inappropriately designed drainage systems. | -Soil/fertility loss.<br>-Increased sediment loads in rivers.<br>-Low crop yields.<br>-Loss of agricultural land. |

| Issues | Causes | Impact |
|---|---|---|
| Over-abstraction of groundwater | -Inadequate surface water sources in terms of quantity and quality.<br>-High investment and treatment costs for surface water supply schemes.<br>-Degradation of groundwater recharge areas. | -Depletion of groundwater reserves.<br>-Land subsidence due to rapidly receding water table.<br>-Drying up of rivers and streams due to reduced base flows. |
| Lack of adequate and reliable water resources related data and information | -Lack of and/or inadequate technical and financial resources to install appropriate monitoring equipment and ensure sustainable operation of the monitoring networks.<br>-Unreliable data collection, processing, quality control, and storage procedures and standards.<br>-Lack of data sharing and information exchange protocols. | -Poor planning and decision-making processes.<br>-Poor designs for water related and drainage infrastructure.<br>- Water use conflicts. |

# 2.0 Hydro-climatology of the SMM Catchment

## 2.1 The Sio-Malaba-Malakisi river catchments

The Malaba-Malakisi catchment (1,750 $km^2$) lies at the south and southwest sides of Mount Elgon, the fourth highest mountain in East Africa. There are two tributaries in the upstream reaches of the catchment known as Lwakhakha and Malakisi. The Lwakhakha originates from Mt. Elgon and flows along the common border between Kenya and Uganda. The uppermost streams of the Malakisi River are entirely in Kenya. The Tolotso is one of the tributaries to the Malakisi. The Malakisi joins the Lwakhakha south of Tororo to form the Malaba, which subsequently enters Uganda before swinging northwest and flowing into Lake Mpologoma which finally drains into Lake Kyoga. River Kami is another tributary to the Malaba and its sub-catchment area also straddles the border. The Manafwa River in Uganda flows adjacent to the Malaba and is also part of the Mpologoma drainage system.

The smaller Sio catchment (1,390 $km^2$) lies almost entirely in Kenya and has a river length of 85 kilometers (km). The Walatsi is the main tributary of the Sio River, and joins it downstream of Nambale Market. Other smaller tributaries of the Sio include the Lelekwe, Mwitsula, and Wakhungu which also join the Sio near Nambale. From there, the Sio flows southwest to form the border with Uganda about 3 km south of the Kisumu-Busia road, passing through an extensive wetland in its middle reaches, and then along the border to Lake Victoria. As it enters Lake Victoria, the river is about 20 meters wide. However, during the rainy seasons (March to May and October to November), the river widens considerably as the land is quite flat in the last 5 km of its lower reach. Figure 1.1 illustrates the drainage basin and main rivers.

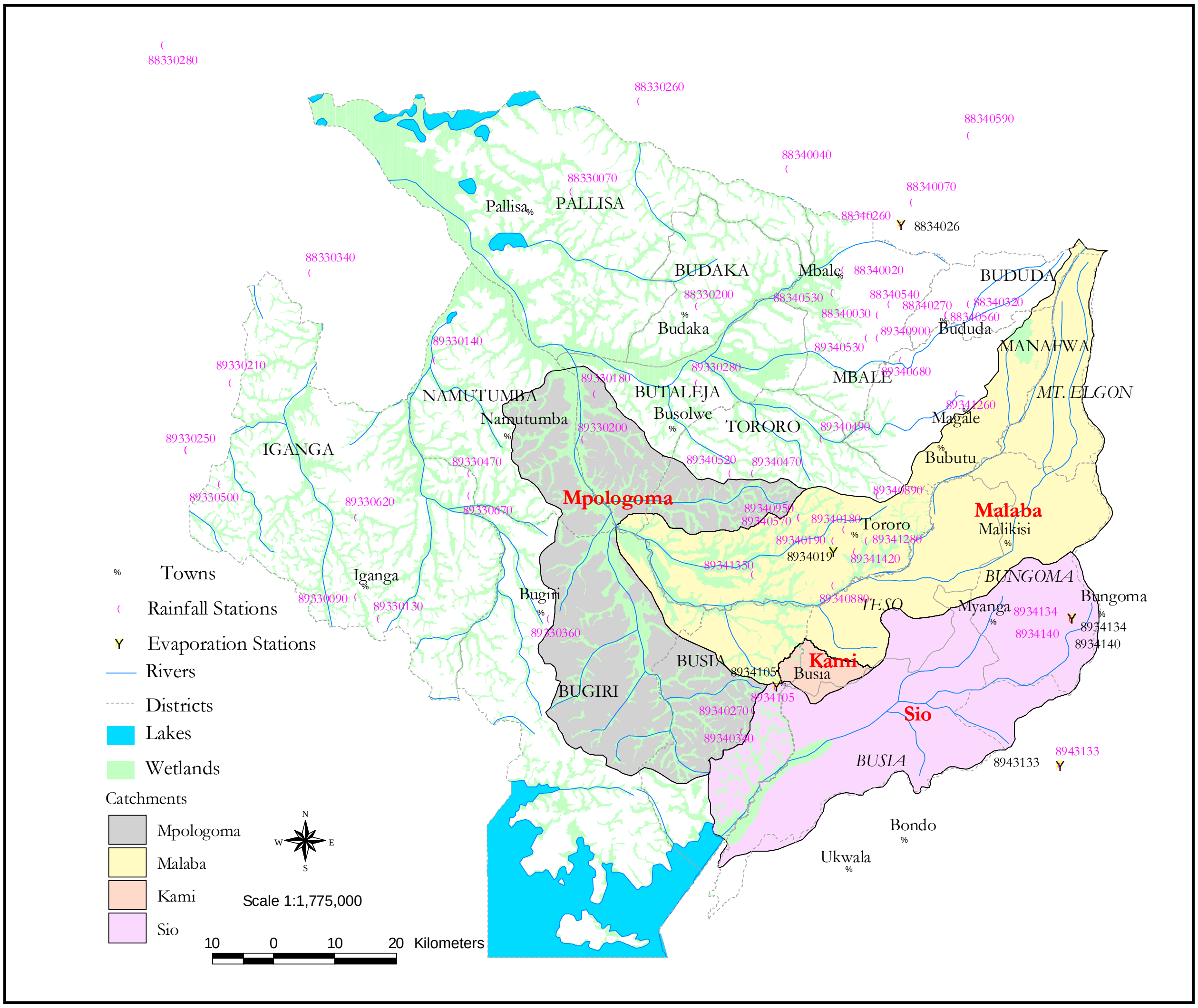
## 2.2 Monitoring practices and networks

In both countries, the respective Meteorological Departments (KMD & UMD) are responsible for climatological data collection, analysis and dissemination. The monitoring stations are equipped with standard rain gauges which are read once daily at 9:00 AM by individuals hired by the institutions and paid honoraria. In the recent past, a few automatic weather stations have been established at strategic locations in the Lake Victoria Basin through the support of the Lake Victoria Environment Management Project (LVEMP). Automatic weather stations exist at Bungoma, Mbale, and Lolui islands within the catchment area. In Kenya, some stations are manned by the Provincial Administration through the Chiefs and District Officers offices. In the past, institutions such as agricultural research stations, schools, farms, and some industries voluntarily collected rainfall data and posted it to the central processing agencies.

The Kenya Ministry of Water and Irrigation through the Department of Water Resources also operates a network of rainfall stations. Similarly in Uganda, the Directorate of Water Resources Management (DWRM) also operates a number of strategic stations on some Lake Victoria islands and near some key towns. Most of these stations have been donated by Food and Agriculture Organization (FAO) projects including the Lake Victoria Water Resources Project which developed a database for the Lake Victoria Basin containing data and information on hydrology, rainfall and climate parameters. Additional data on rainfall and climate was consolidated under the Lake Victoria Environmental Management Project and the Kenya Marine Fisheries Research Institute offices in Kisumu. Through a memorandum of understanding between UMD and DWRM, rainfall data has been quality assured and utilized for hydro-climatic studies in Uganda. Figure 2.1 illustrates the distribution of climatological monitoring stations within the SMM catchment.

A review of rainfall data from stations in Uganda and Kenya from the 1940s to date shows that the quality of data varies with station and period. The period before the 1970s has in general good quality rainfall data. However, with the civil unrest in Uganda and the Asian exodus (most stations on farms were run by people of Asian origin), the networks started to deteriorate. Many station years are incomplete or missing altogether during this turbulent period. The most authoritative and authentic data was collected during the Hydro-meteorological Survey Project of the catchments of Lakes Victoria, Kyoga, and Albert (WMO, 1974). After this project most of the stations were not maintained. A few have been rehabilitated over the last 10 years, but overall the data remains fragmented.

**Figure 2.1: Climatological stations in the SMM catchment**




## 2.3 Climatological patterns

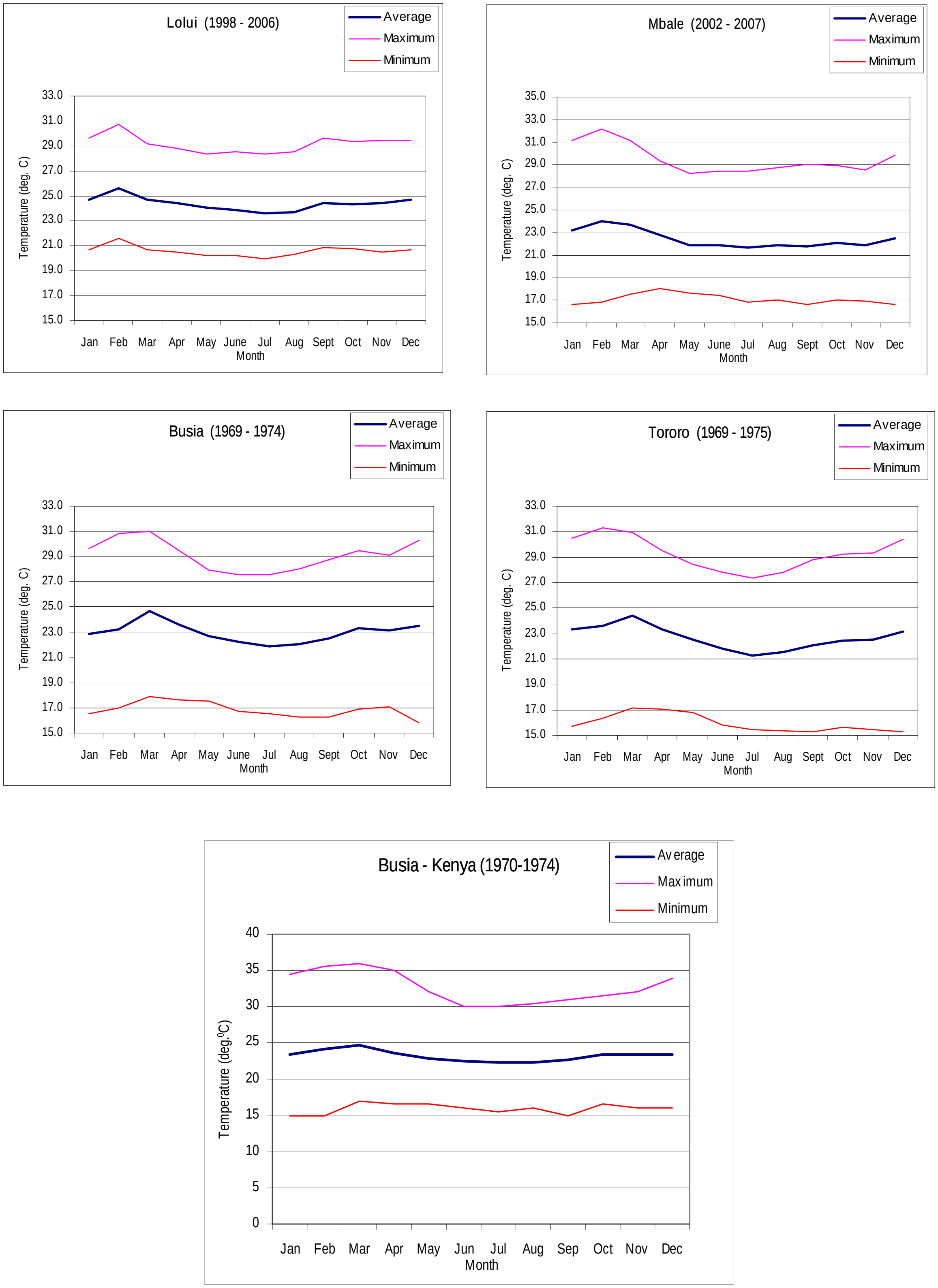
The climate of the SMM catchment area can be categorized as humid and sub-humid. The climate is mostly affected by the movement of the Inter-Tropical Convergence Zone (ITCZ) but the effects are appreciably modified by the presence of Lake Victoria and the local topography.

### 2.3.1 Temperature

The climate on the mountain is Montane with mean annual temperatures varying from less than 10 $^{o}$C at over 3,050 m elevation to 15 $^{o}$C at 2000 m elevation. In addition, to proximity to Lake Victoria, there is also a strong orographic influence on temperature regimes experienced within the SMM. Mean maximum temperature is about 27.5 $^{o}$C around low lying areas and about 5 degrees lower around the slopes of Mt. Elgon. A mean monthly minimum temperature of 15 $^{o}$C was recorded in the plains, falling to 10 $^{o}$C higher up the slopes of Mt. Elgon (H.L. de Baulny, 1969). The orographic influence on the temperatures is markedly evident around Mbale and Tororo where much convective activity generally occurs over the highlands during the warm season. Vertical transport of heat over the mountainous regions influences the behaviour of the maximum temperatures while the altitude favors the production of a lower minimum temperature. On the other hand, the effect of lake Victoria on the temperature regimes of island stations such as Lolui and shoreline stations, e.g., Busia, is to limit the temperature range of variation.

Representative values of the monthly average maximum, minimum, and mean temperatures for selected stations within the SMM in Uganda are illustrated on Figure 2.2 below.

**Figure 2.2: Monthly maximum, minimum, and mean SMM temperatures**



### 2.3.2 Wind

Winds over the SMM catchment closely follow the pattern of the apparent movement of the sun across the equator through the Inter-Tropical Convergence Zone (ITCZ). The ITCZ and its influence affect the regime of most of the meteorological parameters including rainfall, wind speed and direction, and temperature. In the months of January-February and June-September, the wind pattern is predominantly East-West, parallel to the equator, with origins from the Nandi Hills in Western Kenya. These are fairly dry winds. During the period of March-May and October-December, the wind pattern changes toward the south.

### 2.3.3 Rainfall

Part of the rainfall experienced over the SMM catchment is due to ITCZ. Extensively low pressures over Lake Victoria combine with this peculiar wind system to dictate the distribution of rainfall over periphery areas along its shoreline around Busia in Uganda and Kenya where average annual rainfall ranges between 1460 millimeters (mm) – 1600 mm.

However, proximity to Lake Victoria is not an assurance of abundant rainfall. Differences in elevation also exert a significant influence on rainfall distribution. In mountainous terrain, rainfall is of the orographic type where the windward side experiences heavy precipitation while lower lying areas tend to be drier. Elevated areas surrounding Mt. Elgon have average annual rainfalls of over 1800 mm, while the valleys in Iganga and Butaleja receive lesser amounts ranging from 900 – 1180 mm. The seasonal pattern of the rainfall regime in the SMM catchment is such that there are two rainy seasons extending from March to May and late September to November. Figure 2.3 depicts the monthly rainfall distribution (mean, minimum, and maximum values) for selected stations in Uganda. Figures 2.4 and 2.5 show the same statistics for selected stations in Kenya. Figure 2.6 shows the mean spatial rainfall distribution over the whole of the SMM catchment, while Figures 2.7 and 2.8 depict the spatial rainfall distribution during a dry and a wet year. The figures show the occurrence of the long rains (from March through May) and the short rains (from September-October through November), the high rainfall variability (the range between minimum and maximum rainfall is often larger than twice the mean), and the progressively drier climate from east to west. The high rainfall variability makes the SMM catchment potentially vulnerable to both droughts and floods.

**Figure 2.3: Monthly rainfall variation (Uganda)**

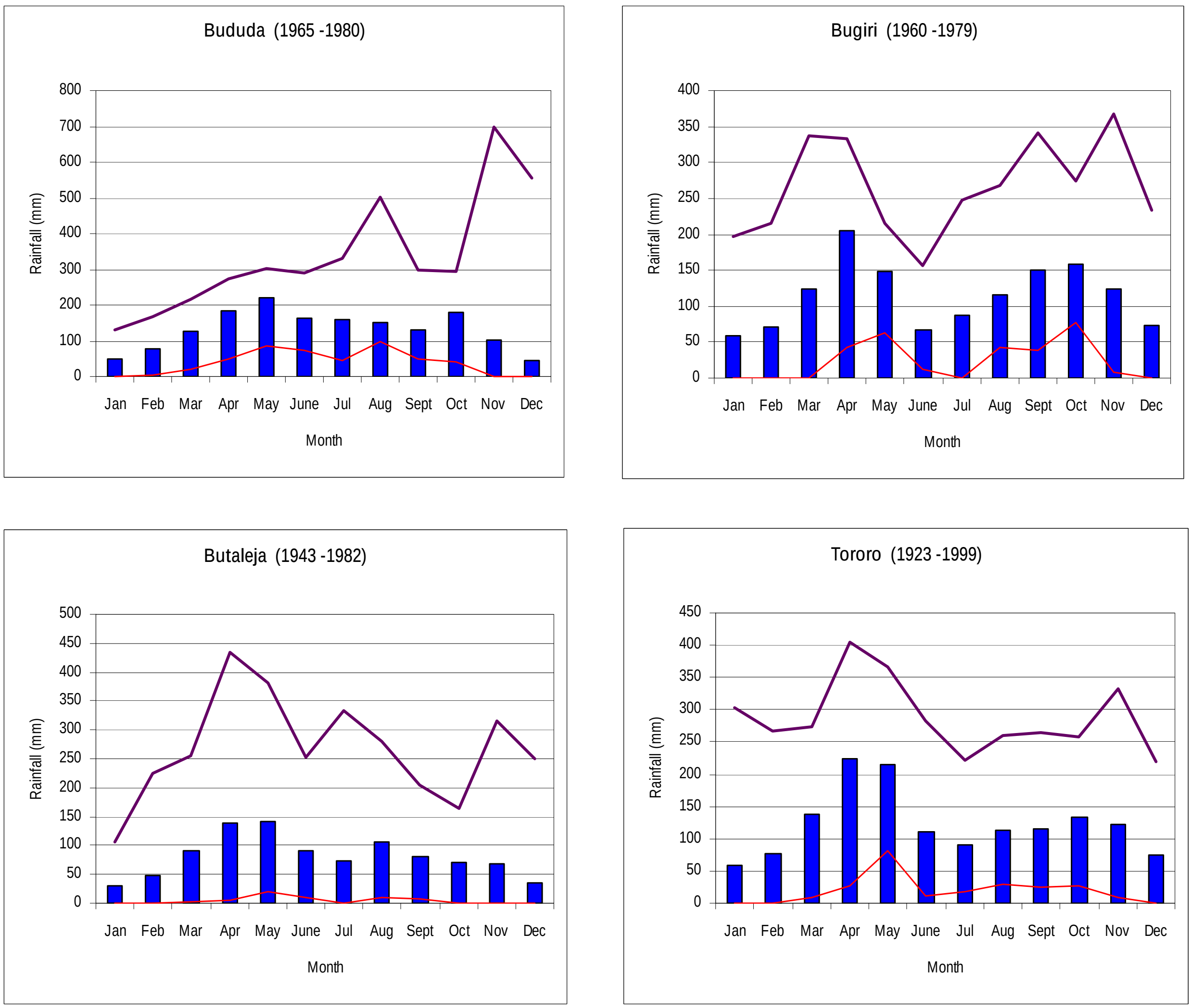


**Figure 2.4: Monthly rainfall variation (Kenya; first group of stations)**

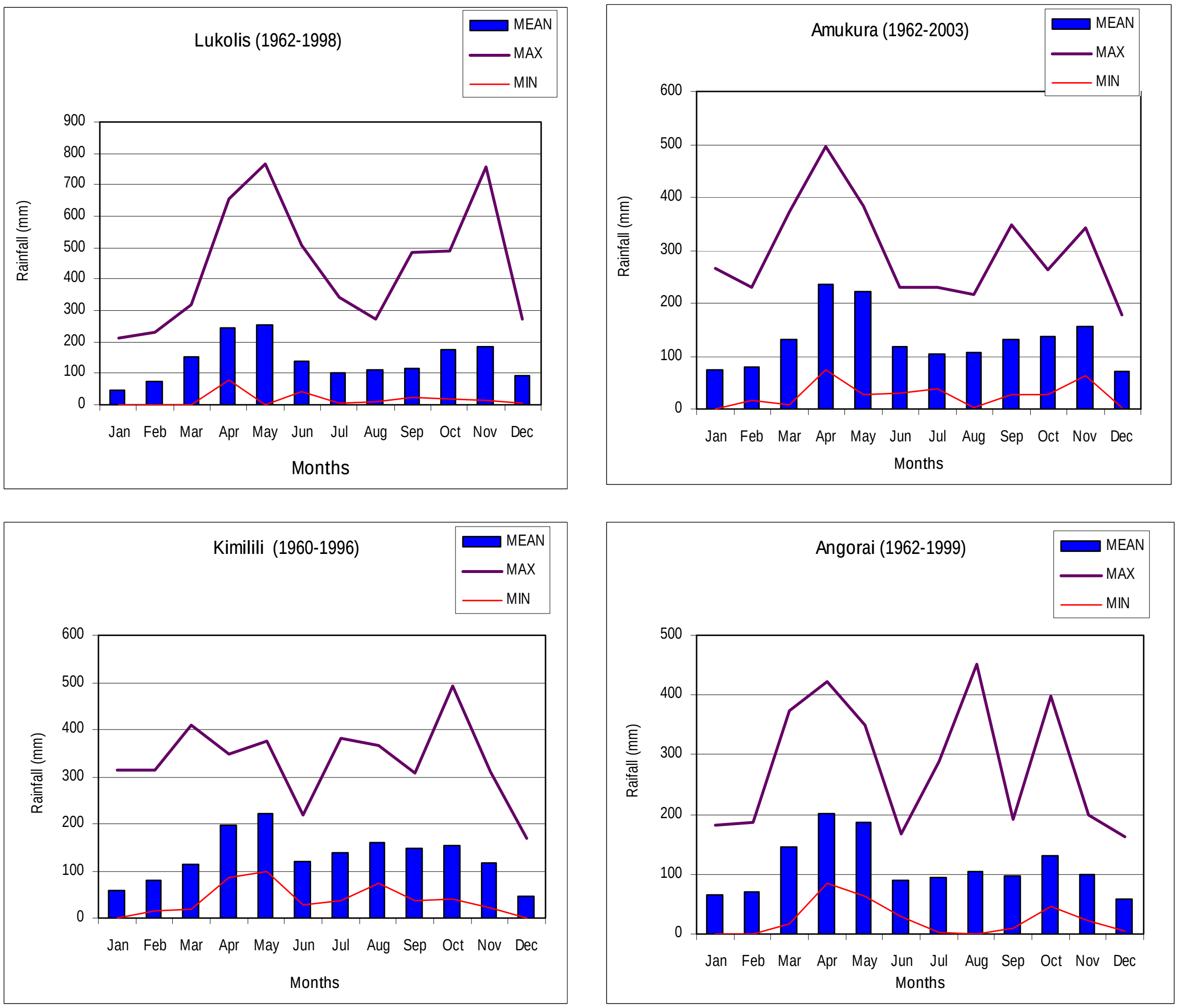
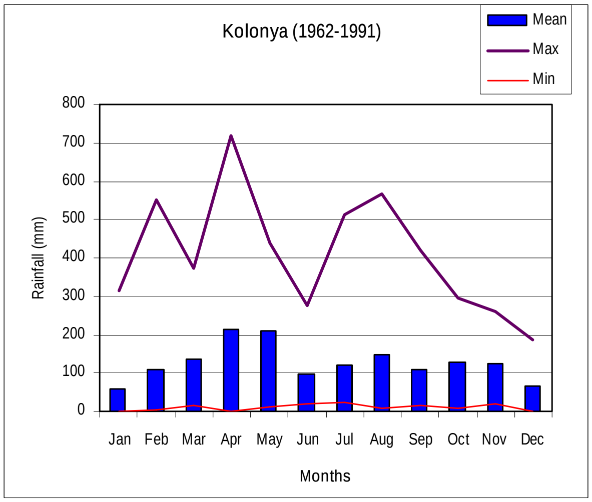
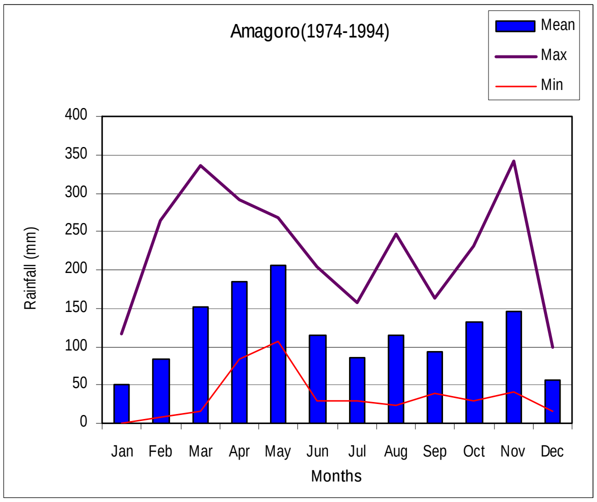


**Figure 2.5: Monthly rainfall variation (Kenya; second group of stations)**



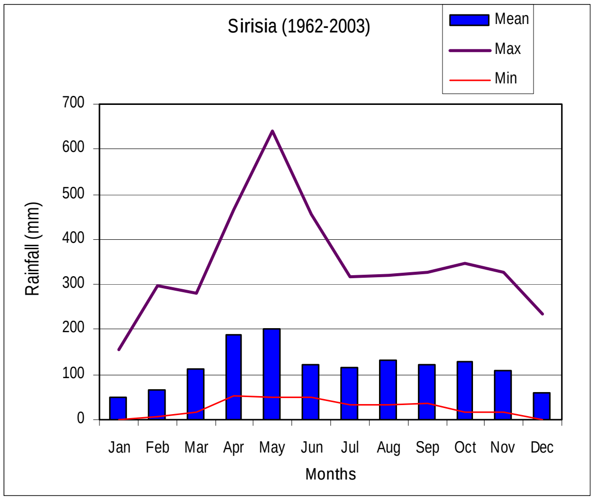



**Figure 2.6: Average spatial rainfall distribution over the SMM catchment**

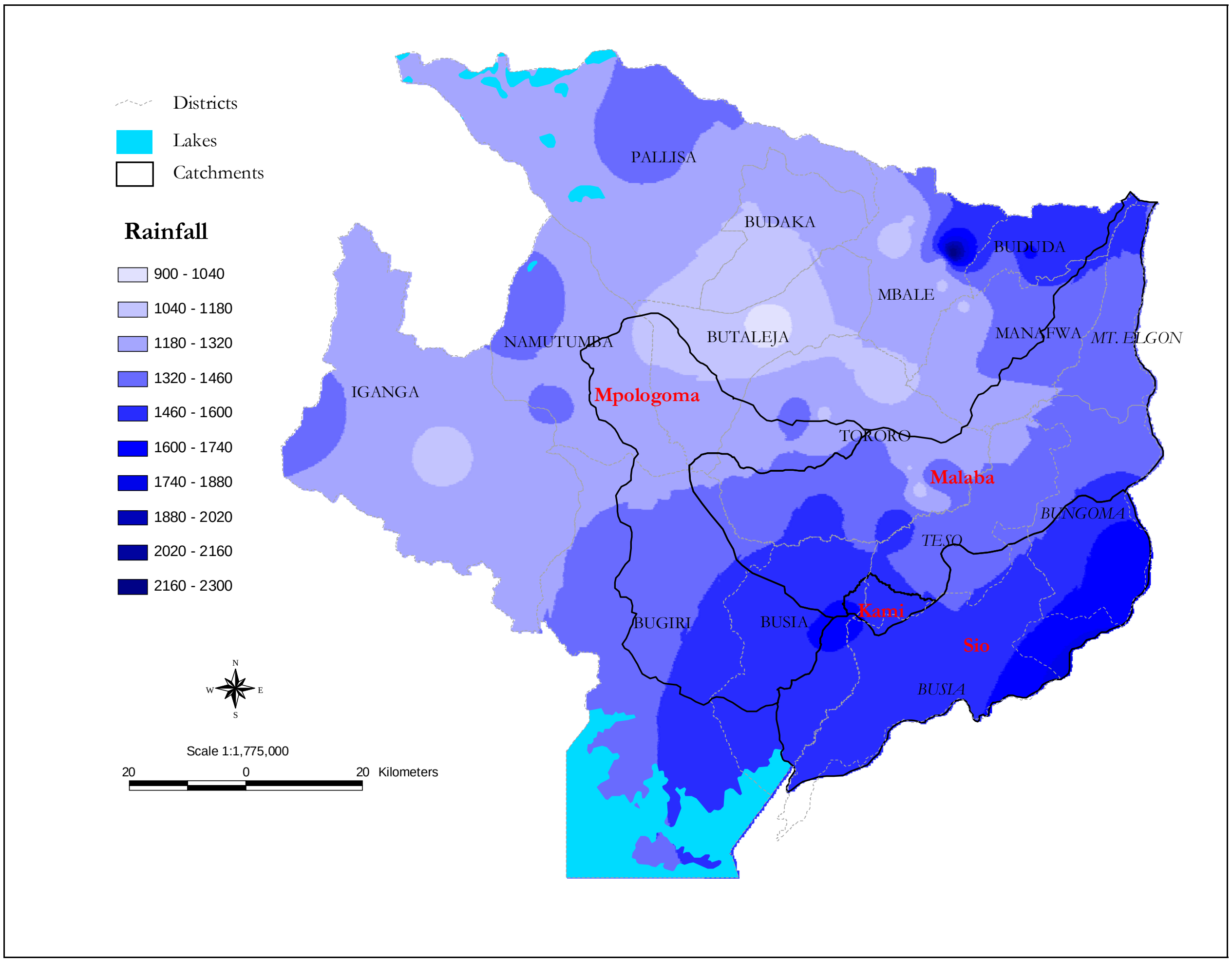


**Figure 2.7: Average spatial distribution of rainfall in a dry year (1973)**

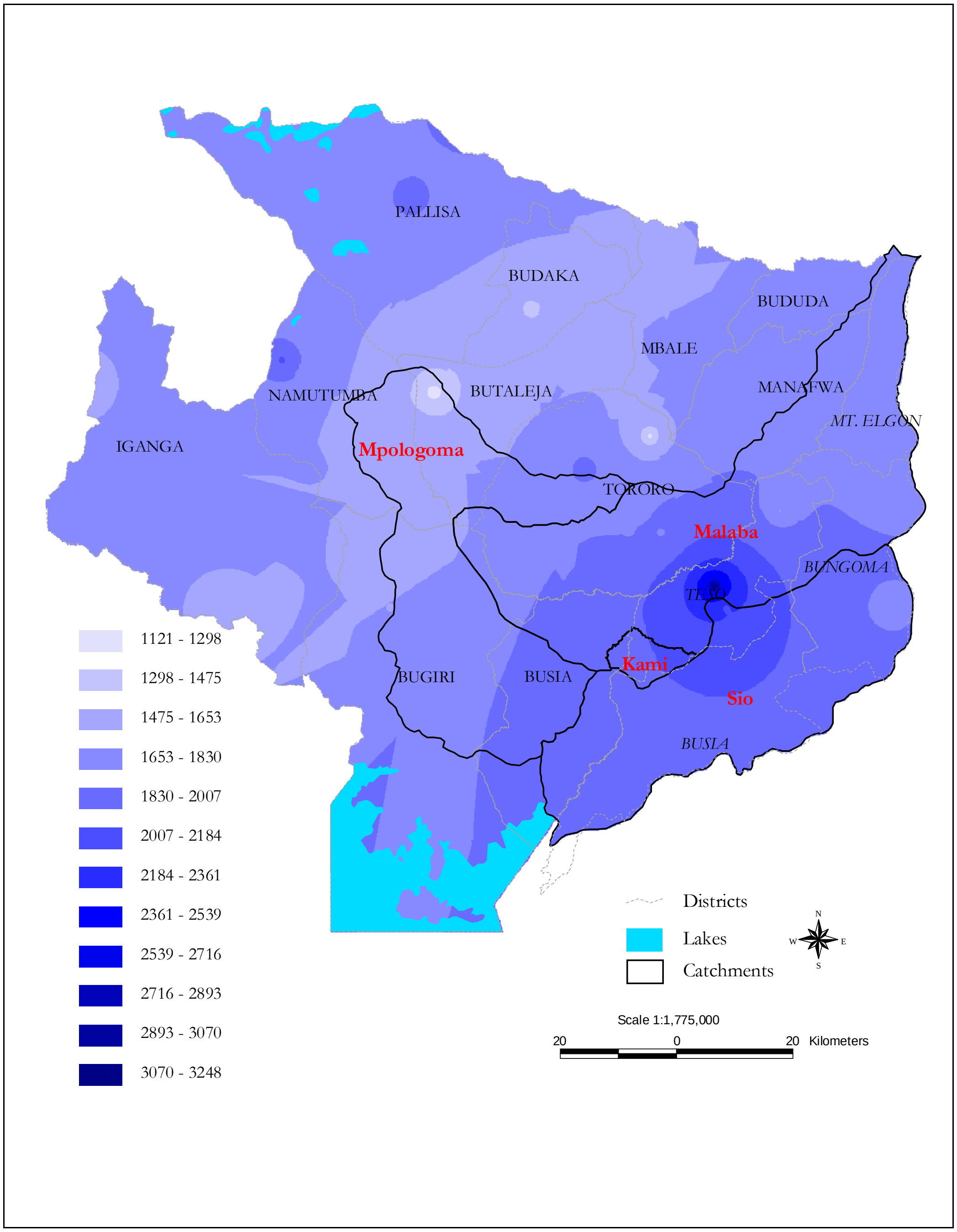
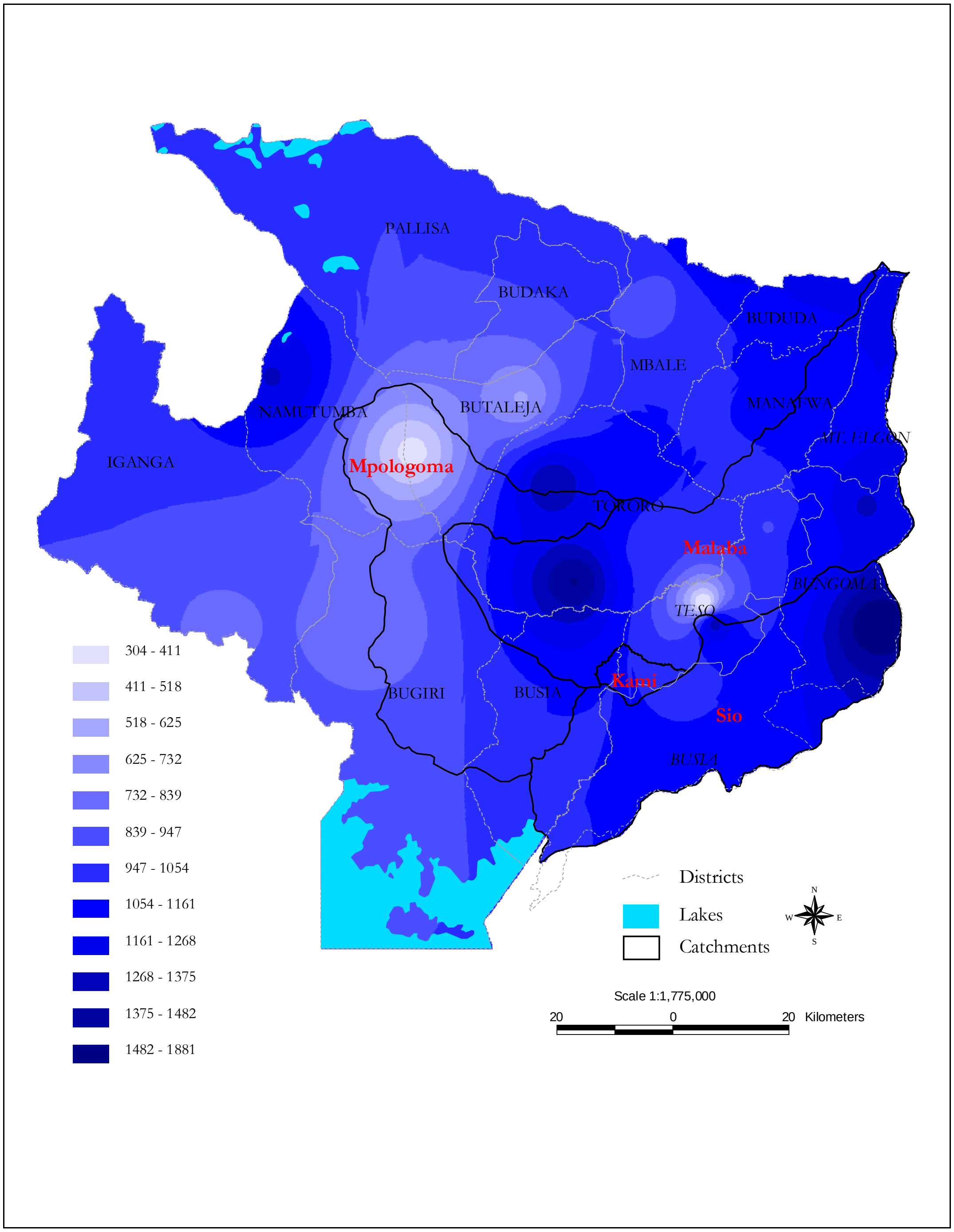
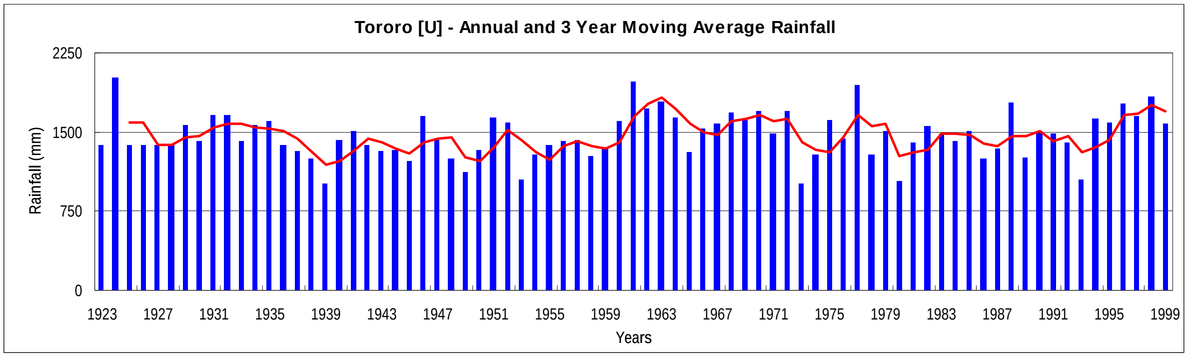


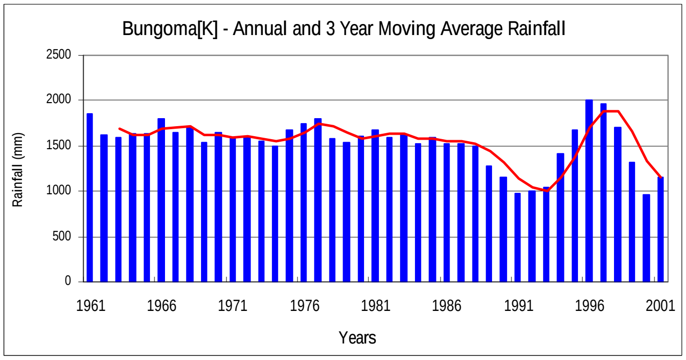
**Figure 2.8: Average spatial distribution of rainfall in a wet year (1963)**

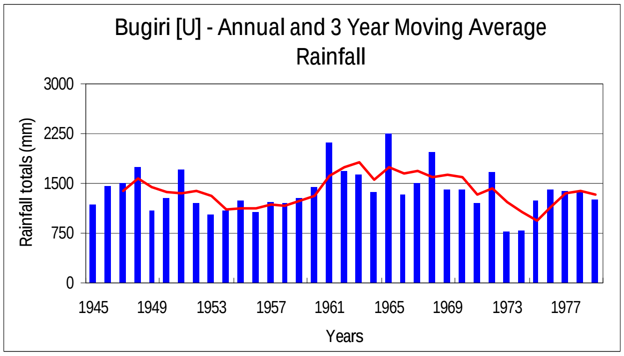


To study the SMM catchment vulnerability during wet and dry periods further, Figure 2.9 presents annual and 3-year moving average SMM rainfall series. The 3-year moving average series is indicative of the long-term rainfall trends and persistence.

**Figure 2.9: Plots of annual and three-year moving average rainfall**



These graphs indicate that for periods as long as three years or more, rainfall can be 25% to 30% higher or lower than the long term mean, with the deficit or excess potentially reaching 50% on an annual basis. Thus, the SMM catchment is prone to floods and droughts.

### 2.3.4 Evaporation

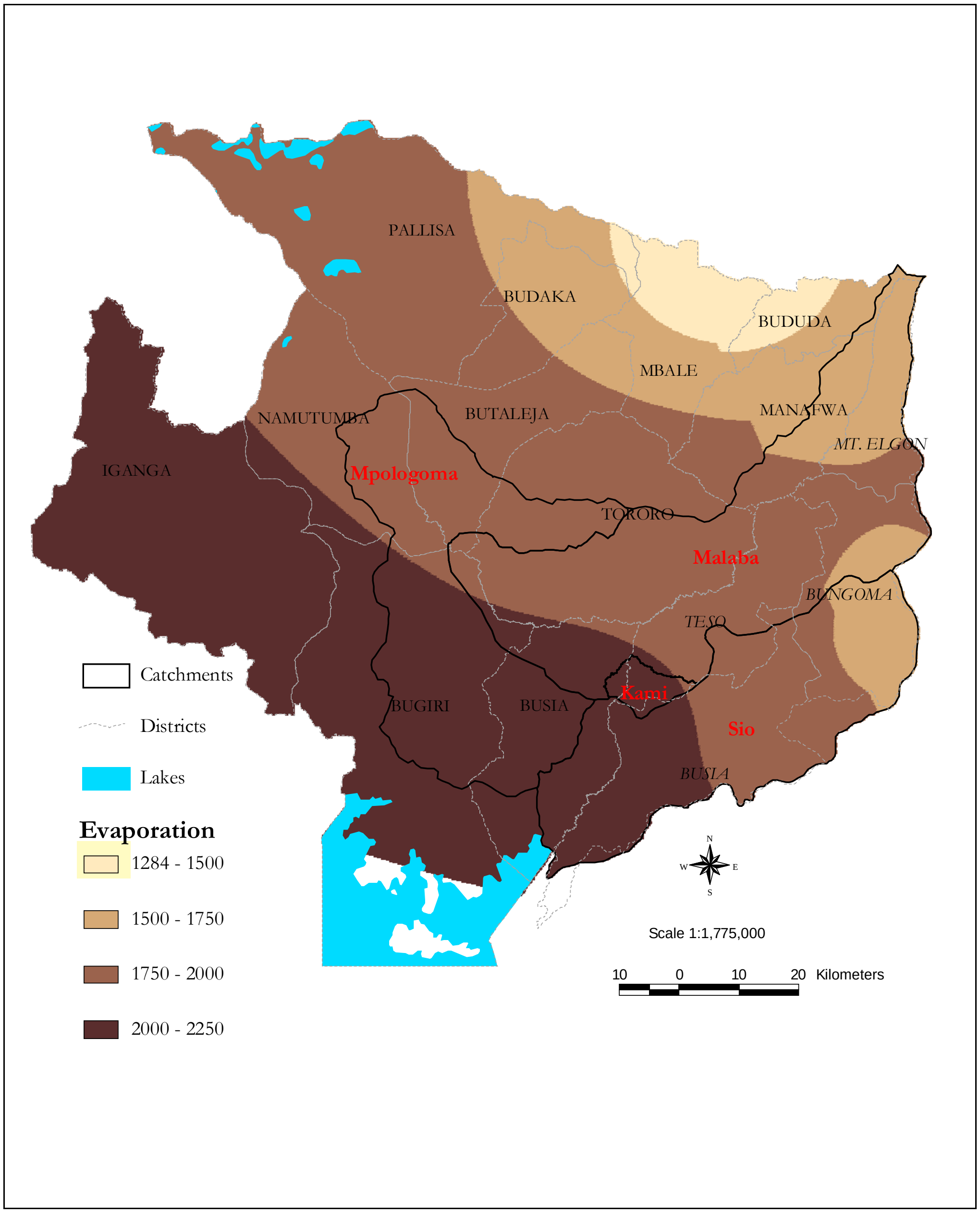
The mean monthly evaporation based on data up to 1990 in Kenya and 1968 in Uganda is shown in Table 2.1. The trends inherent in the spatial distribution of evaporation are similar to those observed for air temperatures. Maximum evaporation occurs in the dry months of January and December with limited variation within the year.

The variation of mean annual evaporation from open water over the Sio-Malaba-Malakisi catchment is illustrated in Figure 2.10. The data used to produce this map is taken from Rijks, Owen & Hanna (1970) who published their estimates in mm/year from observations taken at Tororo (1966-1968) and Busia (1968 only). Supplementary data was also collected from WMO (1974). The WMO data is comprised of observations over the project area in Uganda and Kenya for the period 1969- 1983.

**Table 2.1: Mean monthly evaporation over selected towns in the SMM**

| Location | Mean Monthly Evaporation ($E_o$ in mm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
| Tororo | 220 | 194 | 204 | 160 | 157 | 148 | 147 | 148 | 170 | 164 | 142 | 186 |
| Busia – Uganda | 224 | 177 | 190 | 179 | 191 | 182 | 169 | 185 | 199 | 209 | 189 | 192 |
| Busia – Kenya | 180 | 183 | 223 | 183 | 161 | 144 | 137 | 162 | 167 | 184 | 175 | 172 |
| Alupe | 166 | 158 | 212 | 163 | 143 | 132 | 131 | 147 | 156 | 147 | 151 | 167 |
| Bungoma | 164 | 158 | 174 | 126 | 120 | 108 | 118 | 115 | 124 | 141 | 133 | 151 |

**Figure 2.10: Annual variation of evaporation from open water ($E_o$ in mm)**




As the above figure shows, evaporation increases from north to south. Furthermore, a comparison of Figures 2.7 and 2.9 indicates that although there is a balance between rainfall and evaporation over the catchment, the spatial distributions of the two processes are dissimilar creating net rainfall excess over the eastern SMM region and net rainfall deficits over the central and southern portions.

## 2.4 Climatological monitoring issues

The existing network of climatic monitoring stations does not cover the catchment adequately. In particular, the upper catchment area in Mt. Elgon is essentially ungaged, and there are very few stations near the shores of Lake Victoria in Kenya and the wetland areas near Mpologoma. Furthermore, the existing stations exhibit many data gaps. Out of the historical network of 54 stations in the project area only approximately 10% are actually operational and effective. Rainfall stations are impacted by lack of inspection visits from core staff of UMD and KMD and the provincial meteorologists due to inadequate budgets and unavailability of inspection vehicles. Recent data has either not been collected from many stations or data is not reflected in an up-to-date fashion within the central databases of the managing institutions.

Evaporation is the most poorly estimated parameter as there are currently only two stations capable of taking such measurements within the SMM project area. There is no functional synoptic station in the portion of the catchment area within Kenya. Even those that exist are often missing essential parts.

As such, the monitoring network provides only spotty information on climatic conditions and cannot support reliable rainfall-runoff modeling and assessment investigations. (Such investigations require continuous multi-year observational records.) Finally, there is no coordination and data exchange between the institutions collecting climatological data.

## 2.5 Hydrological monitoring practices and gauging networks

Until recently, the Ministry of Water and Irrigation in Kenya has been responsible for the operation of water resources monitoring networks in the country. However, under the reformed institutional set-up of the water sector, the Water Resources Management Authority (WRMA), with a regional office in Kakamega, is now responsible for water resources monitoring within the SMM in Kenya. In Uganda, collection and archiving of surface water runoff data is still a central function of the Directorate of Water Resources Management (DWRM) at Entebbe.

A limited network of river gauging stations has been established within the catchment area to monitor water levels and discharges of major rivers. Most of the stream gauging stations were established more than 30 years ago. These are commonly fitted with vertical staff gauges and in some cases automatic water level recorders. The stations are maintained and readings recorded twice daily on specially designed forms by locally hired observers who reside close to the stations. The observers are visited by staff of WRMA (Kenya) or DWRM (Uganda) either monthly or quarterly for oversight and compensation purposes. Figure 2.11 shows the distribution of the gauging network within the catchment while Table 2.2 summarizes the details and status of these gauging stations.

**Figure 2.11: River gauging network in the SMM catchment**

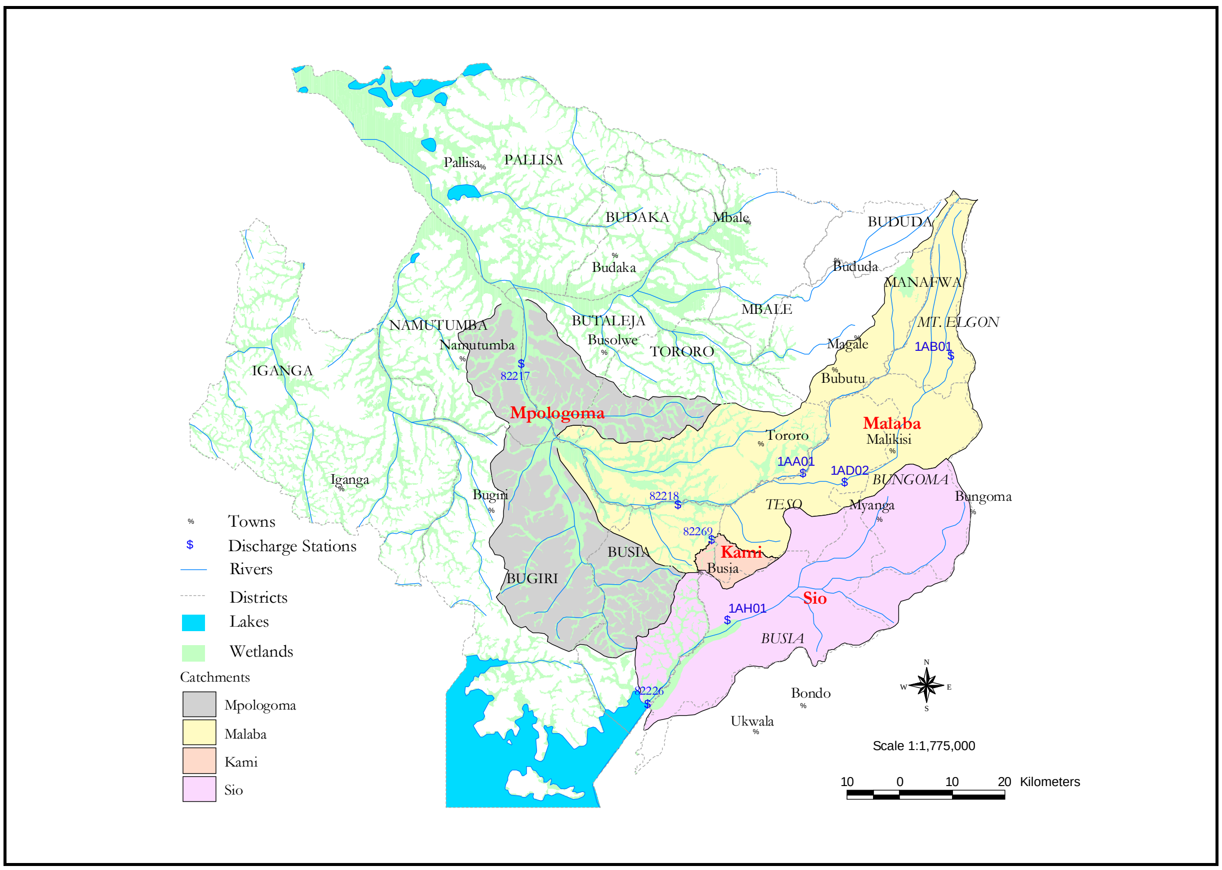


**Table 2.2: River gauging stations in the SMM**

| Name of River/Stream | Station code | Period of Record |
|---|---|---|
| Malaba | 1AA01 | 28/7/1963 – To date |
| Malakisi | 1AB01 | 10/2/1978 – To date |
| Toloso | 1AC01 | 12/3/2002 – 31/1/2003 |
| Malakisi | 1AD01 | 28/7/1963 – 10/1/1969 |
| Malakisi | 1AD02 (replaced 1AD01) | 1/1/1969 – To date |
| Sio | 1AH01 | 7/10/1958 – To date |
| Walatsi | 1AF(NEW) | 2000 – To date (water level) |
| Mwitsula | 1AH02 | 2000 –To date (water level) |
| Wakhungu | 1AH(NEW) | 2003 – To date (water level) |
| Lelekwe | 1AH(NEW) | 2004 – To date (water level) |
| Sio at Lukali | 81269 | 1982 – 1987, 1998 – to-date |
| Kami at Tororo Busia Road | 82226 | 1957-1976 |
| Malaba at Jinja Tororo Rd. | 82218 | 1955 – 1980, 1992 – to-date |
| Mpologoma at Budumba | 82217 | 1949 – 1979, 1997 – to-date |

Station RGS 1AH01 on River Sio in Kenya is presently fitted with an automatic water level recorder. Further downstream in Uganda, the same river has also been equipped with an automatic water level recorder and a data logger that were provided by the ongoing FAO project “Nile Basin Water Resources.” For many of the tributary stations in Kenya, only water levels are available with few or no current meter readings taken altogether. The rest of the gauging stations have unfortunately been vandalized. Vandalism and lack of gauge readers have rendered stations non-operational for extended periods of time and many data gaps.

## 2.6 Rating curves and runoff data

Discharge-water level relationships have been developed for some of the river gauging stations. The recommended practice is to undertake current meter discharge measurements every time a station is visited. The discharge measurements are used for generating and updating rating curves that relate water levels to corresponding river discharges. Discharge measurements are carried out using conventional current meters (CM) or the acoustic doppler current profiler (ADCP).

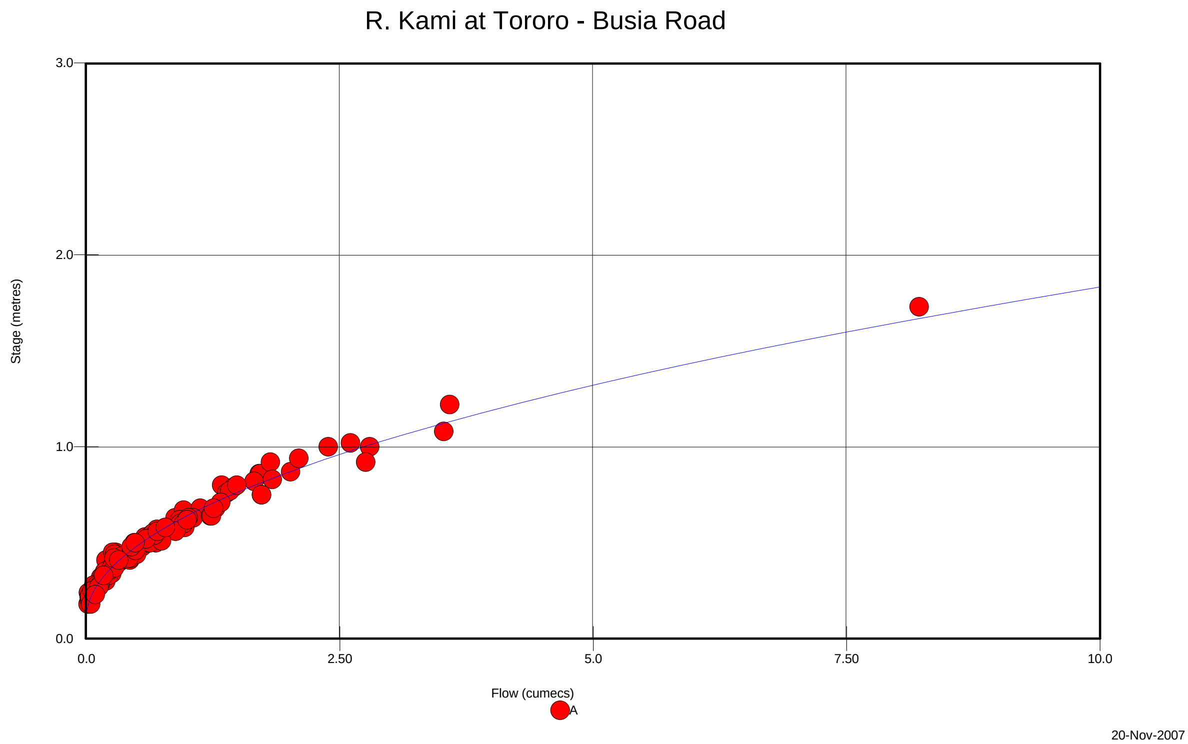
Figure 2.12 illustrate the quality of rating curves for station locations in the SMM. While the rating curves for Kami and Sio are stable, the rating curve for Malaba station in Uganda and Mpologoma have changed in the course of the monitoring period. The rating curve of Malaba in Kenya is satisfactory.

Figure 2.13 (a-d) shows the discharge plots for some of the stations in SMM. The hydrographs show that the discharge records for the rivers are fragmented, with large tracts of data in the seventies and early nineties completely missing. The station at Kami was discontinued after 1976 while observations at Sio in Uganda are only very recent, i.e., September 1998. The Malaba series of daily flow at the Jinja-Tororo road clearly shows that the flow statistics after the station have changed. This is attributed to a change of the rating curve after 1980. After the new station was rebuilt in the mid 90s, very few ratings have been collected to confirm accuracy of these observations. This is another emerging issue about the way the networks are operated within SMM. It shows that lack of sufficient gaugings has affected the reliability of the Malaba River observations in Uganda.

Measurement of low and high flows is particularly problematic for most of the stations. Toward the wetlands, discharges at very low levels are difficult to quantify due to extremely low velocities. Quite often, monitoring teams are not able to capture flood events as these pass long before the teams arrive due to difficulties in disbursing monitoring funds or lack of specialized monitoring equipment. Flow duration characteristics for some of these rivers are also shown in Table 2.3, illustrating the potential for high streamflow variability. This data are based on actual measurement, not naturalized flows.

The total annual contribution of the streams from the south western quadrant of Mt. Elgon (including the Malaba) is approximately 10% of the total surface runoff to Lake Kyoga while a recent water balance study for Lake Victoria (COWI, 2004) established that the long term average discharge from the Sio is 11.4 $m^3/s$, or 1.5% of the total inflow (tributary) contribution to Lake Victoria.

# Figure 2.12(a): Rating curves at selected Malaba River locations



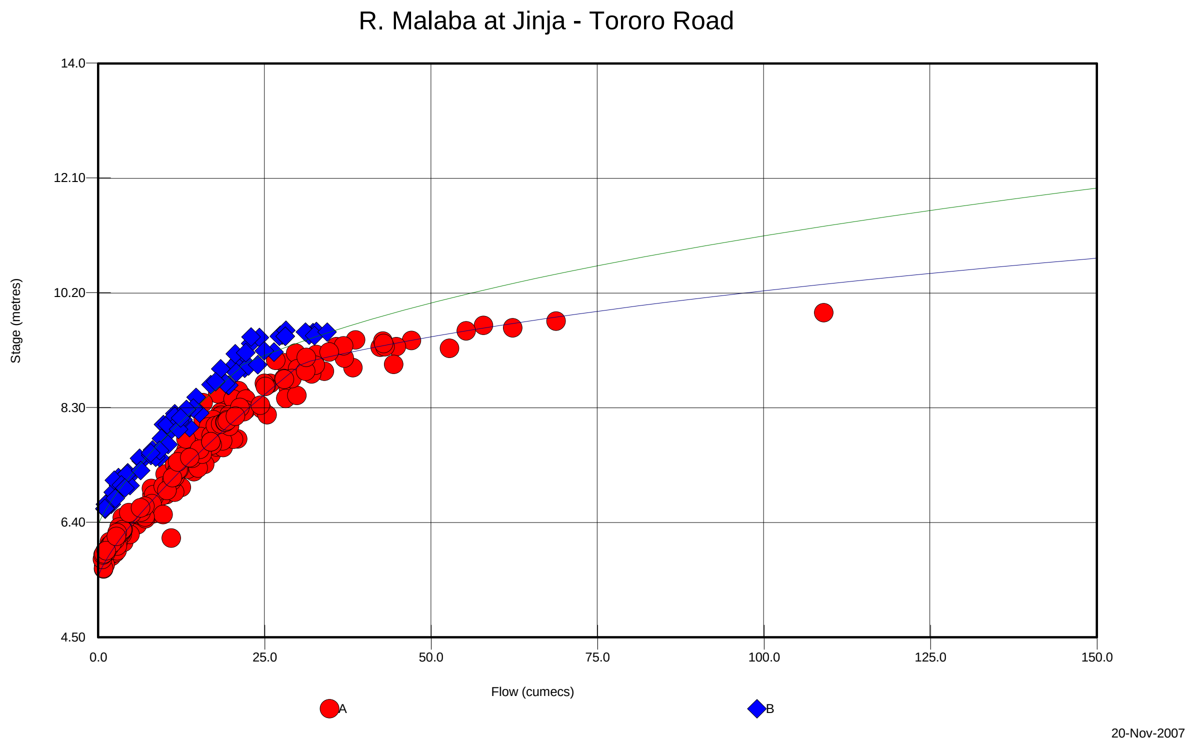
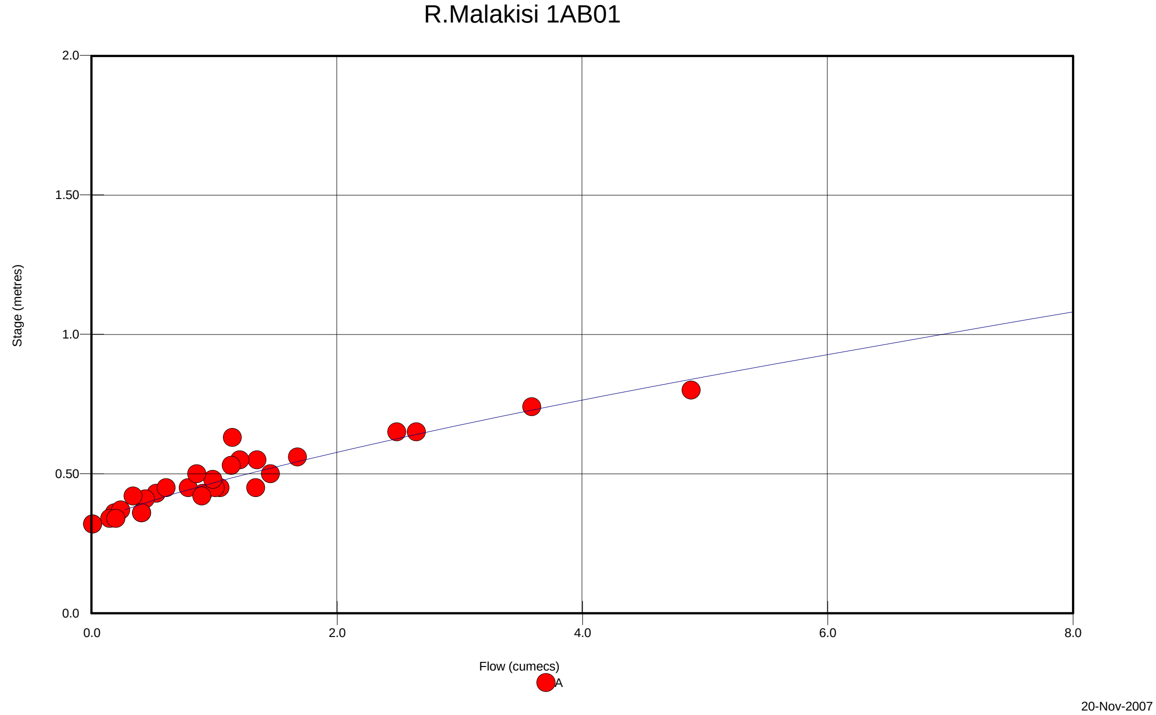



**Figure 2.12(b): Rating curves at Malakisi River locations**



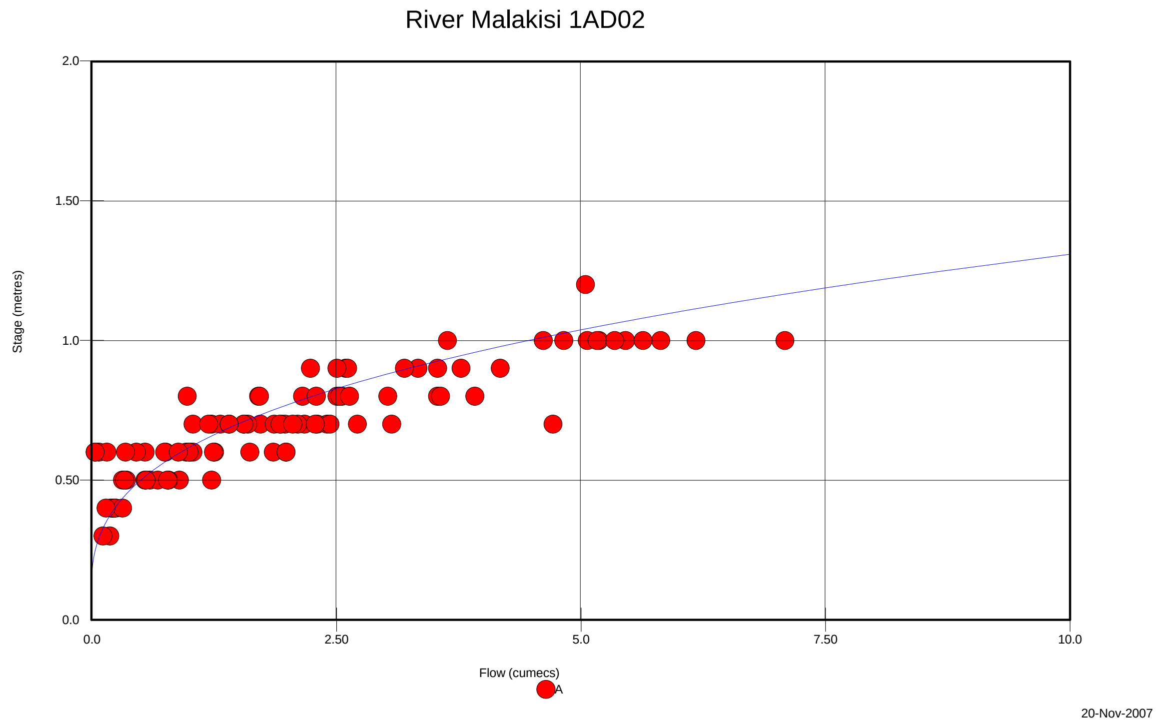
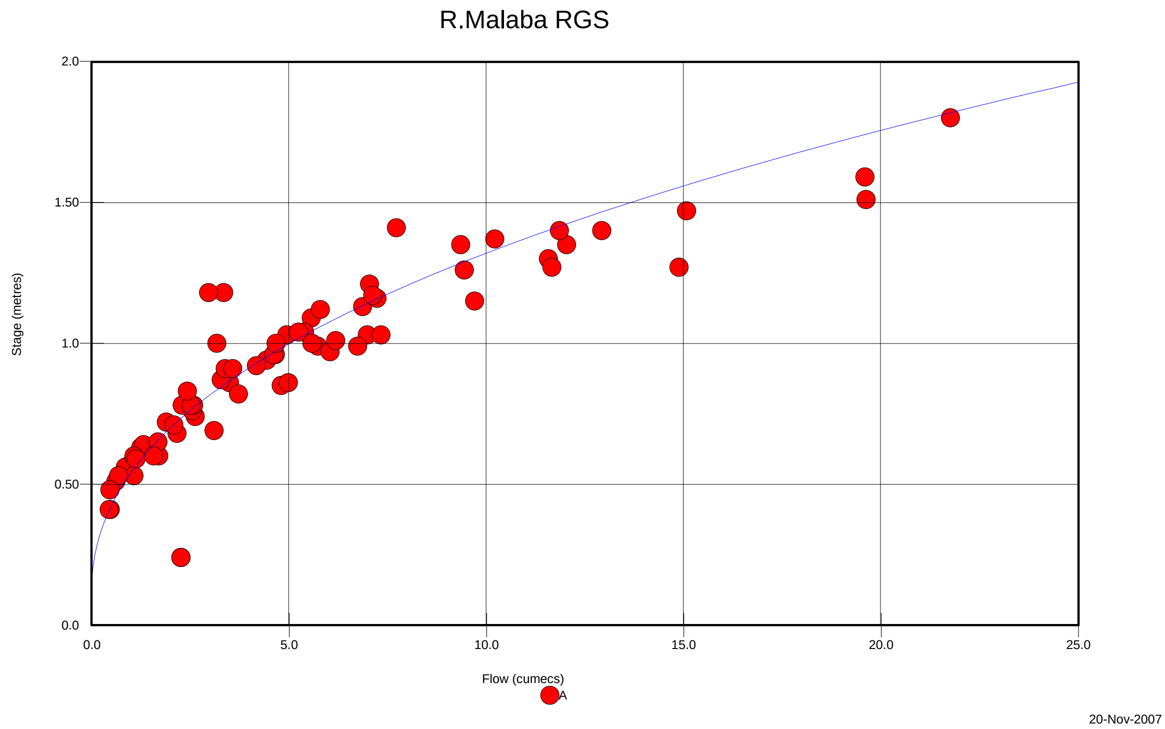
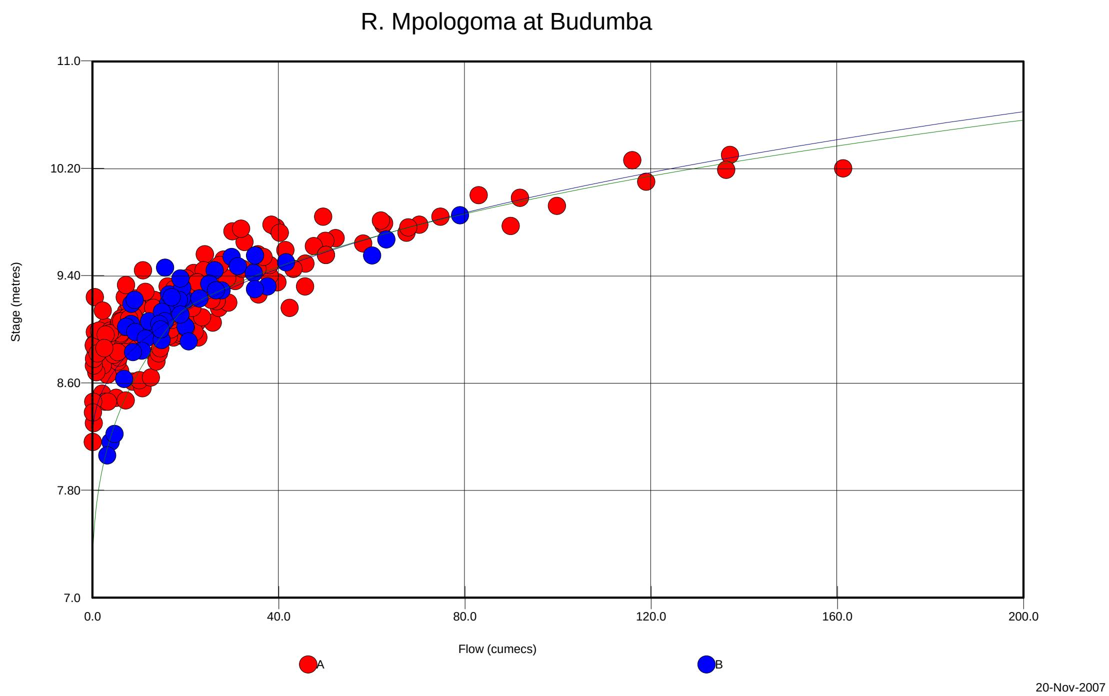
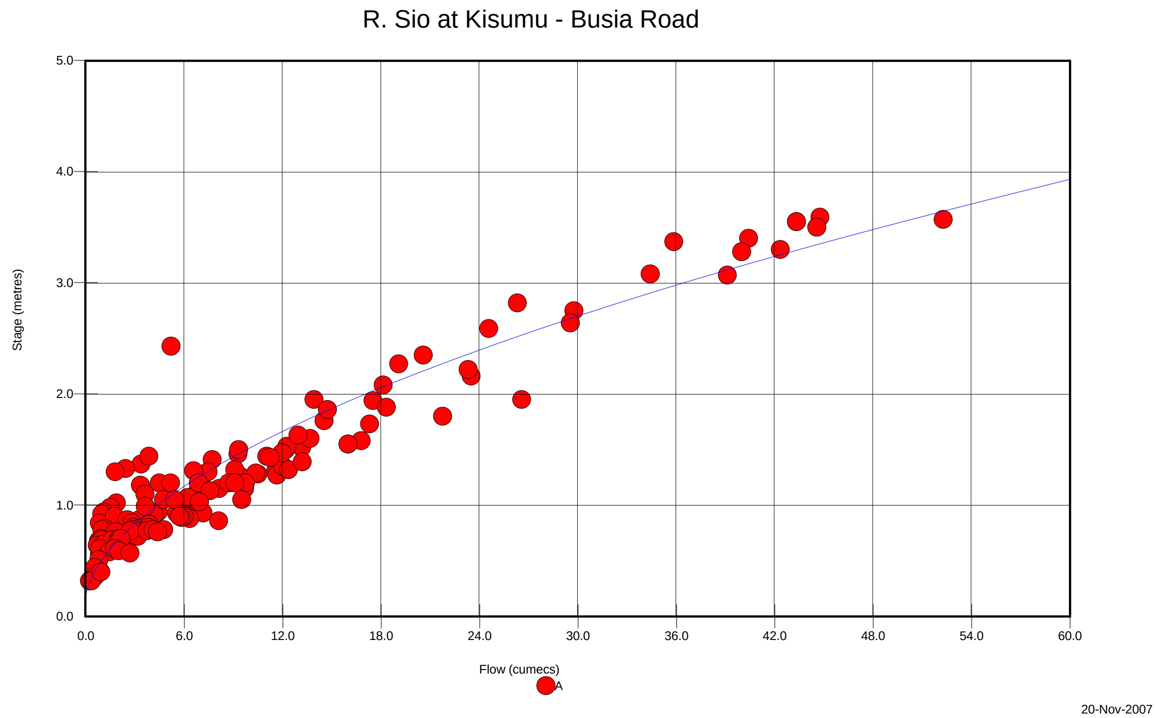



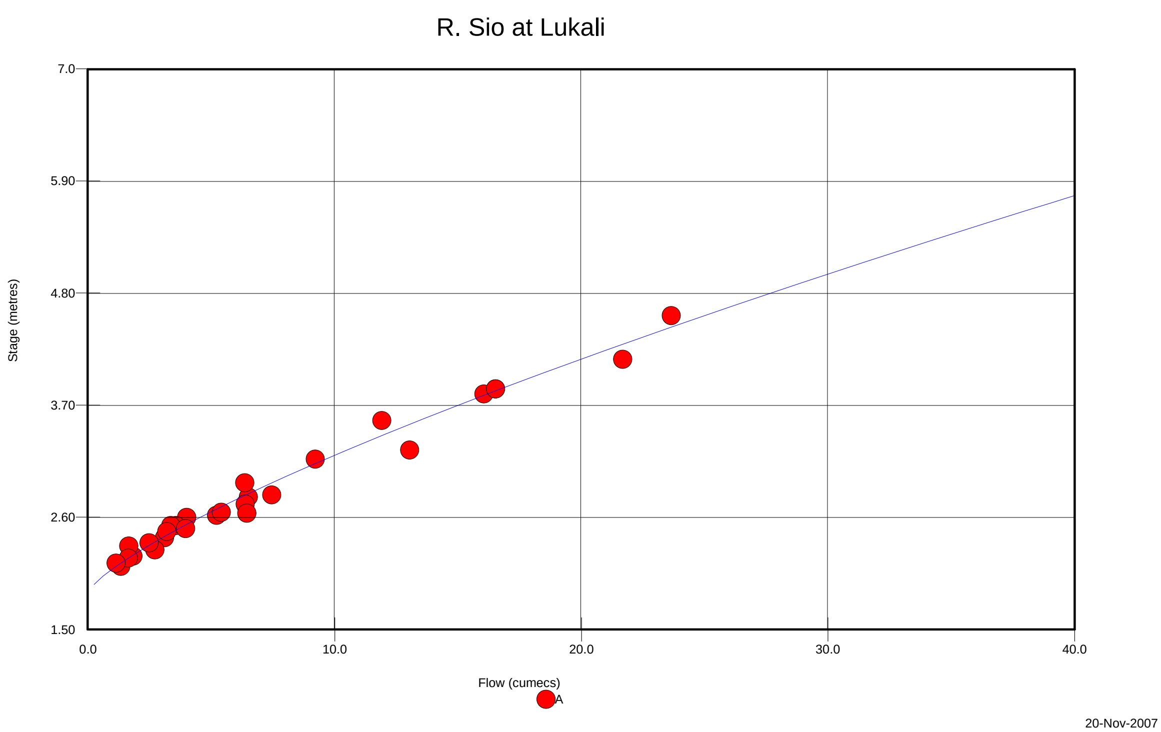
**Figure 2.12(c): Rating curves for Malaba and Mpologoma Rivers**



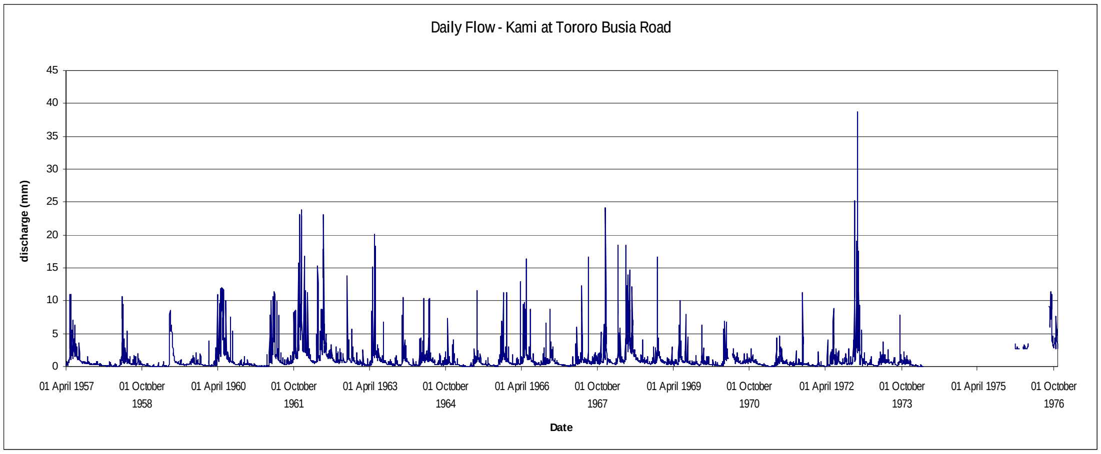



## Figure 2.12(d): Rating curves at Sio River locations

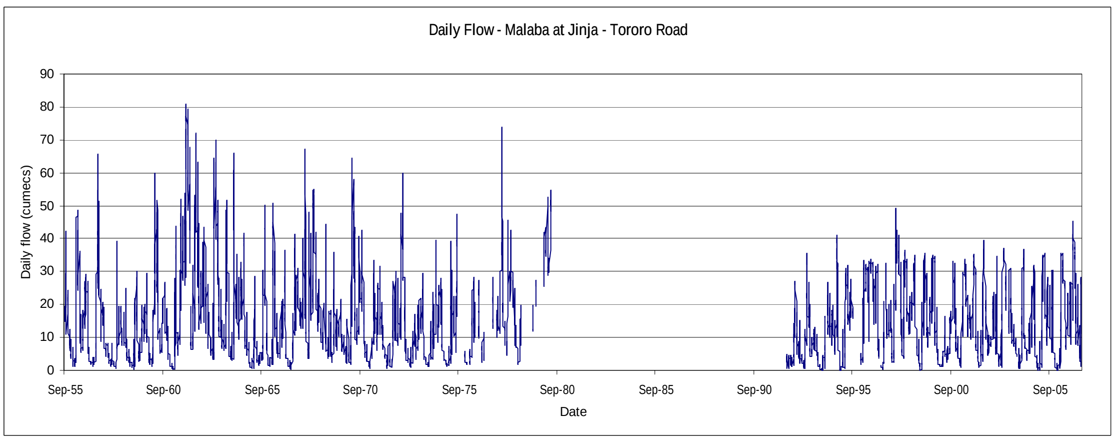


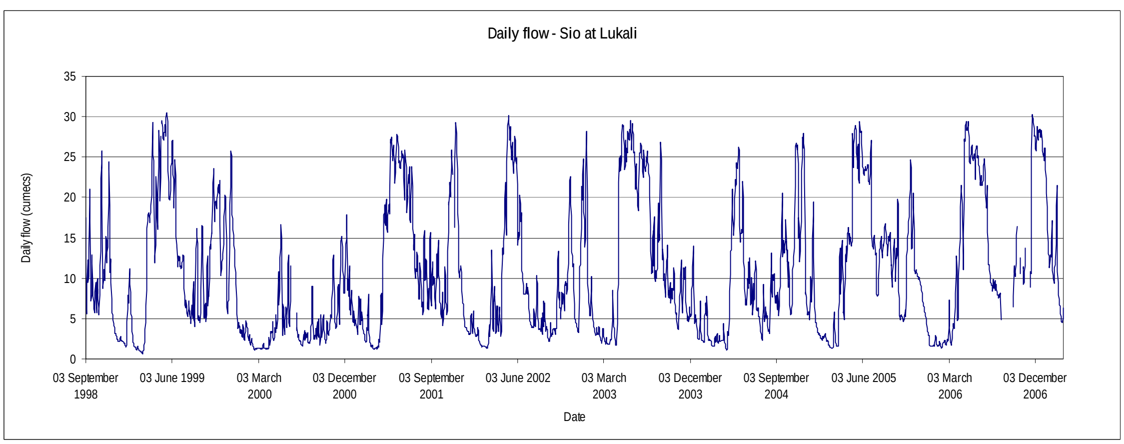
## Figure 2.13(a-d): Flow discharges for the SMM rivers



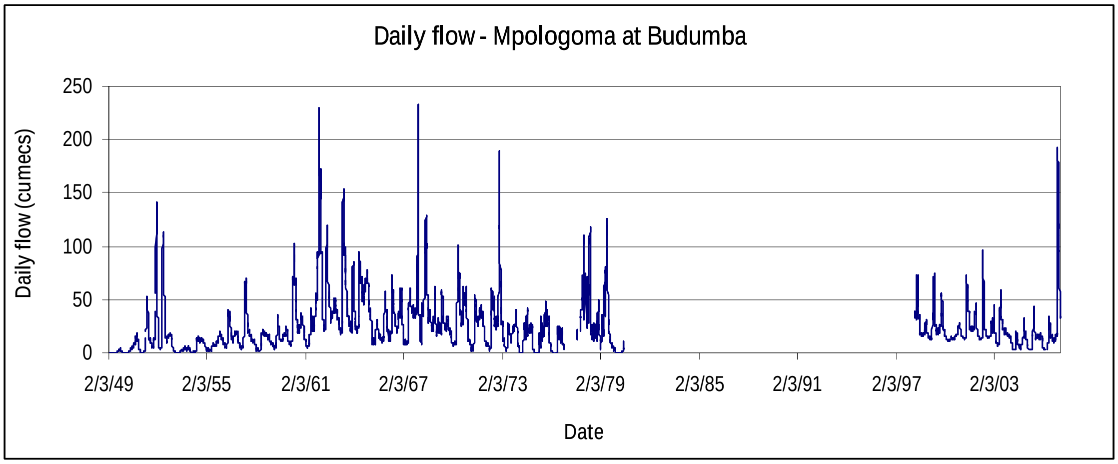

a)




b)




c)




d)

**Table 2.3: Flow duration parameters for SMM rivers**

| Parameter ($m^3/s$) | River<br>Kami | Malaba at Jinja Tororo Rd | Sio at Lukhale | Mpologoma at Budumba |
|---|---|---|---|---|
| 95 percentile ($Q_{95}$) | 0.06 | 1.46 | 1.53 | 0.12* |
| 90 percentile ($Q_{90}$) | 0.11 | 2.35 | 1.99 | 2.03* |
| 75 percentile ($Q_{75}$) | 0.28 | 5.63 | 3.68 | 8.42 |
| 50 percentile ($Q_{50}$) | 0.55 | 12.57 | 8.20 | 17.39 |
| 25 percentile ($Q_{25}$) | 1.13 | 23.32 | 16.25 | 31.38 |
| 10 percentile ($Q_{10}$) | 2.50 | 36.78 | 25.11 | 52.11 |
| 5 percentile ($Q_5$) | 4.39 | 45.81 | 27.83 | 70.07 |
| Mean daily flow | 1.18 | 16.29 | 10.70 | 23.91 |

* Poor estimation of low flows

## 2.7 Issues in water resources monitoring

Hydro-climatic monitoring in the SMM is inadequate. As a result, data and information regarding the state of the watershed is insufficient and unreliable. The following list indentifies the main deficiencies:

- Lack of harmonized monitoring procedures between Kenya and Uganda;
- Lack of data exchange between Kenya and Uganda;
- Lack of financial resources to establish and operate monitoring networks;
- Lack of instrumentation;
- Lack of human capacity to analyze hydro-meteorological data;
- Lack of comprehensive data bases and analysis tools.

The lack of data bases and analytical tools is being addressed by the development of the SMM DSS under the SMM transboundary integrated water resources management and development (TIWRMD) project. The SMM DSS is a personal computer based system that houses all previously discussed data, relational databases, a geographic information system, various data analysis tools, a river model, and user friendly graphical interfaces. The SMM DSS is described in a separate document.

## 2.8 Groundwater resources

### 2.8.1 Geology

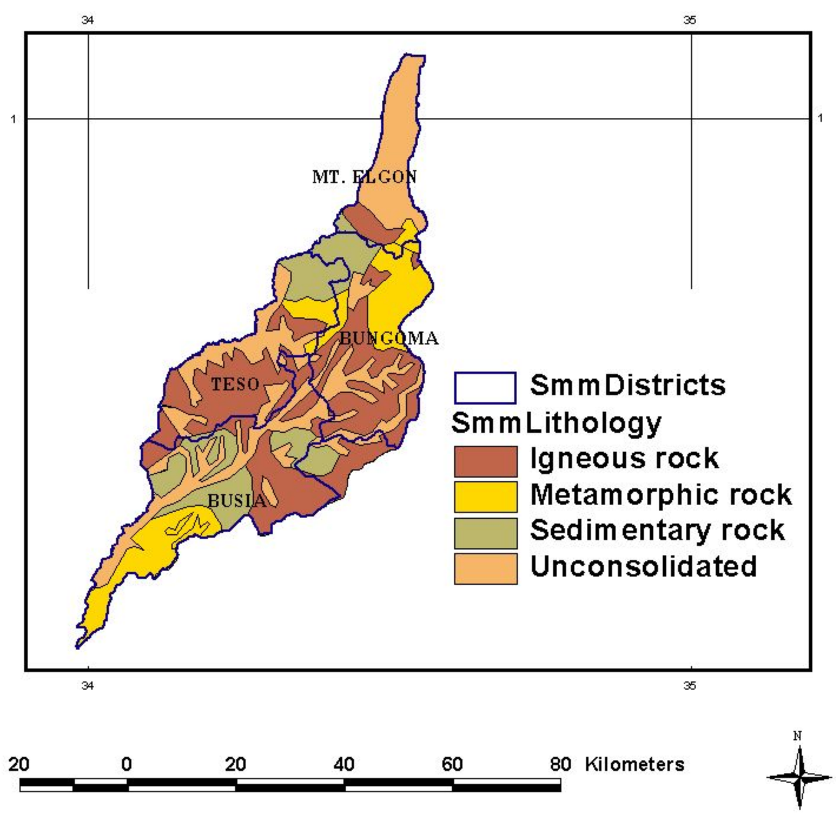
The geology of the SMM catchment can be classified in terms of its major formations as follows:

- Mt. Elgon and all lands above 2000 m consist of decomposed tertiary volcanics-phonolites and agglomerates tuffs.

- The middle zone includes Mumias granites consisting of weathered/ decomposed/fractured granite intrusions.
- The lower zone consists of Nyanzian volcanics (basalts, rhyolites, andesites, and rhyolitic tuffs over basement).
- The Nyanzian volcanics and the Mumias granites are separated by Kavirondian sediments consisting of grits and conglomerates.
- Along the Sio river mouth, the geology consists of Late Pleistocene and Holocene alluvial and swamp deposits (clays, silts, sands and gravels).

The general geological definition of the SMM catchment area in Kenya is depicted in Figure 2.14.

**Figure 2.14: Geology of the Sio-Malaba-Malakisi catchment (Kenya)**



Most of Eastern Uganda is underlain by rocks of the basement complex which include a variety of granites, migmatites, gneisses, schists and smaller areas of other kinds of strongly folded metamorphic rocks. The names of the soil units are usually those of the village or township near which the soils were first studied. Some of the more extensive units have been given a county or sub-district name. Three broad classifications of soils exist in the project area. These are:

- Soils derived from volcanic rocks;
- Soils derived from Volcanic & Precambrian rocks (rocks formed between 3000 and 6000 million years ago);
- Soils derived from the Buganda surface & its remnants.

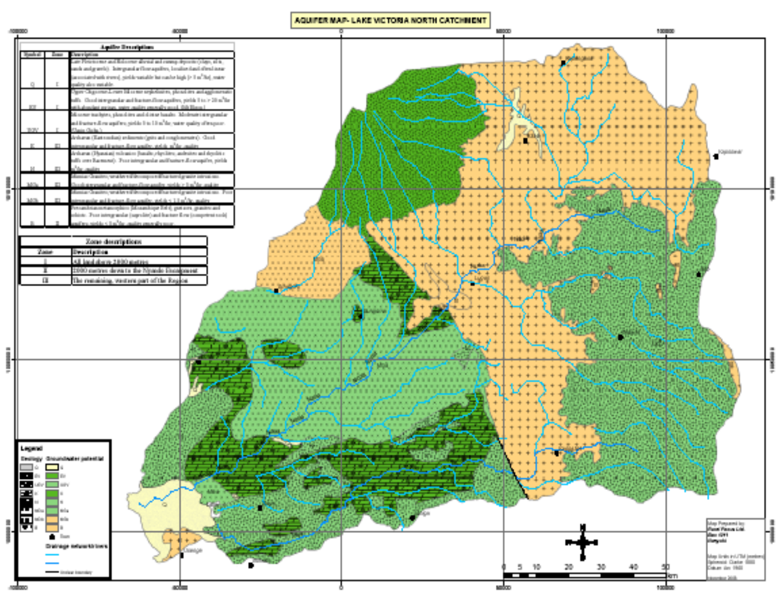
Rocks around Mt. Elgon are present as volcanic plugs, e.g., in Tororo which has been eroded into a single steep sided hill. These Carbonatite intrusions form many other prominent hills around Tororo town and Osukuru. Bedrock outcrops are also more common in elevated areas but tend to be more isolated. The rest of the surrounding area consists of a flat plain. The geology of Tororo district consists largely of undifferentiated Precambrian granitic and banded gneisses interspersed with high grade granulite and other metarmophic formations.

Most of Busia district in Uganda is underlain by two distinct geologies of mobilized and intrusive granites. Nyanzian System metavolcanics, banded ironstones, quartzites and greywackes underlie the remainder. The drainage is characterized by two primary dendritic systems, one along the Lake Kyoga and the other along Lake Victoria. Figure 1.3 depicts the geology and soils of the SMM catchment in Uganda.

### 2.8.2 Kenya

Groundwater resources in the upper SMM catchment constitute a safe domestic water supply source for rural communities, particularly when developed through shallow wells. However, the abundance of surface water resources and the expense involved in the development of groundwater wells has resulted in minimal groundwater utilization. The groundwater aquifer system in the upper catchment comprises of various geological formations. In the Mt. Elgon region, it includes decomposed tertiary volcanics-phonolites and agglomerate tuffs, supporting good inter-granular and fracture-flow aquifers with yields from 5 to over 20 $m^3$/hr. In the Mumias and Kavirondian granites, borehole yields vary from less than 1.5 $m^3$/hr to over 5 $m^3$/hr. Figure 2.15 shows the groundwater aquifer system for the Lake Victoria North Water Catchment Area which includes the Sio and the Malaba -Malakisi sub-catchments.

**Figure 2.15: Aquifer map for Lake Victoria north catchment in Kenya**




In Teso district, the northern side of Angurai Division has a low groundwater table where deep wells/ boreholes of between 60-150 m are recommended. The southern side has high water table, where shallow wells of about 20 m to 35 m depths are found. Shallow wells in Malaba Township are highly prone to contamination due to poor sanitation.

The Water Resources Management Authority (WRMA) has initiated a program to classify the groundwater resources in the country according to their perceived importance based on the following categories:

- Strategic aquifers: Aquifers used to supply significant amounts/proportions of water to an area where there are no alternatives, or where alternative developments would be too expensive;
- Major aquifers: High-yielding aquifers with good quality water;
- Minor aquifers: Moderately-yielding aquifers with variable water quality;
- Poor aquifers: Low-yielding aquifers with poor to reasonable quality water;
- Special aquifers: Aquifers or parts of aquifers designated as “special aquifers” by the Authority.

Based on the above classification, aquifers in the Mt. Elgon region are classified as major aquifers as they represent the recharge zones for the catchment. Other major aquifers are those used as water supply sources for urban centers. The major aquifers around urban centers are threatened by deteriorating water quality.

### 2.8.3 Groundwater monitoring

The Water Resources Management Authority regional office in Kakamega has initiated a program to establish a borehole monitoring network by identifying boreholes at various locations. The boreholes will be used to monitor groundwater changes in level and quality. The regional office has already identified one monitoring borehole in Busia Town and three boreholes in Bungoma Town. Additional boreholes are expected as the monitoring program evolves.

### 2.8.4 Groundwater resources in Uganda

#### *2.8.4.1 Water level variation*

Uganda’s groundwater monitoring network currently comprises of 15 monitoring stations. These are unevenly scattered throughout the country. Monitoring wells utilize existing boreholes rather than boreholes drilled for this purpose. Out of the 15 monitoring stations, only one is located within the SMM catchment, i.e., at Pallisa. It is considered to be an impact station, i.e., one that monitors changes of groundwater levels due to groundwater abstraction. Figure 2.16 illustrates the variation of groundwater levels at Pallisa from January 1998 to the end of March 2007.

**Figure 2.16: Variation of groundwater levels at Pallisa**

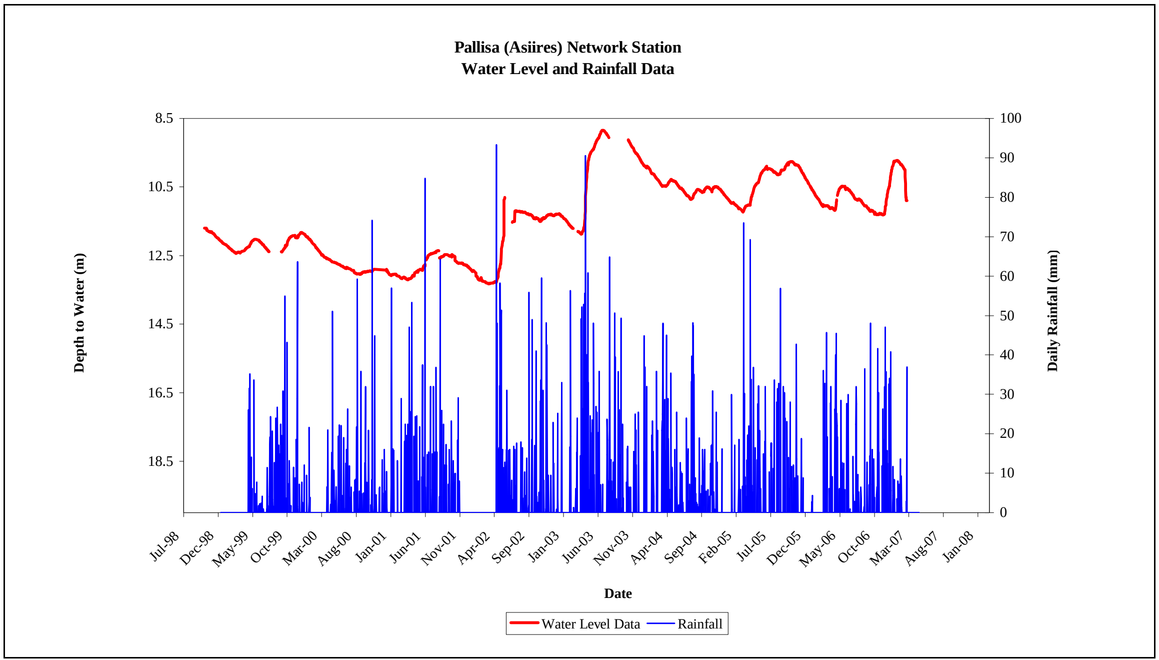



Figure 2.16 illustrates a clear influence of rainfall on groundwater levels. However, the impact of groundwater abstractions appears to be insignificant. The Uganda Directorate of Water Resources Management in Uganda has set up a National Groundwater Database (NGWDB) to store all the available groundwater data. The database currently stores close to 20,000 borehole records and data on a few hundred shallow wells.  The RUWASA (Rural Water Supply and Sanitation) Project contributed a considerable volume of groundwater resource data to the NGWDB as have a number of other organizations and drilling companies involved in groundwater development. Through this mechanism, all the collected groundwater data will find its way to the NGWDB. The districts maintain simpler databases and are supported by a Technical Support Unit to collect all data on water sources

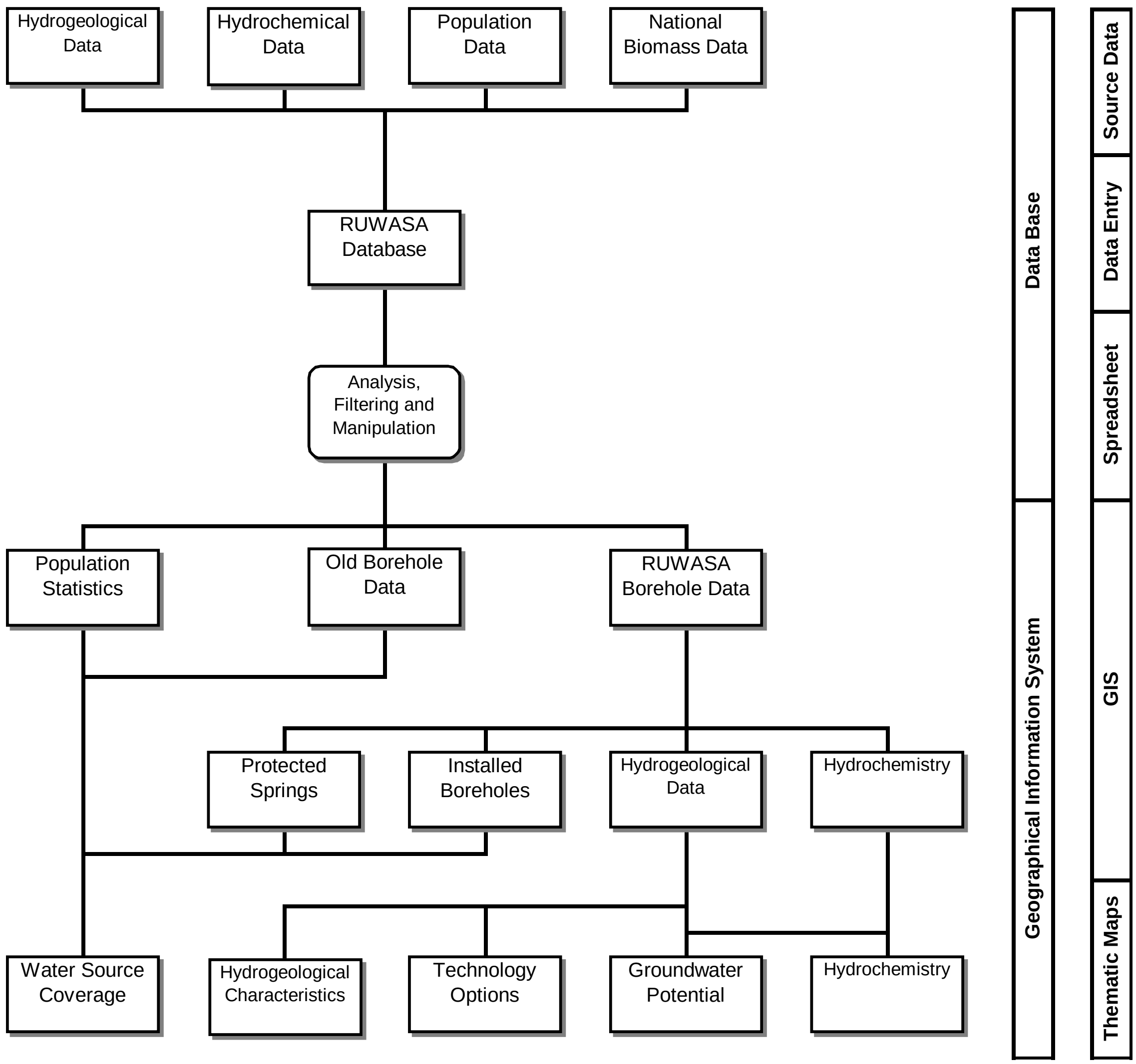
constructed in the Districts in the project area and for entering it into the District database. This data is also included in the SMM DSS developed by the SMM TIWRMD project.

#### *2.8.4.2 Groundwater mapping*

Groundwater reports are available for the Uganda districts of Mbale, Tororo, Busia, Bugiri, Iganga and Pallisa. The newly created districts of Namutumba, Bududa, and Manafwa were carved out of the old districts and are therefore also represented. The reports were prepared by RUWASA in collaboration with WRMD. They contain a synopsis of the groundwater regime and groundwater development in these Districts as of 2002 and are largely based on the information collected during the implementation of Phase II of the RUWASA Project. Data was compiled mostly from District Data Books including a comprehensive compilation of all borehole water source information such as general location, geophysical survey results, drilling and test pumping data, as well as water quality information. These District Data Books are arranged on a source-by-source basis and are intended as a physical archive for District records.

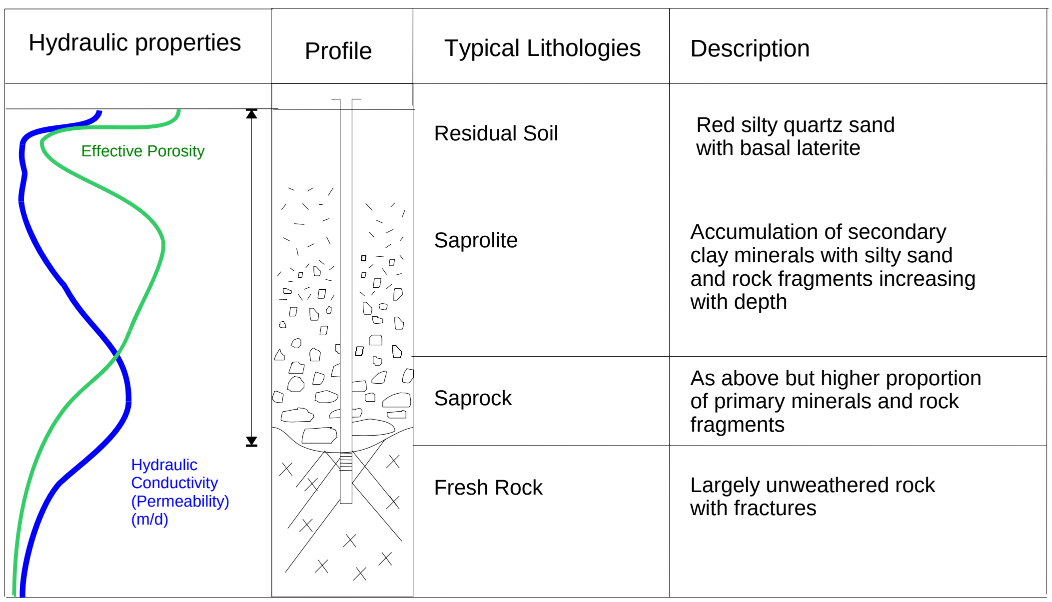
Other sources of data are the National Biomass Project and the Department of Statistics. Data provided by the National Biomass Project consist of topographic, land use, and vegetation information that is already in digital GIS form. This data was used to develop the base map on which the various thematic district maps are based. The Department of Statistics provided historic and current population data for each District. Samples of water taken during drilling from all productive boreholes as well as from all boreholes where a hand pump was installed were analyzed for purposes of defining groundwater quality. An assessment of the natural hydro-chemical parameters of these waters and their variance with accepted quality standards or guidelines was also made based on the National Guidelines for Water Quality. The use of these various data groups in developing Groundwater Maps by means of GIS software such as ILLWIS and ArcView is illustrated schematically in Figure 2.17

**Figure 2.17: Data sources and map production**




Hydrogeological conditions in the catchment are typical of Precambrian Basement terrain where aquifers occur in the weathered overburden (regolith) and in the fractured bedrock. In Tororo and Busia boreholes are typically drilled into fractured bedrock, which is required to provide sufficient transmissivity, but with the main storage still being provided by the overlying saturated regolith. Figure 2.18 illustrates a schematic profile of a typical basement regolith aquifer. Optimum sites for boreholes thus exist where the overburden is thickest (i.e., improved potential for greater storage in the regolith) and a significant fracture zone is present in the underlying bedrock (signifying increased potential for higher transmissivity). Since in-situ weathering is the primary process in overburden development, and weathering is usually most intense in fractured rocks, such criteria frequently co-exist. The analysis of existing borehole data within SMM indicates an average first water strike depth ranging from 25.4 to 26.9 m and a main water strike depth of about 43 m. Groundwater conditions are usually confined or semi-confined, and the piezometric surface generally mirrors the local topography, with groundwater flow trending in the same direction as the surface water flow.

**Figure 2.18: Schematic profile of a typical basement regolith aquifer**




The hydrogeological regime in the Basement rock terrain of Eastern Uganda is thus characterized by relatively low yielding boreholes that frequently tap aquifers both in the regolith and the underlying fractured bedrock. The upper regolith aquifer may itself possess sufficient transmissivity and storage to provide sustained hand pump yields from dug wells, auger wells, or shallow boreholes. The most transmissive zone is usually found in the basal regolith that is mechanically disaggregated and contains few or no secondary clay minerals. The main storage in a regolith aquifer is generally in the more porous, clayey saprolite, or the uppermost sandy collapsed zone (see Figure 2.18 above), and is recharged annually by rainfall. However, this makes the regolith aquifer susceptible to pollution, especially where soil horizons are thin and potential sources of pollution such as pit latrines extend substantially into the regolith.

A fractured bedrock aquifer frequently exhibits considerably better transmissive properties than a regolith aquifer, but groundwater storage in the fracture system may be limited where it is not enhanced by the presence of improved storage in the overlying weathered material. In the absence of this storage, the underlying fractures may be susceptible to the effects of overexploitation, although small groundwater withdrawals by means of a hand pump are unlikely to cause serious depletion. In fissured bedrock aquifers permeability is generally correlated to a large degree with the frequency of fracture occurrence and interconnectivity, and it can be assumed that the likelihood of open fractures generally decreases with depth.

According to the various District Groundwater Reports, decreasing permeability with depth in weathered bedrock is also known to occur, probably by the sealing of fissures by clay mineral formation. In general, groundwater from a Basement aquifer is most usually potable, although zones of increased salinity, elevated fluoride, increased hardness, and high iron content do occur. Aggregated thematic groundwater maps prepared for districts in the project area by the RUWASA Project in collaboration with WRMD are now described in terms of their content and presentation.  Groundwater aggregated maps for part of the catchment area are presented within the main body of this monograph.

#### *2.8.4.3 Groundwater quality map*

Groundwater Quality Maps depict zones of parameters such as Chloride, Total Dissolved Solids (TDS), Nitrate and hardness that either exceed guideline values (GV) or exceed maximum acceptable values (MAV). These water quality maps illustrate the spatial distribution of particular groundwater quality problems in each District. In Uganda, national guidelines developed by DWD for portability of groundwater are based on the concentration of individual natural chemical constituents and their influence on health, taste, color, and general acceptability (Table 2.4). In addition, the guidelines also include important recommendations on the permissible bacteriological content of groundwater (usually introduced by pollution) as this may have very significant health implications.

**Table 2.4: National guidelines for groundwater quality**

| Parameter | WHO Guideline Value (mg/l) | Uganda National Guidelines (mg/l) | | Possible Impact |
|---|---|---|---|---|
| | | Guideline Value (GV) | Maximum Acceptable Value (MAV) | |
| Total Hardness as $CaCO_3$ | 500 | 600 | 800 | Scale and scum |
| Total Iron | 0.3 | 1 | 2 | Taste, colour, staining |
| Manganese | 0.1 | 1 | 2 | Taste, colour, staining |
| Chloride | 250 | 250 | 500 | Taste |
| Fluoride | 1.5 | 2 | 4 | Dental/skeletal fluorosis |
| Sulphate | 250 | 250 | 500 | Taste, gastrointestinal irritation |
| Nitrate as $NO_3$ | 50 | 20 | 50 | Blue baby syndrome |
| Nitrite as $NO_2$ | 3 | 0 | 3 | |
| TDS | 1500 | 1000 | 1500 | Taste, corrosion/encrustation |
| Turbidity (NTU) | 5 | 10 | 30 | Appearance |
| PH | - | 5.5-8.5 | 5.0-9.5 | High: Taste<br>Low: Corrosion |
| E. Coli (no/100ml) | 0 | 0 | 50 | Gastrointestinal diseases |

There are three distinct quality categories. These are potable water, water of acceptable quality but above Guideline Value (GV), and water above the Maximum Acceptable Value (MAV). These categories are tabulated in Table 2.5 below.

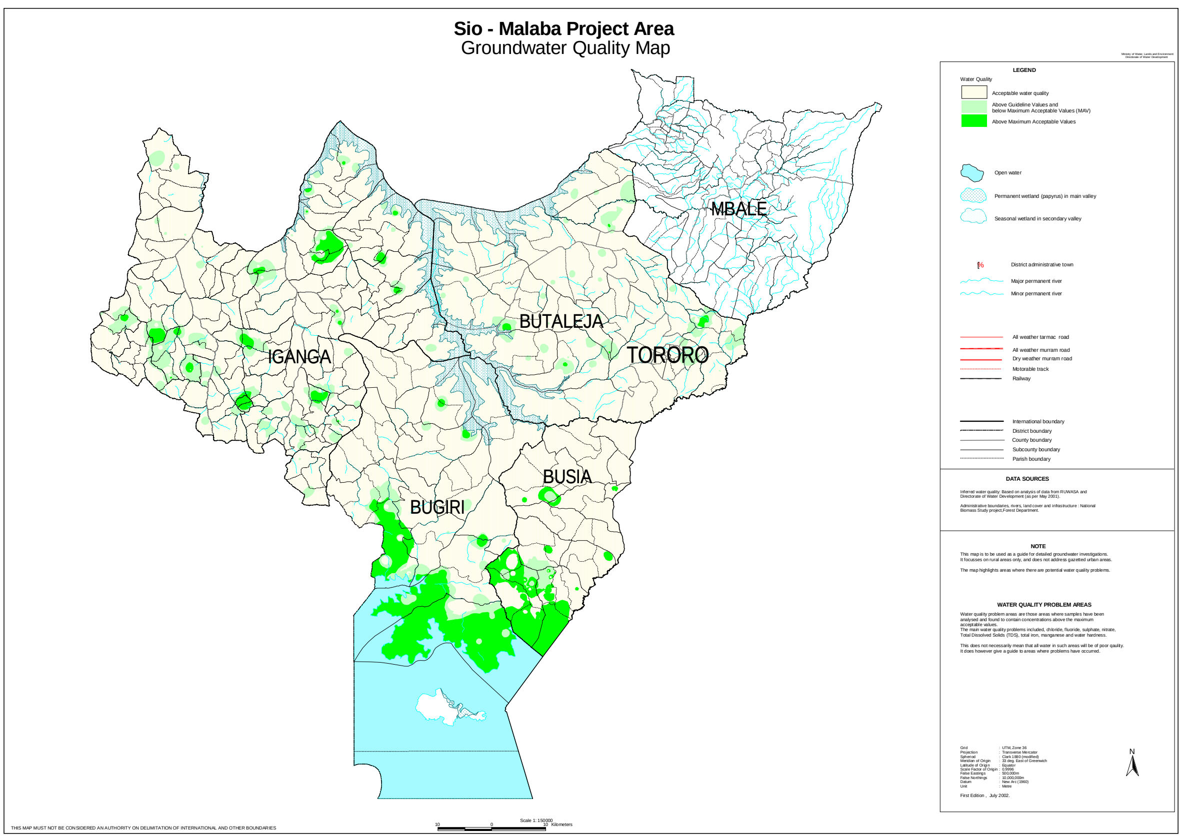
**Table 2.5: Groundwater quality categories**

| Quality Category | Comments |
|---|---|
| All parameter values below Guideline Value (GV). | Water is of potable quality in all respects |
| Some parameter values above Guideline Value and below Maximum Acceptable Value. | Water is generally of acceptable quality but some parameters may be above the Guideline Value, and adverse taste or usage problems may arise. |
| Some parameter values above Maximum Acceptable Value (MAV). | Water is not acceptable for human consumption due to high levels of adverse chemical or bacteriological constituents. |

The distribution of groundwater quality in relation to the Guideline Value or the Maximum Acceptable Value is depicted on the map by colour coding the zones that exceed these values.

The general groundwater quality map for the catchment area in Uganda (Figure 2.19) indicates that over most parts of Tororo groundwater is of acceptable quality. Only in isolated areas in Masimasa, Kachonga, Mulanda, and Budumba is groundwater quality above GV. Poorer groundwater quality around Kwapa and Osukuru appears to be influenced by mineralization related to the presence of significant carbonatite intrusions that form the hills.

**Figure 2.19: Groundwater quality map**




Similarly in Busia, much of the groundwater is of acceptable quality. Only in the southwest portion of the district, particularly bordering Lake Victoria and Bugiri District in Lunyo and part of Lumino sub-counties, is groundwater quality above GV or even above MAV in some locations. Groundwater is of acceptable quality over most parts of Bugiri. However, there are isolated occurrences of poor quality groundwater in Nabukalu, Kapyanga, and Buswale sub-counties, and large areas of Banda, Buyinja, and Nankoma sub-counties where groundwater quality is a serious problem with a number of water quality parameters above MAV. Groundwater Quality is also of acceptable quality in Manafwa and Bududa.

The spatial distribution of various specific hydrochemical parameters that have influence on the potability of groundwater is important in understanding the non-acceptability of water sources, or the occurrence of water-related health phenomena. According to the District Groundwater Reports, flouride and total iron content are elevated in Kwapa, Kisoko, Butaleja, and Mazimasa. Total iron content is high in Kwapa, Paya, Nabuyonga, and Mazimasa. Elevated sulphate levels have also been noted in Mazimasa. Elevated Nitrate values occur in Budumba, Mulanda, and Kirewa in Tororo, and appear to be confined to the margins of the main swamp systems and the more extensive seasonal wetlands, probably as a result of organic matter in the groundwater. Higher Nitrate values are also apparent around Tororo town. Nitrate in high quantities can become a health hazard and may also be indicative of organic anthropogenic bacterial pollution.

In Busia, chloride and hardness, as well as total dissolved solids, are elevated in the south-western portion of the district, and above GV in parts of Lunyo and Lumino sub-counties bordering Lake Victoria. Elevated nitrate values also occur in the southwest portion of Busia, with values greater than MAV in Malaba, Jinja, and Nalwire.  These elevated levels are likely related to the margins of the main swamp systems and the extensive seasonal wetlands in this area. In Manafwa and Bududa, elevated total iron values occur over much of the more mountainous areas of Bushika, Bulucheke, Bukigai, Buwagogo, and Buwabwala. This is probably due to the volcanic nature of the aquifers. In Bugiri, chloride, sulphate, hardness, as well as total dissolved solids are elevated in the southern and south-western portions of the District and are above GV over most of Banda and Buyinja sub-counties and parts of southern Nankoma sub-county. Elevated fluoride values also occur in the western part of Buyinja where values are above GV but below MAV. Elevated total iron is present in Banda, Buyinja, Nankoma, and in isolated localities in Bulesa, Nabukalu, Kapyanga, and Buluguyi sub-counties. Fluoride and hardness are slightly elevated in Namutumba, and above GV on the fringes of the Mpologoma River system.

#### *2.8.4.4 Groundwater potential map*

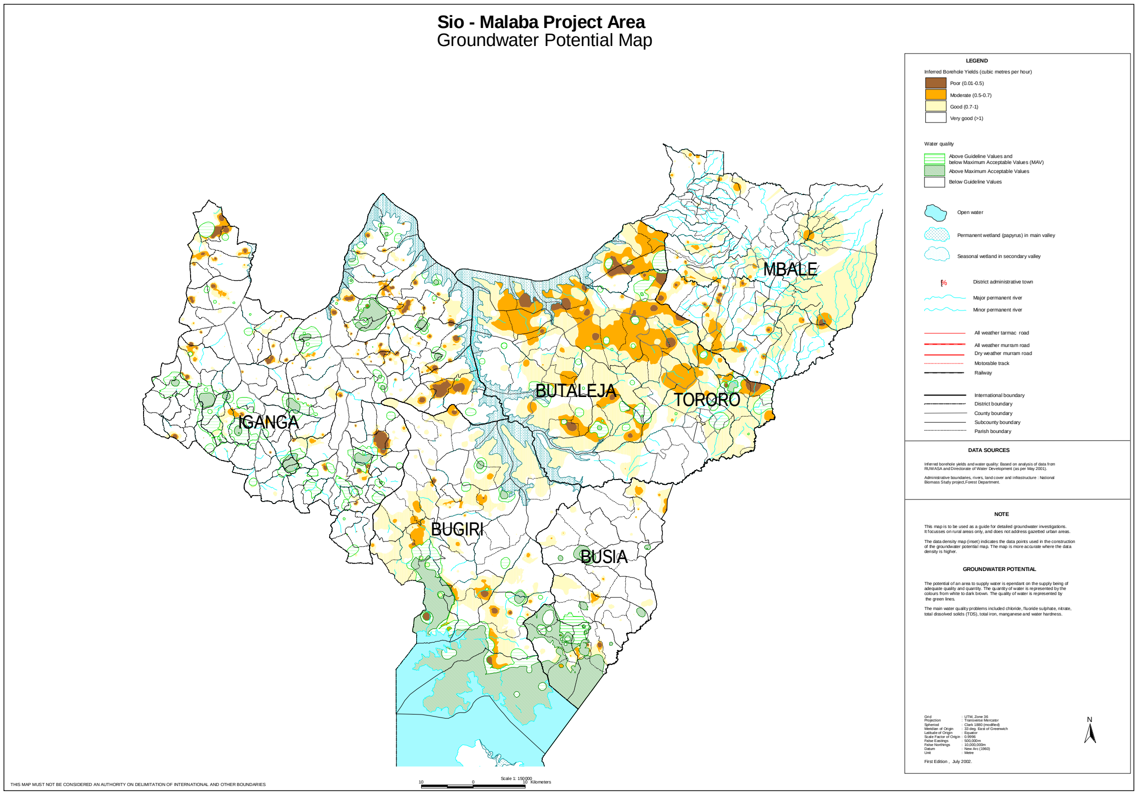
Groundwater potential is a very broad term and may be influenced by many factors. The definition of groundwater potential used in the development of this map is: *"The ability of a particular area to supply an adequate quantity of groundwater of potable quality to satisfy the demand of that area."* In order to categorize 'groundwater potential' it is thus necessary to categorize the principal factors that influence it, i.e., yield and water quality. According to the District Groundwater reports, borehole yield was classified into four categories with respect to the ability of the source to satisfy the minimum yield requirements for a rural water supply, while the water quality parameters are based upon the hydrochemical characteristics of groundwater. This categorization of 'groundwater potential' which combines both the yield and the water quality factors is illustrated in Table 2.6.

**Table 2.6: Groundwater potential categorization**

| Groundwater Potential | Yield Characteristic | Water Quality Characteristic |
|---|---|---|
| Poor | Yield < 0.5 m3/hr | Hydrochemical values above MAV |
| Moderate | Yield 0.5 – 0.7 m3/hr | Hydrochemical values above GV |
| Good | Yield 0.7 – 1 m3/hr | Hydrochemical values below GV |
| Very Good | Yield > 1 m3/hr | Hydrochemical values below GV |

Groundwater potential is depicted on Figure 2.20 by a color designation of a range of yields, overlain by hatched areas relating to the water quality characteristics. It is thus very possible to have a particular area that has 'good potential' with respect to yield but 'poor potential' with respect to water quality. In such cases, the overall groundwater potential would be designated as 'poor' because of the water quality characteristics.

**Figure 2.20: Groundwater potential map**




Much of the northern half of Tororo District has poor to moderate groundwater potential. Potential appears to improve from moderate over the central areas to good in the South. Busia District has good to very good potential with respect to both groundwater quantity and quality. However, there are some zones in Lunyo and Lumino sub-counties where potential is poor with respect to borehole yield as well as water quality, and zones in Buteba where it is poor with respect to borehole yield. There are also isolated occurrences of poor quality groundwater in Buwenge Parish in Buhehe sub-county, Butangasi Parish in Masaba Sub County and Busia and Buwembe Parishes in Bulumbi sub-county.

Groundwater potential in Bugiri District is good to very good with respect to groundwater quantity over much of the district, although potential with respect to quality is variable and generally poor in the south and southwest. There are zones in Buyinja, Muterere, Buwunga, and Kapyanga sub-counties where potential is poor with respect to borehole yield, and most of Banda, the western part of Buyinda, and the southern part of Nankoma sub-counties where the potential is poor with respect to groundwater quality. The potential in Manafwa and Bududa can be categorized as good to very good with respect to both groundwater quantity and quality. However, there are limited zones in Bumbo, Butiro, Bugobero, and Busiu sub-counties where potential is moderate but rarely poor with respect to borehole yield, and zones in Bugobero and Busiu where it is below GV with respect to groundwater quality.

#### *2.8.4.5 Hydro-geological characteristics map*

The hydrogeological characteristics of an aquifer would most usually include calculated parameters such as transmissivity and storage, but unfortunately the RUWASA data collection programme and subsequent dataset was not designed to reliably assess these parameters. Instead, measured parameters during the drilling process namely; Overburden Depth, First Water Strike, Main Water Strike, and Static Water Level, were presented as thematic maps (Appendix 1). These parameters are elaborated as follows:

**Overburden Depth:** This gives an indication of how the depth of weathering and hence the thickness of the potential regolith aquifer varies across the districts. The depth to the base of the weathered zone or the overburden depth was taken from the borehole logs that had been interpreted individually by a hydrogeologist.

Much of Tororo District appears to have an overburden thickness of between 15 and 25 meters, with zones of thicker overburden up to 40 meters occurring in Kirewa, Butaleja, Paya, Iyolwa, and Nagongera sub-counties. Thinnest overburden occurs in Kisoko. Busia District appears to have an overburden thickness of between 30 and 40 meters, with zones of thicker overburden occurring in Bulumbi, Masaba, Masafu, and Dabani sub-counties.

Thinnest overburden occurs in Lunyo sub-county where thickness ranges from 15 to 30 meters. Most Bugiri District appears to have an overburden thickness of between 15 and 25 meters, with zones of thicker overburden occurring in Bulesa and parts of Buswale, Muterere, and Kapyanga sub-counties. Thinnest overburden occurs in Nabukalu sub-county. In Namutumba, overburden thickness is 15-25 meters or less towards the Mpologoma River system. Fringe areas near Manafwa and Bududa have an overburden thickness about 25 meters, with zones of thicker overburden occurring in the more mountainous areas of Bushika, Bulucheke, Buwagogo, Bukigai, Bupoto, Bumbo, and Buwabwala sub-counties.

**First Water Strike and Main Water Strike:** The depths at which the borehole encounters water ('Water Strike') were noted during the drilling process. The shallowest depth at which water was encountered is designated the First Water Strike and the depth at which the principal inflow into the borehole was recorded is designated the Main Water Strike. These depths may be coincident, or they may be completely different, depending on the nature of the aquifer at the particular locality (See Appendix 1)

The First Water Strike indicates that groundwater will be encountered most of Tororo District between 15 and 25 meters below surface, although deeper first water strikes are likely to occur in Kirewa, Busaba, Rubongi, and Molo sub-counties. With respect to the Main Water Strike, it is almost everywhere deeper than 30 meters, and over much of the district greater than 40 meters ground surface. Only in Mulanda sub-county is the Main Water Strike less than 25 meters below ground. In Busia District, groundwater will be encountered between 15 and 30 meters below surface, although deeper first water strikes are likely to occur in Bulumbi and the southeastern parts of Lunyo, Lumino, Buhehe, and Masafu sub-counties. With respect to the Main Water Strike it is almost everywhere in the range of 15 to 25 meters meters, although in Lunyo sub-county and along the main watershed it is often less than 15 meters below ground surface.

Groundwater will be first encountered over most of Bugiri District between 15 and 30 meters below surface, although deeper first water strikes are likely to occur in parts of Buswale, Buleba, and Kapyanga sub-counties and over much of Banda and Buyinja sub-counties. With respect to the Main Water Strike it is almost everywhere less than 30 meters, and over much of the central and northeastern portion of the district, it is in the range of 15 to 25 meters below ground level. Main Water Strike is likely to be greater than 40 meters below ground surface in Bupoto and Buwabwala sub-counties near Mt Elgon.

**Static Water Level (SWL)**: The Static Water Level at a particular locality is the level at which the groundwater surface stabilizes under the influence of natural hydrostatic pressure. The Static Water Level is used as a measure of the aquifer condition at the particular locality, i.e., to denote whether the aquifer is 'Confined' or 'Unconfined' with respect to atmospheric pressure. If the groundwater aquifer is 'Confined' then it is under a pressure that is higher than normal atmospheric pressure, and it will rise in the borehole to a level higher than that at which it was encountered. Namely, the Static Water Level will be shallower than the Water Strike level. If the groundwater aquifer is 'Unconfined' then the groundwater pressure is equal to the atmospheric pressure and the Static Water Level will be the same as the Water Strike level. The RUWASA database contains Static Water Level information as meters below ground level.

The map of Static Water Level (SWL) in the SMM catchment in Uganda shows the depth of the static water table below ground level and not the piezometric surface. A piezometric surface map was not attempted, as the true elevation of each of the boreholes is not reliably known. It is also a fact that in Basement aquifer terrain, piezometric surfaces are highly complex since many preferential flow zones occur according to fracture intensity, interconnectivity and depth of weathering. Under such conditions, the construction of a piezometric surface requires considerably more detailed hydrogeological information. In the absence of a piezometric surface map, the real groundwater flow directions cannot be determined or depicted, although in this type of Basement regolith aquifer, it is generally the case that groundwater flow directions mirror the topography. The location of most springs at the edges of the wetlands was found to largely confirm this assumption.

The Map indicates that in the districts of Manafwa and Bududa static levels in the lower elevation zones are at a depth of less than 10 meters, increasing to a maximum of 25-30 meters in an easterly direction as ground elevations rise. Over a large portion of Tororo, static water level is at a depth of less than 10 meters. In Busia, static water level is less than 15 meters below ground surface, except in the zones corresponding to deeper first water strikes. The Static Water Levels in Bugiri District become deeper in a north to south direction across the district. In the north and northeast, the static water level is at a depth of less than 10 meters. In the center and east largely in the range of 10 to 15 meters, and in the south increasing to 25-30 or even >30 meters below ground level over much of Banda and Buyinja sub-counties. The Static Water Levels are generally shallower (<10m) in the northeast towards the Mpologoma River system.

## 2.9 Groundwater monitoring issues

The preceding sections on groundwater are presented separately for Kenya and Uganda due to the significant dissimilarities and differences of approach with regard to issues on hydro-meteorological monitoring, groundwater quantification, mapping and non-uniformity of Geographical Information System (GIS) data.

More specifically, GIS data sets from Uganda and Kenya are difficult to edge match and have been acquired from different agencies and sources with different geo-referencing formats. The many inconsistencies within the data sets need to be resolved. A number of similar data sets have different resolutions. This makes it difficult to interpret them from a common basis. The groundwater regimes and spatial variations of the upper catchments in Kenya are not as comprehensively documented as the lower groundwater regimes in Uganda. There is therefore a need to resolve the differences across the border and ensure a duplication of similar efforts in Uganda and Kenya.

## 2.10 Major lakes in the SMM catchment

The Sio-Malaba-Malakisi river systems feed into two lakes, namely, Lake Victoria and Lake Kyoga. The Sio River discharges into Lake Victoria while the Malaba River discharges into Lake Kyoga.

### 2.10.1 Lake Victoria

Lake Victoria is the largest lake in Africa and the second largest lake in the world with open water surface area of 68,800 $km^2$. It has a land catchment area of 194,000 $Km^2$ extending into Rwanda and Burundi. The lake itself is shared between Kenya 6%, Uganda 43%, and Tanzania 51%. The annual rainfall over the lake is almost balanced by evaporation from the lake surface, thus emphasizing the water resources significance of land surface runoff. The lake plays an important role in the hydrology of the basin, as it modifies the regional rainfall pattern.

The Lake Victoria fisheries resources and diverse biodiversity support the livelihoods of an estimated 33 million inhabitants who live within its basin (EAC, 2006). At least 3 million persons are directly involved in the fishery industry. It is estimated that the annual fish catch from Lake Victoria is about 750,000 metric tons, generating more than US$ 400 million per year of which, US$ 250 million is exported. Lake Victoria is also an inland water transport linkage for the three EA States and a source of urban supply for a total population of nearly 5 million in the major towns of Mwanza, Kampala, and Kisumu. In addition to the cities and urban centers, several rural villages also obtain their water supply from the lake and rivers within the basin. Lake Victoria also acts as a reservoir for Uganda's hydro-electric facilities (Nalubaale and Kiira) which are located at the lake outlet in Jinja and have 316 MW installed power capacity. Lake Victoria is therefore of great socio-economic importance to the East African region.

Finally, the lake is a receptor of wastes and a source of water borne diseases. The Lake Victoria drainage basin contributes a high proportion of surface runoff to the lake which carries with it a broad range and large amounts of sediments and pollutants. For example, the Integrated Water Quality/Limnology Study for Lake Victoria (COWI, 2004) estimated the pollution loading in the Sio catchment resulting from municipal point sources in Kenya as follows:

**Table 2.7: Municipal point load from Sio catchment (COWI, 2004)**

| **Town** | **Population (2001)** | **Pollution loading (kg/day)** | | |
|---|---|---|---|---|
| | | BOD | Total-N | Total-P |
| Busia | 46,903 | 331 | 77 | 32 |
| Nambale | 26,556 | 239 | 40 | 16 |

Similarly, industrial load for BOD was estimated to be 290 tons/year, while Total Nitrate & Total Phosphorus loads was put at 57 tons/year and 24 tons/year respectively. There are number of other studies associated with Lake Victoria that are readily available and can be referred to separately. Some of the recent studies have considered regulation of Lake Victoria, e.g., the Acres studies of Owen Falls extension (Acres, 1990). Others have analyzed the Water Management of Lake Victoria's resources and have utilized the Lake Victoria Decision Support Tool (WREM Inc., 2003). A Nile Decision Support Tool (Nile DST) is also available for purposes of assessing the benefits and tradeoffs associated with various basin wide water development and management options in Lake Victoria and the Nile. This tool was developed as part of the Nile Basin Water Resources Project (GCP/INT/752/ITA) in collaboration with the Nile focal point institutions in the 10 countries of the Nile Basin (Georgakakos, 2003).

### 2.10.2 Lake Kyoga

The Malaba-Malakisi river systems drain into Lake Kyoga; a complex shallow lake system comprising of two main arms: Kyoga, extending into the Soroti-Kojweri arm and the Kwania arm. The two arms together with the Upper Victoria Nile inflow form an elongate and digitate aquatic landscape in central Uganda. The main Lake Kyoga complex covers about 6270 $km^2$ of open water located between 10 and 20 at an altitude of about 1100 m a.s.l. Lake Kyoga is shallow—the average depth is 3 m—but deeper areas (5-8 m) occur towards the River Nile flow-through channel. Numerous floating islands (sudd) are common in the open water. Extensive papyrus-dominated beds are a characteristic feature of the highly irregular swampy coastline and a large portion of the entire Kyoga basin catchment. Apart from the Victoria Nile and Kyoga Nile which are respectively the main inflow and outflow of the lake, numerous other rivers (e.g., Manafwa and Mpologoma) drain into the predominantly wetland landscape which is also occupied by at least 30 smaller satellite lakes.

There are several fish species of economic importance in Lake Kyoga. Among others, these include Tilapias, cat fishes, and lung fish also found in Lake Victoria. The major economic activity around Lake Kyoga is fishing. The fisheries sub sector around Lake Kyoga supports an estimated 200,000 people. The estimated quantity of fish landed in the year 2005 from Lake Kyoga was 56,000 tons (COWI, 2007). Other economic activities include paddy rice farming around wetlands and papyrus harvesting. However, Lake Kyoga is prone to flooding around its shoreline due to floating masses of papyrus that are often dislodged from upstream areas during heavy rains and deposited at its outlet causing blockages. A number of studies associated with Lake Kyoga are also available. Most of these studies address fisheries research. Recently, however, a study on the planned restoration of Lake Victoria (COWI, 2007) was also published as the main EIA (environmental impact assessment) document to support removal of aquatic weeds and mitigate flooding.

# 3.0 Water Supply and Sanitation

## 3.1 Water supply overview (Uganda sub-basin)

The water sector is one of the priority sectors in Uganda, as it directly impacts on the people's quality of life and overall productivity. Water supply and sanitation are among the highest priority issues emphasized in the national Poverty Eradication Action Plan (PEAP), which is the key government framework aiming to eradicate poverty through the creation of an enabling environment for rapid economic development and social transformation. Water is a strategic resource, vital for sustaining life, and promoting development and environmental sustainability. Access to clean and safe water and improved sanitation facilities and practices are pre-requisites for a healthy and productive population. The national targets for water supply and sanitation in both urban and rural areas are shown in the table below:

**Table 3.1 National targets for water supply and sanitation in Uganda**

| | *National Targets for Water Supply and Sanitation* |
|---|---|
| *Urban Areas* | Achieve 100% safe water coverage and 100% sanitation coverage in urban areas by 2015, with an 80%-90% effective use and functionality of facilities. |
| Rural Areas | Achieve 77% safe water coverage and 95% sanitation coverage in rural areas by 2015, with an 80%-90% effective use and functionality of facilities. |

The definition of coverage in the table above, relates to percentage of the population with access to an improved water source within a walking distance of 1.5 Km in a rural area and 0.2 Km in an urban area. For sanitation, coverage refers to the percentage of the population with sanitation facilities in their place of residence.

## 3.2 Water supply overview (Kenya sub-basin)

Kenya also embraces the Millennium Development Goal 7, according to which water is an indispensable life supporting natural resource that must be well managed and conserved. The Kenya Government has been investing resources to reduce the segment of the population without access to clean water. In addition, the water sector reforms are intended to improve the efficiency and effectiveness in water resources management and development. Water resources utilization in the SMM catchment in Kenya has focused in the provision of rural and urban water supplies and minor irrigation.

The main water sources in the SMM catchment are rivers, small dams, lakes, ponds, boreholes, shallow wells, protected and unprotected springs, and roof catchment. Poor farming practices, lack of clear ownership of these water facilities, and no clear law to protect them exposes these water sources to pollution. Some areas in the catchment suffer acute water shortages especially in the dry months of September to March. The most affected areas include the rural markets of Amagoro and Angurai in Teso District. There is great demand for water in the districts in terms of physical facilities, and some community water projects are mismanaged.

## 3.3 Key actors in the water supply and sanitation sector in Kenya and Uganda

Under the ongoing water sector reforms in Kenya, Water Services Boards (WSBs) have been established in seven catchment areas to spearhead the development of domestic and industrial water supplies. These Water Service Boards are:

- Lake Victoria North Water Service Board (LVNWSB)
- Lake Victoria South Water Service Board (LVSWSB)
- Rift Valley Water Service Board (RVWSB)
- Athi Water Service Board (AWSB)
- Coast Water Services Board (CWSB)
- Tana Water Services Board (TWSB)
- Ewaso North Water Services Board (ENWSB)

Under the new arrangements, the SMM catchment falls under the Lake Victoria Water Services Board (WSB). The LVWSB is responsible for the provision of domestic and industrial water supplies in the region through Water Service Providers (WSP). WSPs sign Service Provision Agreements (SPAs) with the WSB to provide water supply and sanitation services to specific areas, particularly urban areas. For areas where the board has not recruited a WSP, the District Water Officers operate the water supply systems on behalf of the board. These water supply systems include both urban and large rural water supplies. Other rural water supplies are managed by the communities through the establishment of Water Users Associations (WUAs).

With the introduction of the new water sector reforms in Kenya, the provision of water supply and sanitation services is now fully open to the private sector.

In Uganda, strategic planning, design, and development of urban water and sewage systems country wide is the function of the Directorate of Water Development in the ministry of water and environment (MWE).

The National Water and Sewerage Corporation (NWSC) is mandated to operate and provide water and sewerage services in areas entrusted to it on a sound commercial and viable basis.

Within the SMM, NWSC provides such services to Tororo, Mbale, and Malaba towns. The Minister for Water and Environment is required to enter into a performance contract with NWSC regarding its operations in accordance with the provisions of the Water Statute. The Directorate of Water Resources Management (DWRM) is responsible for regulating and controlling water abstraction and wastewater discharge through the use of permits. The permit system ensures that use of water resources is environmentally friendly and promotes sustainable development. These controls also ensure that water is not considered as a free good but as a good with value to be paid for.

Provision of water and facility maintenance is a role of Local Governments in liaison with the MWE and is carried out in accordance to identified local priorities. Under the framework, the MWE appoints town councils as urban water and sewerage authorities, through three-year performance contracts. The town council in turn appoints a water board, which owns the assets, sets the tariff, and oversees the operation of the services. The water authority enters into two-year management contracts with local private operators, who were given the mandate to manage the technical, commercial and financial operations of the water and sewerage services.

In the rural water sector, Water and Sanitation Committees, Water User Groups, and Water User Associations have been instituted as local community level organizations, to ensure the sustainability of the water supply and sanitation facilities through proper management, operation, and maintenance by the user communities. Non Governmental Organizations (NGOs) involved in water sector activities have formed a network called Uganda Water and Sanitation Network (UWASNET) for improved coordination of their activities in the water sector. The network also provides a platform for constructive engagement with government and donors in the water sector and serves to promote sharing of experience between the members. The Ministry of Health is responsible for promotion of sanitation and hygiene education in schools.

## 3.4 Monitoring indicators

The Millennium Development Goals (MDGs) are a set of time bound and measurable goals and targets for combating poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women that were agreed amongst world leaders in September 2000 at the UN Millennium Summit. In particular, target 10 of the MDGs addresses water supply and sanitation and calls upon member states to **"halve by 2015 the proportion of people without access to safe drinking water and basic sanitation"**. Target 10 is monitored through indicators 30 and 31, which are the proportions of people with sustainable access to safe water sources and improved sanitation respectively. Some of the currently used monitoring indicators in the water sector in Uganda that are of relevance to the MDGs and appear in subsequent monograph sections are outlined below.

**Table 3.2 Sector monitoring indicators**

| ***Golden Indicators*** | *Indicators* |
|---|---|
| ***Golden indicators*** | ▪ Percentage of people within 1.5 km (rural) and 0.2 km (urban) of an improved water source<br>▪ Percentage of improved water sources that are functional at time of spot check<br>▪ Average investment cost per beneficiary of new water and sanitation schemes<br>▪ Percentage of people with access to improved sanitation (households and schools)<br>▪ Percentage of people with access to hand-washing facilities |
| ***Specific indicators for urban water supply and sanitation*** | ▪ Percentage of unaccounted for water<br>▪ Number of water and sewage connections<br>▪ Percentage of the urban population with on site sanitation facilities (septic tanks, Ecosan, pit latrines, etc.) |
| **Other water sector indicators** | ▪ Percentage of people that use improved sanitation (households and schools) |

## 3.5 Water supply facilities and sources in the Kenya SMM sub-basin

Table 3.3 depicts water supply facilities in the SMM catchment in Kenya. Urban water supply facilities include Bungoma, Webuye, Kimilili, Busia, Nambale, and Malaba. Table 3.4 presents a summary of the water resources situation in the SMM while Figure 3.1 illustrates the safe water coverage in the catchment. Additional information on urban and rural water supplies in the SMM districts in Kenya is provided in Appendix 2.

**Table 3.3: Water supply facilities in the Kenya SMM sub-basin**

| District | Water Scheme | Typical population served | W/S Operator |
|---|---|---|---|
| **Mt. Elgon** | Chesikaki | 15,000 | DWO |
| | Chepkube | 5,000 | Community |
| | Mt. Elgon East* | 10,000 | Community |
| | Kipnyokos | 4,000 | Community |
| | Lwandanyi | | Community |
| | Cheptais | | Community |
| | Chesiker | 5,000 | Community |
| | Kutere/Kipsabula | 2,000 | Community |
| **Teso** | Malaba-Kocholia* | 20,000 | DWO |
| | Angurai | | DWO |
| | Amagoro | 2,300 | " |
| | Amukura | | " |
| **Busia** | Busia-Mundika* | 20,000 | WESCO |
| | Funyula-Bumala | 10,000 | WESCO |
| | Nambale* | 7,000 | WESCO |
| | Munana | 4,000 | DWO |
| | Busia Hills | 12,000 | " |

| | | | |
|---|---|---|---|
| | Port Victoria | 15,000 | DWO |
| | Butula | 6,000 | DWO |
| | Onana | | Community |
| | Budwongi | 6,000 | " |
| | Bujumba | | " |
| | Ejinja | 3,000 | " |
| | Ojibo | | " |
| **Bungoma** | Bungoma* | 50,000 | DWO |
| | Kimilili* | 30,000 | DWO |
| | Lwakhakha-Lwandanyi-Cheptais | 37,000 | Community |
| | Chwele | 3,500 | |
| | Kibichori-Bokoli | 30,000 | |
| | Old Kibichori | 9,000 | |
| | Kibabii | 1,000 | |
| | Maeni | 1,600 | |

*Source: LVNWSB*

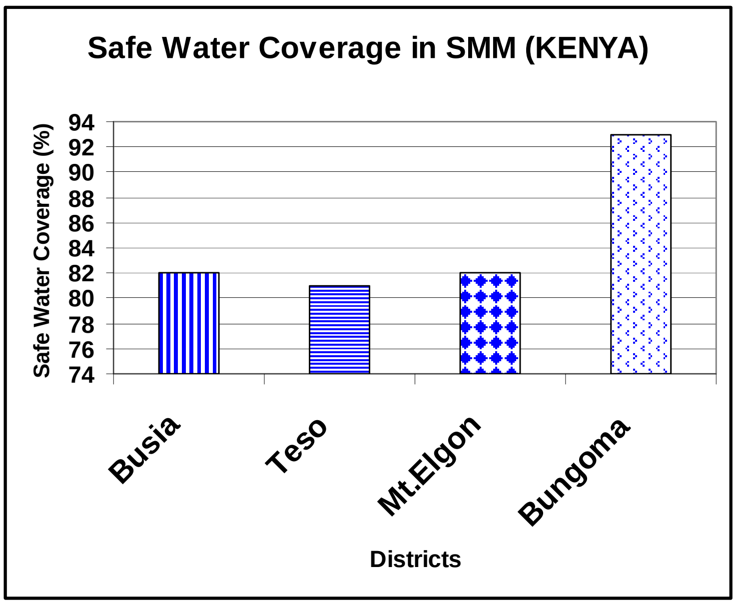
**Table 3.4: Water resources situation in the Kenya SMM sub-basin**

| **PARAMETERS** | **DISTRICT** | | | |
|---|---|---|---|---|
| | **Busia** | **Teso** | **Mt. Elgon** | **Bungoma** |
| Total number of households | 81,697 | 38,258 | 25,529 | 199,435 |
| Number of household with access to piped water | 4,000 | 2,039 | 4,000 | 65,248 |
| Number of household with access to portable water | 17,000 | 28,854 | 17,000 | 120,194 |
| Number of permanent rivers | 12 | 2 | 12 | 2 |
| Number of wells | 41 | 100 | 41 | 289 |
| Number of protected springs | 220 | 75 | 220 | 198 |

| | | | | |
|---|---|---|---|---|
| Number of boreholes | 13 | 62 | 13 | 183 |
| Number of dams | 1 | 4 | 1 | 44 |
| No. of household with roof catchment (%) | 10 | 22 | 10 | 30 |
| Average distance to a portable water point | 300m | 2Km | 300m | 1 Km |
| Safe water coverage | 82% | 81% | 82% | 93% |

*Source: District Development Plans (Bungoma, Busia, Teso, Mt. Elgon) 2002-2008*

**Figure 3.1: Safe water coverage in the Kenya SMM sub-basin**




### 3.5.1 Projected water demands

For the Kenya SMM sub-basin, potential water demand projections for domestic and industrial water use and livestock watering has been estimated for three time periods: 1990, 2000, and 2010. These are summarized in Table 3.5:

**Table 3.5: Projected water demand in the SMM Kenya sub-basin (M$^3$/Day)**

| **Basin** | **1990** | | **2000** | | **2010** | |
|---|---|---|---|---|---|---|
| SMM | D & I* | LS** | D & I | LS | D & I | LS |
| | 32,365 | 4,952 | 58,621 | 5,953 | 94,106 | 7,118 |

* D & I – Domestic and Industrial water requirements
**LS - Livestock water requirements

*Source: National Water Master Plan Study, 1992*

### 3.5.2 Water tariff structure

The current operational water tariffs for domestic water supplies in Kenya were gazetted in 1999 and are summarized below.

1. Rural Water Supplies: (volumes in $m^3$)

    a) No meter connection: Charges are Ksh. 200.00 per month

    b) With meter connection:

    WS < 10 $m^3$ per month: Ksh. 200.00 per month

    10 < WS < 20 per month: Ksh. 25.00 per $m^3$ in excess of 10 $m^3$

    20 < WS <50 per month: Ksh. 30.00 per $m^3$ in excess of 20$m^3$.

    50 < WS <100 per month: Ksh. 45.00 per $m^3$ in excess of 50 $m^3$

    100 < WS <300 per month: Ksh. 75.00 per $m^3$ in excess of 100 $m^3$

    WS > 300 per month: Ksh. 100.00 per $m^3$ in excess of 300 $m^3$

    *(In 2007 exchange rates, 1 USD is approximately equivalent to Ksh. 70.)*

2. Urban Water supplies:

   The rates for metered urban water supplies are similar to the metered rural water supply tariffs.

3. Water sold through metered water kiosks: Ksh.15.00 per $m^3$

4. Water sold by a retailer at a kiosk: Ksh 2.00 per a container of 20 litres

5. Bulk sale of water to an undertaker for resale: Ksh. 15.00 per $m^3$

6. Water demands for Boarding Schools:

   - WD < 600 $m^3$ per month: Ksh. 20.00 per $m^3$
   - 600 < WD < 1200 $m^3$ per month: Ksh. 25.00 per $m^3$ in excess of 600 $m^3$
   - WD > 1200 $m^3$ per month: Ksh 25.00 per $m^3$ for any other learning institution
   - For all other supplies in excess of permissible demands: Ksh. 45.00 per $m^3$

For urban centers with sewerage facilities, effluent discharge is charged at 75% of water used. The above water tariffs were introduced before the introduction of the current water sector reforms. Under the water sector reforms, water supply operators have to generate their operation and maintenance costs. In this regard, there will be a need to vary the existing water tariffs. To this end, each Water Service Provider is collaborating with the Water Services Board and preparing tariff proposals to be forwarded to the Water Services Regulatory Board for evaluation and approval.

## 3.6 Water sector in Uganda

### 3.6.1 Urban water supply

The urban water and sanitation sub-sector in Uganda is considered to include all towns with population above 5,000 and gazetted Town Councils. Many such urban areas within the SMM comprise an urban core with dispersed surrounding settlements. Major towns such as Tororo and Malaba are served by the National Water & Sewerage Corporation (NWSC).

Seventy-eight % of households in Tororo town are connected to the NWSC grid, while the population served in Malaba is 68%. The water supply system for Tororo and Malaba draws water from River Malaba, approximately 10 km from Tororo town. There are approximately 1,800 connections in the system and 47 public standpipes. Average water abstractions from the Malaba River supplied to Tororo and Malaba towns are as follows:

- Domestic: 16,000 $m^3$ – 20,000 $m^3$/month
- Commercial: 10,000 $m^3$/month
- Institutional: 10,000 $m^3$/month
- Public stand pipes: 2,000 $m^3$/month
- Ministries, Police, and Defense: 30,000 $m^3$/month
- Local Authorities and Parastatals: 2,000 $m^3$/month

*(In 2007 exchange rates, 1,700 UShs are approximately equivalent to 1 USD.)*

According to the Water & Sanitation Sector Performance report for 2006, the operating status of the remaining towns in the SMM outside the jurisdiction of NWSC and managed by local governments is shown in Table 3.6

**Table 3.6: Operating data for selected urban water supplies (2006)**

| No. | TOWN | PRODUCED ($m^3$) | SUPPLIED ($m^3$) | UFW (%) | TOTAL CONNECTIONS | UNIT COST of PRODUCTION (Shs/$m^3$) |
|---|---|---|---|---|---|---|
| 1 | BUGIRI | 10,756 | 9,454 | 12.1 | 624 | 1,668 |
| 2 | BUSIA | 32,593 | 27,161 | 16.7 | 582 | 400 |
| 3 | BUSOLWE | 2,927 | 2,517 | 14 | 229 | 682 |
| 4 | IGANGA | 6,236 | 3,627 | 41.8 | 405 | 496 |
| 5 | LWAKHAKHA | 5,498 | 4,224 | 23.2 | 1,412,750 | 617 |

With regard to the towns with town councils, extremely low costs of producing water are generally associated with gravity fed schemes (e.g., Budadiri and Lwakhakha), while high operating costs are associated with poor operational status (e.g., Iganga).

According to the Water & Sanitation Sector Progress Report (2006), the tariffs in the small towns in Uganda range from UG Shs. 800 to 2,500 per $m^3$ (or UG Shs. 16 to 50 per 20 liter jerry can). Efforts to make the tariffs uniform in the towns at UG Shs. 800 per $m^3$ (UG Shs. 16 per 20 liters) by the Minister of Water, Lands and Environment in July 2005 have not been implemented in many towns as this measure does not enable the recovery of operation and routine maintenance costs. On average, the revenue collected in the small towns covers 84% of the production costs. Billing and collection efficiencies are 96% and 88% respectively. Conditional Grants, for O&M grants are provided from the center to (a) subsidise O&M costs and (b) undertake extensions to the systems.

Data from the 57 towns all over the country indicates that only 17 towns break even (i.e., revenue collected equals to or is greater than the operation and maintenance costs). According to the Uganda Urban Water Sector Reform Document (July, 2003), the towns that were without piped systems at that time are tabulated in Table 3.7.

**Table 3.7: Towns without piped water supply systems (MWLE, 2003)**

| District | Name of Town | 2002 census population |
|---|---|---|
| Bugiri | Nankoma | 7,886 |
| Busia | Masafu | 3,863 |
| Iganga | Iganga | 38,009 |
| Tororo | Nagongera | 9,507 |

### 3.6.2 Urban tariff levels and pricing policy

According to the Uganda National Water Development Report (2005), current NWSC tariff structure is based on affordability and uniformity across the country while ensuring cost recovery. These tariffs are not adequate for system expansion, but are in most cases able to cover operation and maintenance costs. Major investments in system improvement and extension are currently financed separately from sources outside the tariffs (grants from government and donors), and this is likely to continue for some time until the towns become more viable. Full cost recovery (operation and maintenance, depreciation, and investment) would require a significant increase in tariffs. The 2003-2004 water tariffs by user category are shown in Table 3.8. Overall average tariff levels are high by regional standards and there is substantial cross-subsidy of household users by industrial and commercial users.

**Table 3.8: Average tariffs by user category (NWSC, 2003/4; MWLE, 2003)**

| **User Category** | **NWSC, 2003/4**<br><br>**Ush/m$^3$** | **Uganda Urban Water Authorities** |
|---|---|---|
| Public standpipes (Bulk) | 449 | 1,000 |
| Public stand pipes (Jerrycan) | 25-50 | 25-50 |
| Domestic– Private Connection | 693 | 1,000 |
| Government and Institutions | 854 | 1,000 |
| Commercial and Industrial | 1,187 – 1,324 | 1,000 |
| Weighted Average – Uganda | | 1,037 |

NWSC applies an additional 75 – 100% of the applicable tariff in case of a sewerage connection.

### 3.6.3 Rural water supply

The Rural Water Sector in Uganda makes a distinction between Rural Growth Centers (RGCs) and the rest of the rural district. RGCs are settlements or trading centers with populations ranging between 500 – 5000 persons. They are generally made up of a core trading center and a fringe. The majority of RGCs have nuclear settlements around the commercial zone or core, which tends to be densely populated. The core is a center of commercial establishments, generally shops, systematically laid out along the main road. The RGC fringe, on the other hand, tends to be more rural in nature and is composed of mainly residential houses widely spaced from each other. RGCs are considered to fall within the rural section of the district, since they are neither gazetted nor meet the preconditions for classification as town councils. They are, however, considered to have the potential to develop into towns, because of their recognized and visible growth characteristics.

RGCs are commonly served by large production boreholes coupled to a pipe-borne supply. This supply system has a limited number of house/yard connections and includes public standpipes that serve the densely populated settlement areas, where it is expected that there will be demand for private connections. In these areas, water kiosks, or at least stand pipes, are provided to serve the people without private connections. Drilled boreholes are and will continue to be the main option for rural water supply in rural areas. Protected springs are also favored because they offer the lowest cost of construction. Shallow or dug wells offer an economical and generally reliable source for water supply. The level of rural water supply coverage and functionality based on recorded systems within Uganda's National Rural Water Supply Database (NRWSD) is presented in the Table 3.9.

**Table 3.9: Rural water supply coverage and functionality by district (NRWSD, 2007)**

| DISTRICT | Population served by point sources 2002 | Projected rural population June 2007 | % Functionality of water supply sources | % Coverage for 2007 (Population within 1.5 Km walking distance) | % Coverage quoted by District |
|---|---|---|---|---|---|
| BUGIRI | 163,528 | 494,239 | 80 | 33 | 52 |
| BUSIA | 140,134 | 214,155 | 95 | 65 | 61 |
| NAMUTUMBA | 162,580 | 195,219 | 94 | 83 | - |
| MANAFWA | 115,738 | 304,220 | 89 | 38 | 42 |
| BUDUDA | 67,254 | 142,633 | 79 | 47 | 46 |
| PALLISA | 183,400 | 419,619 | 87 | 44 | - |
| BUTALEJA | 91,118 | 179,039 | 83 | 51 | 45 |
| TORORO | 240,312 | 391,742 | 94 | 61 | 52 |
| **Total** | **2,328,128** | **4,681,732** | | | |

Other details on water supplies in the districts are attached as Appendix 3. Most of the districts with high coverage above the national average are endowed with high potential for the low cost technology options (i.e., springs and shallow wells). Detailed information about the relative numbers of safe water sources by technology down to county resolution can be extracted from the NRWSD and the National Rural Water Supply Atlas (2001). In the atlas, information is presented in bar graphs and pie charts to facilitate the user to visualize district functionality of facilities, variety of available safe water sources (boreholes, protected springs, and communal tanks).

### 3.6.4 Rural water operation and maintenance issues

The Water Statute established a community level management framework for rural water supply infrastructure that includes:

- Water User Groups (WUGs) formed by a set of individuals or households to collectively plan and manage point source supply;

- Water and Sanitation Committees which are the executive bodies of the WUGs;

- Water User Associations (WUAs) which are forums for representatives from several WUGs where water supply is from a common source.

These organs are empowered to set tariffs and collect revenue for operation and maintenance of the system, with the approval of the DWD Director. Moreover, local authorities may organize the communities to form themselves into WUGs and WUAs. According to the Rural Water and Sanitation Reform study, a three-tier system for community based operation and maintenance basically for hand pumps is widely prevalent in many districts in Uganda as follows:

- A hand pump caretaker at the user level. The caretaker reports to a user committee and all work at this level is generally expected to be carried out on a voluntary basis. The user group collects funds for the maintenance of the hand pump.

- One or two hand pump mechanics at sub-county level. They are basically private operators but are appointed and to some extent regulated by the sub-counties in terms of fees to be charged for payments of repairs.

- A repair service at District level to support communities with repair services beyond the capacity of the hand pump mechanic.

Community contributions for operation and maintenance are an essential component of this system. The contributions can be in kind (material and labour) or cash. The RUWASA program laid the blueprint for community subsidies for capital investment or operating costs for water supply facilities. During its lifespan, RUWASA insisted on a flat rate contribution depending on the technology used as shown in Table 3.10.

**Table 3.10: RUWASA community contributions (Rural Water Reform Study, 2000)**

| **Technology** | **Community Cash Contribution (UGShs)** |
| --- | --- |
| Bore hole w/hand pump | 180,000 |
| Spring protection | 45,000 |
| Gravity flow Scheme | 45,000 (per tap) |
| Shallow Well w/hand pump | 90,000 |
| Borehole Rehabilitation | 45,000 |

These guidelines are still followed within SMM. The RUWASA project also ensured that communities have been organized into some form of water committees for all new bore holes constructed since then. Hand pump mechanics have been trained at sub-county level in all these areas. Caretakers have also been trained. Initial attempts of District based revolving spare parts supplies have generally been abandoned in favor of attracting the private sector. (The Districts viewed the proceeds from spare part sales as income and failed to replenish the revolving fund).

However, at the user level, many user groups and committees are not effectively established. User committees and caretakers are often frustrated working by purely voluntary principles. Water fee collection is generally organized on an ad-hoc manner. Thus repairs may take long to be implemented and major repairs cannot be financed without substantial subsidies.

At sub-county level, hand pump mechanics are frustrated by low or no payments. No sustainable system is in place for continuous training of hand pump mechanics. At District level, District level repair services have in reality only been provided through specific donor funded programs. No private sector capacity for such repair services has been established, and no clear mechanism has been established to have these repair services provided on a demand basis with users significantly contributing to the costs. The availability of hand pump spares through the private sector has in a number of cases proven problematic.

### 3.6.5 Eastern umbrella organization for water and sanitation (EUOWS)

Eastern Umbrella Organization for Water & Sanitation (EUOWS) has been conceived as an organization to be responsible for supporting and strengthening the performance of water supply and sanitation boards and water user committees to operate and maintain piped water systems in rural growth centers, small towns, and gravity schemes. EUOWS will be particularly responsible for making technical expertise available for routine maintenance. Its linkage to DWD is through the Water Authorities Division.

### 3.6.6 Participation of women in the rural water sector

In rural Uganda, women have the responsibility of fetching water for home use; yet, their involvement in water and sanitation planning and management is extremely limited. In recognition of this, the Sector developed the following indicators to measure and encourage the participation of rural women: *"percentage of water user committees/water boards in which at least one woman holds a key position".* A key position refers to Chairperson, Vice Chairperson, Treasurer or Secretary. District reports do not indicate the proportion or number of water user committees in which at least one woman holds a key position. Instead, they indicate only the number of female WUG members. Table 3.11 is adapted from the Uganda Water Sector Performance Report, 2006, and it presents findings regarding women involvement in key positions on water user committees in the Districts of Tororo and Bugiri.

**Table 3.11: Women involvement on water user committees**

| Position | Tororo (4) | | | Bugiri (2) | | |
|---|---|---|---|---|---|---|
| Chair person | 0 | 0 | 0 | 0 | 0 | 0 |
| Vice chair | 1 | 0 | 1 | 0 | 1 | 0 |
| Treasurer | 1 | 0 | 1 | 1 | 0 | 0 |
| Secretary | 1 | 1 | 0 | 1 | 1 | 1 |
| **% of WUC in which a women holds a key position** | | | | | | |
| District | 100% | | | 100% | | |

While this table shows that gender balance is considered by some District Local Governments, much more needs to be addressed regarding women participation.

In Kenya, the involvement of women in the management and development of water resources has not been appreciated in the past. However, their inputs and responsibilities are being appreciated under the new water sector reforms which aim at raising their participation in management committees by at least 30%.

## 3.7 Water supply sector financing in Kenya and Uganda

The Kenya Water Act 2002 has facilitated the establishment of the Water Services Trust Fund (WSTF; Water Act 2002, Section 83) whose objective is to assist in financing the provision of water services to areas of Kenya lacking these services. Funding to the fund is raised through the National Parliament and from donors. In this regard, donors supporting water supply and sanitation services are encouraged to channel their funding through the Water Services Trust Fund. The funds are managed by a board of trustees who provide grants to project proponents.

Under these conditions, communities develop water supply project proposals with the assistance of a Support Organization (SO) and forward their project proposal through the relevant Water Service Board to the WSTF. The Government is also financing water and sanitation development through a state corporation “the National Water Conservation and Pipeline Corporation (NWC&PC)”.

Under its Public Investment Plan, the Government of Uganda annually budgets for investment in the water and sanitation sectors. Investments covered under Government budget vary from urban water supply provided through the National Water and Sewerage Corporation to rural water and sanitation programs through the DWD of the Ministry of Water, Lands, and Environment. Using locally generated revenue, Local Governments can use part of the fund for investment in the water sector. Donors or External Support Agencies (ESAs) and NGOs have contributed substantially in financing investment in the water sector. The RUWASA Project has been the main contributor to increased sanitation and water supply coverage within districts in the project area during the period 1996-2001. Activities in this project included construction of boreholes, shallow wells, springs protection and sanitation improvement. The program covered 10 Districts in Eastern Uganda and had a budget of 250 million DKK (Danish currency) with annual expenditures ranging from 36 to 7.2 million USD annually.

Private sector funding in the water supply sector has not yet materialized in Uganda. It has been limited mainly to investment for limited users such as individuals (contractors and consultants), institutions, and organizations. In most cases, it is very difficult to quantify in aggregate terms how much of such investment takes place on an annual basis. Water can attract an economic fee through charging user fees at commercial rates subject to the limitation of the Water Statute, 1995. Various arrangements can be put in place for private investors to develop, produce and provide water to users under Build Operate Own (BOO), Build Operate Own Transfer (BOOT), Build Operate and Lease (BOL), and other arrangements to Local Governments and users. These arrangements are recognized and promoted in the National Water Policy, although it is acknowledged that they are more suited to an urban setting and have little relevance to the rural water sector, except perhaps for the Rural Growth Centers. The failure to attract private funding for provision of water for public use is due to the lack of enabling legislation.

Investment requirements to meet the desired MDG targets up to the year 2015 have been estimated to be $134,891,972 and $1,585,820 for the urban and rural water sectors respectively. Details of these investment requirements for each district within SMM in Uganda are attached as Appendix 3.2. NGO investments in the water sector are difficult to quantify but with decentralized service delivery NGOs role and input in the sector has not only increased but widened to assist some communities and institutions to attain an unmet need for safe water and acceptable sanitation facilities. NGOs are involved in community mobilization, training activities, offering technical assistance, funding a variety of water and sanitation related activities, and actual service provision.

## 3.8 Urban sewerage services and treatment capacities

In the SMM catchment, sanitation is mainly by use of pit latrines. Other facilities include septic tanks, cess pools, bucket latrines, and the bush. However, there are major problems in informal settlements where there is insufficient coverage of pit latrines. Some urban centers have introduced commercial public toilets, a measure that has made a significant difference.

Generally, all four districts in Kenya lack operational sewerage systems, and where they exist, sewerage works are functioning poorly. For example, the Alupe complex lagoons in Teso district are clogged and the system is practically useless.

The only towns with basic effluent treatment facilities are Bungoma, Webuye, and Busia. The Bungoma sewage treatment plant and the Webuye sewage treatment plants have been operating at 25 per cent capacity. Kimilili, Malakisi, and Sirisia have no sewage treatment plants and sewage is released untreated directly into the rivers.

In Busia district of Kenya, the sewerage works were constructed and commissioned in 1983. The sewerage scheme, with a capacity of 3520 $m^3$/day, was designed for the expected wastewater production in 2000. The current flow of wastewater to the treatment plant is only 330 $m^3$/day, representing 9.4% of the design wastewater flow. This low wastewater production level is attributed to low connections (estimated at 490) and limited piped water service to the town.

The existing sewerage system in Tororo Municipality consists of 6 km of collection piping which only serves central parts of the Western Division. It was constructed in 1954 and provides about 1.5% coverage of the municipality by means of 150 connections. The treatment facility consists of two facultative ponds in parallel feeding into a smaller maturation pond. A constructed wetland was added as final treatment for the effluent in

October 2001. The dimensions of the plot are estimated to be 75 m by 70 m with an estimated effluent discharge flow rate of 70 $m^3$/day. Private lagoons at the Tororo Girls School and Majansi High School have since been abandoned due to lack of maintenance. Other residents, especially the poorest, use public waterborne toilets (primarily in the central part of the town) and traditional public and private pit latrines (in other town areas). Wealthier residents have septic tanks. Due to rocky soils in the Eastern Division and collapsing soils in the Western Division, pit latrine excavation is difficult and expensive.

Table 3.12 shows the influent load figures to the main NWSC ponds. The data is derived from waste flow data between July 2001 and July 2003.

**Table 3.12: Influent loads for Tororo sewage stabilization ponds (COWATER, 2004)**

| **Parameter** | **Units of measure** | | | |
|---|---|---|---|---|
| | **Mg/l** | **Flow (m3/d)** | **Load kg/d** | **g/cap/d** |
| Total Suspended Solids (TSS) | 1145 | 121.4 | 139 | 40 |
| COD | 1122 | 121.4 | 136 | 75 |
| $BOD_5$ | 685 | 121.4 | 83.3 | 40 |
| Fecal coliforms | 5.00E + 07 | 121.4 | - | - |

The sewerage lagoons do not receive any toxic waste from industries but BOD5 continues to be high because less water is used for flushing waterborne toilets. TSS values could be attributed to algae growth, particularly in the facultative ponds. Table 3.13 compares effluent quality with discharge standards.

**Table 3.13: Effluent quality and discharge standards (COWATER, 2004)**

| **Parameter** | **Units of measure** | | | |
|---|---|---|---|---|
| | TSS (mg/l) | BOD5 (mg/l) | COD (mg/l) | FC/100 ml |
| Maximum | 243 | 34 | 27 | 1.6E+03 |
| Minimum | 975 | 230 | 498 | 1E+05 |
| Average | 393 | 94 | 189 | 3.56E+04 |
| **Discharge standards** | **100** | **50** | **100** | **1E+04** |

The general conclusion is that the effluent does not comply with the discharge standards set by the National Environment Regulations (Standards for Discharge of effluent into Water or land, 1999). Malaba and Busia towns have no sewerage systems. Sewerage extensions and connections are constrained by high costs (about UGShs. 3,441 per $m^3$ of sewage compared to UGShs. 586 per $m^3$ of water produced), poor urban planning, and low demand.

## 3.9 Sanitation and hygiene

The Government of Uganda has singled out hygiene and sanitation among the five most effective steps to reduce infant and maternal mortality rates. The under age 5 mortality rate is estimated at 152 deaths per 1000 live births, and maternal mortality rate is estimated at 505 deaths per 100,000 live births (UDHS 2000-2001).

According to the available data from the Water and Sanitation Sector performance report (2006), the current national latrine coverage stands at 58%. Information extracted from various district reports utilize access to improved pit latrines as a proxy measure for sanitation coverage in rural areas. These statistics are tabulated in Table 3.14.

**Table 3.14: Latrine coverage for selected districts in Uganda**

| District | Latrine coverage |
|---|---|
| Bududa | 48% |
| Busia | 82% |
| Manafwa | 43% |
| Tororo | 69% |
| Bugiri | 55% |

According to the Water & Sanitation Performance Report for the year 2005, Busia District experienced a decline in their latrine coverage of 2% which was attributed to reduced funding to sanitation programmes (e.g., home improvement competitions) and reduction in enforcement of by-laws related to latrine construction and use.

According to School Sanitation Guidelines (2001), each school should have excreta disposal facilities and well maintained latrines. However, the Uganda School Sanitation and Hygiene Survey (2005) found that the majority of Primary Schools in the country have poor hygiene practices. These mainly include irregular hand washing after latrine use, and hand washing without soap. It is estimated that the simple act of washing hands with soap can reduce the diarrhea risk by almost half, and respiratory tract infections by a third. In the SMM districts visited during this study, Busia reported a coverage of 62% while Bugiri reported only 8%.

For the four SMM districts in Kenya, the latrine coverage in 2002 is reported in Table 3.15.

**Table 3.15: Latrine coverage for the Kenya districts within SMM**

| **District** | **Latrine coverage (%)** |
|---|---|
| Bungoma | 70 |
| Busia | 90 |
| Teso | - |
| Mt. Elgon | 60 |

*Source: District Development Plans (2002-2008)*

## 3.10 Investment requirements for sanitation in urban and rural areas in Uganda

Investment requirements for the required sanitation facilities necessary to facilitate achievement of the Millennium Development Goals have been quantified for the rural areas under the rural water and sanitation action plan (MWE, 200). It is indicated that a total of USD 1,585,820 would be required for Districts within the SMM in Uganda alone. The Sanitation Master plan for Busia Town Council outlined the various intervention measures, estimated costs associated with an improved sanitation system, and estimated a total requirement of 1.6 billion UGShs. for lagoons, improved onsite sanitation, and a limited sewerage system and improved drainage.

A feasibility study for the Tororo sewerage and sanitation system commissioned by NWSC (COWATER, 2004) recommended a total capital investment cost of UGShs 5,500 million for improvements to sewerage and onsite sanitation infrastructure.  It also estimated that O&M costs for existing and planned improvements over a 15 year time frame would be UGShs. 15,157 million.

## 3.11 Solid waste management

Currently solid waste management in all towns and rural growth centers within SMM is very poor, resulting in careless and indiscriminate open space dumping and creating unsanitary conditions on town streets and alleys. Plate 3.1 depicts the situation in Busia Town Council, Uganda. Such nuisance dumps lead to unpleasant odors and are fertile breeding grounds for flies and other vectors. Furthermore, this practice may result in surface water and groundwater pollution by leachate, impairment of soil permeability, and blockage of drainage systems.

**Plate 3.1: Indiscriminate dumping of solid waste in Busia Town Council**

Refuse-bins at either household level or at gazetted places are lacking. This leaves the residents with only one option of crude damping. The transportation method is also crude and irregular as there are no gazetted dumper trucks for transporting refuse. The urban authorities resort to using open trucks and dumping at any open place (crude dumping) as no gazetted dumping sites are in place. Busia Town Council as an urban center lacks a master physical plan. The Town center has haphazardly placed buildings with undefined roads/streets.

## 3.12 Emerging issues in water supply and sanitation services

In Kenya, dams in the catchment area are usually silted and not maintained. Poor farming practices, lack of clear ownership of the water facilities and lack of clear law to protect them exposes these water sources to pollution. Some areas in the catchment suffer acute water shortages especially in the dry months of September to March. The most affected areas include Amagoro and Angurai in Teso District. There is great demand for water in the districts in terms of physical facilities. Some of the community managed water projects are not optimally operational due to mismanagement

The lack of sewerage facilities in urban towns in combination with high urban population growth has resulted in a situation where urban and human wastes are careless disposed of in the towns. This phenomenon is particularly observed in the low income settlements areas, market places, bus parks and along the existing open drainage system. This has created suitable breeding grounds for epidemics, e.g., cholera, typhoid and dysentery.

For areas with septic tanks and no exhauster facilities, the overflow from these septic tanks is directed into the environment and the rivers, thus increasing the pollution of the rivers. In other locations, sewage is directly discharged into the rivers.

River water pollution is exacerbated by surface runoff into the rivers from the towns and rural markets.

Central and Local governments have limited capacity to fund improved sanitation in the project area. The problems are further compounded by the poor nature of housing units that deter orderly connection to sewerage facilities.

Urban and rural reform studies in Uganda have concluded that the water sector cannot sustain itself, service its debt, and raise capital for new plant, nor fund renewal or growth, despite adequate tariffs. It has also been observed that the existing management incentives for small towns are ineffective.

# 4.0 Agriculture

This chapter gives an overview of land tenure including arable land, farming systems, major crops and their annual yields, irrigation potential and planned irrigation projects in the Sio-Malaba-Malakisi catchment. The chapter also gives an overview of livestock production.

## 4.1 Introduction

The Sio–Malaba–Malakisi (SMM) river basin provides an important catchment area for the main in-land lakes including Lake Victoria and Lake Kyoga. All three rivers originate from the Mt. Elgon slopes in Kenya before crossing into Uganda. Figure 4.1 shows the catchment areas for the three rivers. The Sio River originates on the south slopes of Mt. Elgon around Bungoma and flows through rolling plains and extensive wetlands, mostly in Kenya, before it enters Lake Victoria in Uganda. The Malakisi River begins on the upper slopes of Mt. Elgon and meets the Lwakhakha River near Tororo to form the Malaba River which flows into the Mpologoma River and finally into Lake Kyoga. Other major rivers in the general catchment include the Manafwa River which originates from the Western slopes of Mt. Elgon and the Kibimba River which originates from the Southern part of the Bugiri district. Both rivers flow through extensive wetlands into the Mpologoma River that finally flows into Lake Kyoga.

The catchment is characterized by intensive settlement and cultivation on both sides of the border leading to heavy pollution loads into these rivers. Because of the rapid increase in population and the consequent rise in the demand for food and other agricultural commodities, the area under cultivation has increased rapidly. Widespread forest clearing, bush burning and overgrazing have exposed the land to soil degradation. Threats arising from population growth and poor farming methods have been recognized in both Kenya and Uganda for a long time. In their historical outline of the land use/land cover changes in Uganda, Tukahirwa and Veit (1992) indicated that population pressure in the 1920's was already a major factor causing damage to land resources. Over cultivation and inappropriate farming methods were denuding the hill slopes, causing accelerated soil erosion and contributing to the decline in agricultural productivity. Up to this time the resource management within the SMM catchment focused on administrative boundaries with little regard to transboundary and shared resource issues.

The overall objective of the Sio-Malaba-Malakisi, Transboundary Integrated Water Resources Management and Development Project is to create a cooperative framework and develop common strategies for the joint management of the SMM water resources. The specific terms of reference (ToR) for the land use and agriculture component are to assemble information on the current agricultural production practices, identify key issues, and propose investment projects for mitigation. The main study areas are the Tororo, Busia, Bugiri, Butaleja, Pallisa, Manafwa and Bududa districts in Uganda and Mt. Elgon, Bungoma, Teso and Busia districts in Kenya.

## 4.2 Crop production

Typically crop production practices in the catchment are traditional with very few improved farming methods. Most farmers use unimproved, low yielding cultivars/varieties, low densities, and a broadcast method. Such practices not only lead to poor productivity, but they also give rise to poor plant cover that allows soil erosion particularly during heavy rains. A large proportion of farmers practice intercropping or mixed cropping systems. Intercropping utilizes a combination of crops on the same piece of land, and the aim is to intensify production both in space and time. Most intercropping systems combine cereals and legumes. A typical intercropping example is a combination of maize and beans common in both in Kenya and Uganda (see Plate 4.1).

**Plate 4.1: Examples of intercropping system (maize and beans)**

Plate 4.1 illustrates some crops grown in pure and mixed stands in Uganda. For most districts, maize, beans and millet are largely grown as intercrops.

### 4.2.1 Land tenure and major land use types

In Uganda, land ownership, management and control are regulated by the Land Act 1998, which recognizes the following four types of ownership: customary, mailo, freehold and leasehold tenure. Kenya similarly has a wide range of land tenure including: leasehold, freehold/ancestral or customary, and landlord/tenancy tenure. Although there are no records of how much land is under each category in the SMM catchment, the dominant tenure is customary. Customary tenure appears to cut across all the ethnic groups (Bagisu, Samia, Banyole, Basoga, Bagweri and Jopadhola in Uganda and Bukusu, Samia, Iteso in Kenya).

Customary tenure is regulated largely by rules that are limited to a particular ethnic group and may provide for communal ownership and land use. A customary certificate of ownership guarantees a tenant's interest on the land. This procedure provides incentives to the tenant to invest in the proper land management. However, because of population pressure (over 400 persons per square kilometer in Tororo, Busia and Manafwa/Bududa), poverty, and land acquisition largely through inheritance from the head of the family, farm sizes have considerably diminished and land fragmentation is a common practice. This has serious implications to farming practice and productivity.

### 4.2.2 Soil types in the SMM catchment

There are a wide range of soils types in the catchment that vary considerably in fertility, drainage characteristics, and agricultural potential. On the upper slopes of Mt. Elgon, there are essentially three soil types: Andosols (eutrophic soils of tropical regions), Nithosols (or ferrisols) and the Histols (hydromorphic soils).

The Andosols are ashy soils, mostly derived from volcanic and alluvial materials with high nutrient reserves and high organic matter content, and are very fertile. Andosol soils are considered to be of high agricultural potential. However, the limiting factor is the high phosphorus fixing capacity that leads to a phosphorous deficiency for plants.

Nitisols or ferrisols are well developed soils due to sufficient weathering and are reddish – brown to dark color. This soil type is one of the most fertile in the catchment.

Histosols are largely organic soils and are extensively utilized for forestry, grazing and horticulture. In the low lying areas (e.g. Tororo, Busia, Teso Bungoma, Bugiri and Buteleja districts) the dominant soil types are the Ferrasols (Ferrallitic soils) and plinthosols (Ferrugineous Tropical soils). Because of the mountainous terrain and the steep slopes on which these soils occur, all the three soil types are highly susceptible to erosion.

Ferrasols are highly weathered soils with low cation exchange capacity (CEC). They are deep and well drained with moderate to high agricultural potential. They are, however, usually deficient in nitrogen and are acidic due to the presence of aluminum (Al) and Iron (Fe). They therefore require careful management in order to ensure nutrient balance. The plinthiosols are largely found in low lying areas particularly those prone to flooding and water logging such as wetlands and river valleys. During the dry seasons, they have a tendency to crack making ploughing and early planting difficult.

### 4.2.3 Farming systems

The major farming systems in the catchment are largely determined by the rainfall pattern (total amount per year and distribution). Farming covers a wide range of activities including the production of traditional cash and food crops and keeping livestock (cattle, sheep, goats, page and poultry).

In broad terms, there is a distinct spatial specialization between the production of perennial crops and the production of annual crops. The production of perennial crops is associated with areas of high annual rainfall (1000-2100 mm) and a less pronounced dry season.

Bananas and coffee are often intercropped with a wide range of annual crops (maize, cassava, sweet potatoes, coco yams and beans). These crops include most areas in the upper catchment including Mt. Elgon in Kenya and the districts of Manafwa and Bududa in Uganda.

In areas of lower annual rainfall (500-1000 mm) and a fairly prolonged dry season, the main farming activities are the production of annual crops (finger millet, sorghum, maize cassava, sweet potatoes, simsim, pigeon peas, groundnuts Phaseolus beans and cow peas) and various vegetables including cabbages, onions, eggplants and tomatoes.

Within these two broad categories, there are variations in the crop combinations based largely on food preferences and the resources available. In Uganda many studies have identified and proposed different farming systems largely based on the major agro ecological zones, soil types and cropping systems (MAAIF). However, for the purpose of this study, farming systems based on the NEMA classifications (1991) are used. Based on the NEMA classification, Uganda consists of at least nine farming systems ranging from largely perennial crop based to largely annual crop based. At least four major farming systems can be identified within the SMM catchment, each with its soil degradation problems. They include:

a. The intensive banana-coffee farming system

b. The medium altitude banana/coffee farming system

c. The mountain farming system

d. The banana/millet/cotton farming system

Although no Kenyan records for categorizing farming systems were obtained, available information and observations indicate that the situation is similar. However, farming systems are dynamic because there are many factors at play like increased population density, emergence of new producing areas and markets, soil fertility decline, and threats from new pest infestation. The recent wide spread production of rice is an example of change. Rice production (both paddy and upland) has become very important in areas where it was only a minor crop a few years ago largely because of the income farmers are deriving.

The four major farming systems are briefly outlined below.

### *(a) The Intensive Banana –Coffee Farming System*

The bulk of banana-coffee farming is found on the northern shores of Lake Victoria and includes parts of the Bugiri District. The relief is characterized by long gentle slopes and large papyrus swamps. The soils are largely ferrasols/Ferrallitic and include some of the most fertile friable clays. However, in areas with frequent flooding and water lagging, the soils are largely plinthosols. Banana and coffee (Robusta) are the main food and cash crops respectively.

Other crops include maize, cassava, sweet potatoes, groundnuts, beans and many vegetables (onions, cabbages, amaranthus spp). Livestock production forms a major part of the farming system. Recent observations indicate that rice and maize production has become extremely important. Rice is being produced on a large scale (Kibimba rice scheme) and by small holder farmers, and it has largely replaced coffee as a cash crop. Much of the rice is being produced on cleared wetlands.

The most serious problem is the mailo land tenure system which has restricted tenants to small holdings in many areas. Small holdings have been exacerbated by the high population densities. Soil degradation has occurred mainly through repeated use and poor farming methods. Mixed cropping/intercropping is often practiced. The production of perennial crops (coffee and bananas) has beneficial effects on soil conservation because they provide soil cover almost year round. Soil erosion is often serious because of the slow establishment of the coffee and banana crops and where mulch is absent.

### *(b) The Montane Farming Systems*

This system is found above 1800 m altitude on Mt. Elgon where the relief is typically hilly with steep slopes. The soils are mostly Andosols, highly weathered sandy and sandy clay loams with volcanic ash. Land is generally scarce and farm sizes are very small due to high population densities about 400-500 persons per $km^2$ (particularly in the Bududa, Uganda and Elgon, Kenya districts), and land fragmentation is common.

The most important crops grown are bananas, coffee, sweet potatoes, beans, sorghum, Irish potatoes, field peas, maize, wheat and vegetables both in Uganda and Kenya. Intercropping is practiced and anti-erosion bunds along contour lines are common. Generally, grazing land is scarce. Animals are herded and grazed on marginal hillsides, valley bottoms, roadsides and interseasonal fallows. Trees are found around homesteads and in small household woodlots (mainly *Eucalyptus*).

The system sustainability is seriously threatened by the rapid decline in soil fertility due to repeated cultivation. The soil fertility decline is associated with high population density that has led to farm size reduction as well as fragmentation of holdings.

An additional problem has been the destruction of some earlier constructed contour bunds to increase the arable area and make use of the long fallowed land. This has led to increased soil erosion and landslides, and further loss of nutrients and arable land. Many rivers and lakes are being silted due to the enormous hillside soil erosion.

### *(c) The Medium Altitudes, Bananas/coffee System*

This system covers the lower Manafwa, Uganda and the midland Bungoma, Kenya districts. The relief is hilly and most soils are deeply weathered clay loams (ferrasols). The soils are of medium to high productivity. Due to the high population densities and customary tenure, land is highly fragmented. Deforestation in much of the area has reached alarming levels and together with the steep slopes and poor farming practices have led to serious soil erosion and land slides (particularly in the Manafwa and Bududa districts). The major agricultural activities include the production of coffee, banana, maize, beans, cassava, sweet potatoes, horticulture and livestock rearing. On the Kenya side sugarcane production is a major activity, particularly in the Sangalo area.

### *(d) The Banana/millet/cotton System*

Within the catchment, this farming system comprises the Tororo, Busia, Pallisa and Butaleja districts. Similar farming is conducted in parts of Bungoma, Teso and Busia, Kenya. The soils are generally ferrallitic and consist of deeply weathered and leached loamy sands. The area is considered to be of low to medium agricultural productivity because the soils become rapidly exhausted through cultivation. The soils therefore require long fallow periods which are often not possible due to the small farm sizes (average land holding per typical household of seven persons is 0.4 to 3 ha). The loamy sands are highly vulnerable to erosion particularly under heavy rains or on steep slopes. Cotton was a very important cash crop in this area during the 1960s and this is how the farming system derived its name in Uganda. However, cotton subsequently lost its position due to marketing problems.

Other major crops include millet, maize, sorghum, sweet potatoes and cassava. Because of the high population in most of the region, fallow periods are very short and in some cases fallowing has been abandoned altogether.

Ox-ploughing is generally practiced particularly where soils are light. Cattle are an important component of farming and cattle are herded and grazed on communal lands, particularly wetlands. Soil erosion (both by water and wind) is a serious problem particularly in areas that are densely populated (e.g. Tororo and Pallisa). Many rivers have been silted as a result of rill and sheet erosion. For example, at Hisegu in the Kumi district, nearly 7 sq. km of land has recently been formed as a result of siltation in River Manafwa. In the Pallisa district, all of the nine valley tanks, one in each sub-county urgently require desilting.

## 4.2.4 Major crops and annual yields

The following tables summarize some of the major crops and their annual yields for selected SMM districts.

**Table 4.1: Crop production for selected SMM districts (2002)**

**a) Tororo District**

| Crop type | Pure stand | Mixed stand | Yield/ha | Total production (t) |
|---|---|---|---|---|
| Banana | 10,281 | 3,334 | 3.7 | 25,187.75 |
| Cassava | 54,227 | 18,369 | 7.4 | 268,605.20 |
| Sweet potato | 38,071 | 8,217 | 4.0 | 92,576.00 |
| Maize | 28,591 | 18,443 | 1.3 | 30,572.10 |
| Beans | 6,063 | 5,713 | 0.6 | 3,532.80 |
| Millet | 45,245 | 21,791 | 1.2 | 40,221.60 |
| Sorghum | 19,428 | 5,941 | 1.3 | 16,489.85 |
| Groundnuts | 17,535 | 5,353 | 0.6 | 6,866.40 |
| Coffee | 613 | 369 | 0.5 | 245.50 |
| Simsim | 1,065 | 495 | 0.5 | 390 |
| Paddy | 0 | 0 | 0 | 0 |
| Pineapples | 2,650 | 0 | 48 | 63,600 |
| Cowpeas | 0 | 0 | 1 | 2,104 |
| Sunflower | 0 | 0 | 0.9 | 388.8 |
| Irish potato | 0 | 0 | 5.4 | 14,947.2 |

*Source: FAO database*

**b) Busia District**

| Crop type | Pure stand | Mixed stand | Yield/ha | Total production (t) |
|---|---|---|---|---|
| Banana | 2,033 | 938 | 3.8 | 5644.9 |
| Cassava | 25,779 | 10,926 | 12 | 220230 |
| Sweet potato | 4,756 | 1,469 | 4.5 | 14006.25 |
| Maize | 11,950 | 9,625 | 1.5 | 16181.25 |
| Beans | 1,643 | 2,194 | 0.6 | 1151.1 |
| Millet | 3,279 | 2,023 | 1.4 | 3711.4 |
| Sorghum | 3,396 | 1,644 | 1.6 | 4032 |
| Groundnuts | 1,632 | 692 | 0.5 | 581 |
| Coffee | 372 | 139 | 0.9 | 229.95 |
| Simsim | 167 | 136 | 0.1 | 15.15 |
| Paddy | 0 | 0 | 0 | 0 |

*Source: FAO database*

**c) Iganga District**

| Crop type | Pure stand | Mixed stand | Yield/ha | Total production (t) |
|---|---|---|---|---|
| Banana | 8,733 | 4,424 | 4.6 | 30261.1 |
| Cassava | 25,522 | 20,149 | 11.5 | 262608.25 |
| Sweet potato | 61,139 | 15,774 | 4.4 | 169208.6 |
| Maize | 63,153 | 74,953 | 1.5 | 103579.5 |
| Beans | 13,485 | 35,146 | 0.7 | 17020.85 |
| Millet | 11,434 | 9,182 | 1.4 | 14431.2 |
| Sorghum | 386 | 345 | 1.1 | 402.05 |
| Groundnuts | 9,852 | 11,640 | 0.7 | 7522.2 |
| Coffee | 9,976 | 3,937 | 1.3 | 9043.45 |
| Simsim | 449 | 849 | 0.2 | 129.8 |
| Paddy | 0 | 0 | 0 | 0 |
| Vegetables | 2,870 | 0 | 7.5 | 10762.5 |
| Soyabeans | 20,195 | 0 | 1.3 | 13126.75 |
| Cowpeas | 0 | 0 | 1.1 | 1127.5 |
| Irish potato | 0 | 0 | 7 | 11830 |
| Cocoa | 0 | 0 | 0.6 | 588 |

*Source: FAO database*

**d) Mbale District**

| Crop type | Pure stand | Mixed stand | Yield/ha | Total production (t) |
|---|---|---|---|---|
| Banana | 37,118 | 55,723 | 5.3 | 246028.65 |
| Cassava | 19,285 | 13,317 | 8.5 | 138558.5 |
| Sweet potato | 19,052 | 7,101 | 3.7 | 48383.05 |
| Maize | 24,552 | 54,534 | 1.8 | 71177.4 |
| Beans | 23,613 | 55,862 | 0.8 | 31790 |
| Millet | 12,565 | 7,769 | 1.2 | 12200.4 |
| Sorghum | 978 | 524 | 0.8 | 600.8 |
| Groundnuts | 5,311 | 3,056 | 0.4 | 1673.4 |
| Coffee | 12,446 | 20,727 | 1.2 | 19903.8 |
| Simsim | 40 | 37 | 0.1 | 3.85 |
| Paddy | 0 | 0 | 0 | 0 |
| Vegetables | 7,280 | 0 | 8.6 | 31304 |
| Cowpeas | | 0 | 1.1 | 1394.8 |
| Irish potato | 0 | 0 | 7 | 25116 |

*Source: FAO database*

**e) Pallisa District**

| Crop type | Pure stand | Mixed stand | Yield/ha | Total production (t) |
|---|---|---|---|---|
| Banana | 4,196 | 1,513 | 3.8 | 10847.1 |
| Cassava | 45,018 | 13,422 | 13 | 379860 |
| Sweet potato | 17,529 | 5,160 | 4.5 | 51050.25 |
| Maize | 16,547 | 11,571 | 1.6 | 22494.4 |
| Beans | 4,300 | 3,753 | 0.6 | 2415.9 |
| Millet | 26,447 | 17,235 | 1.4 | 30577.4 |
| Sorghum | 20,762 | 8,454 | 1.6 | 23372.8 |
| Groundnuts | 13,127 | 6,105 | 0.5 | 4808 |
| Coffee | 387 | 290 | 0.4 | 135.4 |
| Simsim | 422 | 338 | 0.2 | 76 |
| Paddy | 0 | 0 | 0 | 0 |
| Cowpeas | 0 | 0 | 0.5 | 3997 |
| Irish potato | 0 | 0 | 5.4 | 4573.8 |

*Source: FAO database*

Traditionally, farmers practice intercropping and mixed cropping for a number of reasons. These include:

1. One crop may provide a good microclimate for another when grown in association e.g. bananas may provide shade for young coffee plants.

2. One crop may enhance the soil nutrient status to benefit another crop e.g. beans may fix nitrogen which would benefit maize.

3. There is a possibility of lower labor requirements in intercropping e.g. weeding one crop may prepare a seed bed for associated crops.

4. Intercropping is based on sound biological principles that often produce more total yield than component crops grown in pure stands.

Table 4.1 also indicates that the importance of each crop varies considerably within the catchment. Cassava is very important in Tororo, Busia and Pallisa; bananas are important in Mbale, and maize is extremely important in Iganga. Comparable figures for Kenya are given in Table 4.2 (a-d). Maize and beans are important in the Bungoma, Mt. Elgon and Busia districts and much less in the Teso district. Cassava and sweet potatoes are important food security crops in the Teso and Busia districts, whereas Irish potatoes are the most significant crop produced in the Mt. Elgon district.

The promotion of cassava mosaic virus resistant varieties has been largely responsible for the increased and sustained production of cassava.

**Table 4.2: Crop production in SMM catchment - Kenya**

**(a) Bungoma District**

| **Crop type** | **Area (ha)** | | **Yield (bags)** | |
|---|---|---|---|---|
| | **2006** | **2007*** | **2006** | **2007*** |
| Maize | 65792 | 73500 | 2320425 | 2537508 |
| Beans | 41574 | 9200 | 419990 | 4154488 |
| Finger millet | 1120 | 1850 | 7890 | 17900 |
| Sorghum | 683 | 2040 | 1775 | 19640 |
| Rice | 0 | 0 | 0 | 0 |
| Wheat | 0 | 0 | 0 | 0 |
| Cow peas | 533 | 0 | 2931 | 0 |
| Groundnuts | 1113 | 1000 | 4190 | 10660 |
| Soybeans | 375 | 2000 | 1385 | 26660 |
| Sweet potatoes | 1529 | 1700 | 18348 | 23800 |
| Irish potatoes | 0 | 0 | 0 | 0 |
| Cassava | 235 | 448 | 235 | 448 |
| Banana | 0 | 0 | 0 | 0 |
| Cotton | 568 | 2000 | 398(t) | 2000(t) |

**(b) Mt. Elgon District**

| Crop type | Area (ha) | | Yield (bags) | |
|---|---|---|---|---|
| | **2006** | **2007*** | **2006** | **2007*** |
| Maize | 16950 | 18200 | 782600 | 810000 |
| Beans | 18270 | 17200 | 95350 | 86000 |
| Finger millet | 110 | 90 | 990 | 2000 |
| Sorghum | 98 | 60 | 1045 | 1330 |
| Rice | 0 | 0 | 0 | 0 |
| Wheat | 650 | 720 | 17550 | 19440 |
| Cow peas | 0 | 0 | 0 | 0 |
| Groundnuts | 75 | 0 | 375 | 0 |
| Soybeans | 12 | 12 | 96 | 1200 |
| Sweet potatoes | 170 | 200 | 1700 | 2000 |
| Irish potatoes | 5081 | 5000 | 609720 | 940000 |
| Cassava | 20 | 28 | 20 | 336 |
| Banana | 0 | 0 | 0 | 0 |
| Cotton | 125 | 240(t) | 125(t) | 380(t) |

**(c) Teso district**

| Crop type | Area (ha) | | Yield (bags) | |
|---|---|---|---|---|
| | **2006** | **2007*** | **2006** | **2007*** |
| Maize | 3465 | 4060 | 35382 | 42000 |
| Beans | 1450 | 2260 | 8522 | 11300 |
| Finger millet | 1208 | 1520 | 7602 | 10514 |
| Sorghum | 846 | 1220 | 6799 | 10500 |
| Rice | 161 | 5190 | 5154 | 5510 |
| Wheat | 0 | 0 | 0 | 0 |
| Cow peas | 168 | 205 | 798 | 102 |
| Groundnuts | 340 | 520 | 2144 | 3380 |
| Soybeans | 42 | 150 | 241 | 450 |
| Sweet potatoes | 809 | 680 | 7440(t) | 6800(t) |
| Irish potatoes | 6748 | 6856 | 75416(t) | 45252(t) |
| Cassava | 0 | 0 | 0 | - |
| Banana | 424 | 335 | 270(t) | - |
| Cotton | 794 | 1250 | 635 | - |

**(d) Busia District**

| Crop type | Area (ha) | | Yield (bags) | |
|---|---|---|---|---|
| | **2006** | **2007*** | **2006** | **2007*** |
| Maize | 36105 | 35890 | 616733 | 586120 |
| Beans | 12470 | 1385 | 74070 | 101850 |
| Finger millet | 3857 | 4365 | 25097 | 34885 |
| Sorghum | 17068 | 16060 | 192644 | 153280 |
| Rice | 535 | 784 | 9171 | 26511 |
| Wheat | 0 | 0 | 0 | 0 |
| Cow peas | 140 | 1100 | 765 | 3300 |
| Groundnuts | 717 | 644 | 5263 | 4100 |
| Soybeans | 0 | 410 | 0 | 1455 |
| Sweet potatoes | 10138 | 7160 | 73310 | 57380 |
| Irish potatoes | 0 | 0 | 0 | 0 |
| Cassava | 16750 | 16900 | 1684499(t) | 2028009(t) |
| Banana | 0 | 0 | 0 | 0 |
| Cotton | 1543 | 3500 | 878 | 4375 |

*Source: Annual Report, Western Province Kenya, 2007*

* Figures for 2007 are estimates

In a more recent survey carried out by the National Bureau of Statistics (Uganda), average plot size for the individual crops grown, except tea, ranged from 0.07 ha for cooking banana to 0.41 ha for cotton (Table 4.3). These plot sizes indicate a subsistence situation and that land is a critical and limiting factor in crop production.

**Table 4.3: Average plot sizes (Ha) 2005 and 2006**

| **Crop** | **Crop Area[1] (1,000s of Ha)** | **Number of Plots[2] (1,000s of Ha)** | **Average plot size (1,00s of Ha)** |
|---|---|---|---|
| Maize | 1,539 | 8,422 | 0.18 |
| Finger millet | 262 | 1,353 | 0.19 |
| Sorghum | 328 | 1,678 | 0.20 |
| Beans | 873 | 6,599 | 0.13 |
| Field peas | 27 | 127 | 0.22 |
| Pigeon peas | 22 | 192 | 0.12 |
| Groundnuts | 283 | 1,851 | 0.15 |
| Simsim | 109 | 430 | 0.25 |
| Soya beans | 31 | 229 | 0.14 |
| Cassava | 1,070 | 7,376 | 0.15 |
| Sweet potatoes | 672 | 4,704 | 0.14 |

| | | | |
|---|---|---|---|
| Irish potatoes | 47 | 494 | 0.10 |
| Banana food | 1,112 | 6,214 | 0.18 |
| Banana beer | 299 | 1,943 | 0.15 |
| Banana sweet | 66 | 999 | 0.07 |
| Coffee all | 572 | 3,505 | 0.16 |
| Tea | 40 | 27 | 1.48 |
| Cocoa | 54 | 134 | 0.40 |
| Cotton | 200 | 484 | 0.41 |
| Tobacco | 24 | 102 | 0.23 |

*Notes:* [1]*Total of pure and imputed mixed crop areas*

[2]*Both Pure and mixed*

Table 4.4 shows the planting returns and estimated yields for the Tororo district. The increasing importance of rice production can be seen. In terms of yield per unit area (both actual and expected), rice has greater production than all the other cereals. A recent campaign by the Vice President of Uganda has encouraged farmers to produce more upland rice. Increased upland rice production should positively impact wetlands since fewer swamps will be cleared for rice paddy production.

**Table 4.4: Planting returns and estimated yields for Tororo district**

| Crop | Average Yield Tons/Ha | Estimated Area planted (ha) | Expected Total Yield (Tons) | Estimated 1st Season Production Harvest (Tons) |
|---|---|---|---|---|
| Banana | 4 | 4.5 | 162 | Still growing and perennial |
| Maize | 1.7 | 10.375 | 17,636 | 10,586 |
| Sorghum | 1.2 | 4,665 | 5,598 | 3,358 |
| Finger millet | 0.8 | 4,025 | 11,220 | 6,732 |
| Rice | 2.5 | 13.650 | 34,125 | 20,475 |
| Soyabean | 1.2 | 8.384 | 10,060 | 6,036 |
| Beans | 0.5 | 4,273 | 2,136 | 1,282 |
| Groundnuts | 0.6 | 11,178 | 6,707 | 40,240 |
| Simsim | 0.3 | 12 | 3.6 | 2.16 |
| Cassava | 10 | 1,987 | 19,837 | 19,873 |
| Sweet potatoes | 8 | 3,721 | 29,770 | 20,839 |
| Tomatoes | 25 | 100 | 2,500 | 1,500 |
| Cabbages | 20 | 120 | 2400 | 1,440 |

| | | | | |
|---|---|---|---|---|
| Onions | 12 | 170 | 2,040 | 1,224 |
| Cow peas | 0.5 | 900 | 450 | 270 |
| Sunflower | 1.2 | 100 | 120 | 72 |
| Cotton | 0.6 | 18,000 | 10,800 | 6,480 |
| Coffee | 1.0 | 300 | 300 | - |
| Pineapples | 25 | 3,900 | 97.5 | Perennial and continuous piece meal harvest |

Crop yields in the SMM catchment seem higher in Kenya as illustrated in Table 4.5 which shows the production trends of selected crops in the Mt. Elgon district. For all the districts, the crop yield per hectare improved consistently from 1993 to record levels in 2004. For example maize grain yield was only 1.67t in 1993, but it was 4.09 and 3.35t in 2002 and 2004, respectively. The reason for increased yield is not clear but most probably the farmers adopted improved varieties.

**Table 4.5: Production trends of the major crop in Elgon District (Kenya)**

| **Crop** | **1993** | **1996** | **1999** | **2002** | **2004** |
|---|---|---|---|---|---|
| **1. Maize** | | | | | |
| (a) Area (ha) | 12,262 | 12,182 | 14,402 | 16,150 | 16,500 |
| (b) Total Yield (t) | 20,519 | 30,525.4 | 39,034 | 66,100 | 55,280 |
| (c) Yield/ha (t) | 1.67 | 2.51 | 2.71 | 4.09 | 3.35 |

| | | | | | |
|---|---|---|---|---|---|
| **2. Beans** | | | | | |
| (a) Area (ha) | 8,830 | 6,556 | 10,300 | 12,620 | 14,363 |
| (b) Total Yield (t) | 1,333 | 2,622.4 | 5,150 | 11,720 | 71,765 |
| (c) Yield/ha (t) | 0.151 | 0.40 | 0.50 | 0.93 | 4.00 |
| **3. Irish Potatoes** | | | | | |
| (a) Area (ha) | 187 | 504 | 404 | 1225 | 1600 |
| (b) Total yield (t) | 8 | 4,050 | 4,923 | 18,375 | 24,000 |
| (c) Yield/ha (t) | 0.04 | 10.00 | 12.18 | 15.00 | 15.00 |
| **4. Wheat** | | | | | |
| (a) Area (ha) | 180 | 401 | 190 | 376 | 400 |
| (b) Total yield (t) | 270 | 601.5 | 3,420 | 11,280 | 4,000 |
| (c) Yield/ha (t) | 1.5 | 1.5 | 1.8 | 3.0 | 1.0 |
| **5. Finger millet** | | | | | |
| (a) Area (ha) | 48 | 78 | 88 | 83 | 63 |
| (b) Total yield (t) | 37.3 | 64.4 | 88.0 | 87.4 | 139.7 |
| (c) Yield/ha (t) | 0.78 | 0.82 | 1.0 | 1.05 | 2.22 |

### 4.2.5 Horticultural crop production

The geophysical features in the catchment provide an ideal environment for a wide variety of horticultural crops. However, over the years the performance of these crops has lagged below potential due to the following (and other factors):

i. Over-dependency on perennial crops notably sugarcane, coffee, tea and nontraditional cash crops like cassava, sweet potatoes and simsims;

ii. Traditional and cultural practices on land holdings;

iii. Human attitudes towards intensive labor utilization;

iv. Over dependence on imported horticultural produce.

These deterrents continue to hinder and negatively affect crop production. Table 4.6 gives estimates for the western province of Kenya.

**Table 4.6a: Western Kenya fruit crop production summary – 2006**

| ***Crop*** | **Area Achieved in 2005 (ha)** | **Area achieved in 2006 (Ha)** | **Production (Tons)** | **Value (Ksh.) millions** |
|---|---|---|---|---|
| Bananas | 12,591 | 54 (12,645) | 136,266 | 914.45 |
| Avocadoes | 553 | 5.5 (558.3) | 6,995 | 25.87 |
| Pawpaw | 495 | 11 (506) | 6,918 | 39.41 |
| Mangoes | 537 | 15 (552) | 6,123.2 | 24.63 |
| Pineapples | 1,609 | -13 (1,596) | 32,132.4 | 161.45 |
| Passion fruit | 144.5 | 211.0 | 676.1 | 22.26 |
| Citrus | 16 | 1 (17) | 228 | 6.61 |

**Table 4.6b: Western Kenya vegetable crop production summary – 2006**

| *Crop* | Area Achieved in 2005 (ha) | Area achieved in 2006 (Ha) | Production (Tons) | Value (Ksh.) In millions |
|---|---|---|---|---|
| Tomatoes | 97.3 | 1,178.7 | 27,019 | 257.02 |
| Kales | 1,815 | 2,053 | 23,464 | 273.3 |
| Cabbage | 468.5 | 487.3 | 7,444 | 110.72 |
| Onions | 568 | 674.4 | 6,548 | 82.29 |
| Local Vegetables | 2,123 | 2,427 | 12,170 | 127.0 |
| Carrots | 24 | 50 | 297 | 5.40 |
| Spinach | 16.4 | 24 | 101 | 4.52 |
| Chilies | 275 | 144 | 164 | 17.90 |
| Mushrooms | 1.8 | 1,346kg of spawn | 7,225 kg (fresh) | 2.56 |
| Irish Potatoes | 2,940 | 5,108 | 67,309 | 305.95 |
| Cucumber | | 1.5 | | |
| Coriander | | 1.5 | | |
| Shallots | | 42 | | |
| Field peas | | 89 | | |

| | | | | |
|---|---|---|---|---|
| Garlic | | 39 | | |
| Water melon | | 10.5 | 8.0 | 3.555 |
| Fresh beans | | 15 | | |
| Floriculture | | 0.5 | | |
| Pumpkins | | 156 | | |
| Modia | | 2.5 | | 15 |
| Stronella | | 1.0 | | 0.05 |
| Rosella | | 1.0 | | 0.5 |
| Jalropha | | 1.0 | | |
| Mulberry | | 3.0 | | Not mature |
| Artemisia | | | 9.0 | Not mature |

Most crops in western Kenya are either consumed at the farm level or sold at the local markets. Mt. Elgon mostly trades potatoes and cabbages. Poor road networks and middlemen have contributed to low market farm prices. The formation of a managed marketing association would help farmers. Bungoma and Teso market onions and tomatoes within the province and neighboring towns. The largest produce sold out of the province is bananas, and the major market is the nearby town of Kisumu, Eldoret and Nairobi.

## 4.3 Livestock production

The major livestock types include cattle, goats, sheep, pigs, poultry and rabbits. Ninety percent of the livestock is raised by small holders and pastoralists in a mixed farming and range system, respectively. In both Uganda and Kenya, livestock is an important contributor to the national economy and ensures food security and nutritional balance. In addition, raw products such as milk and meat are important in local agro-processing industries. In mixed farming the livestock also provide farmyard manure and draught animal power (oxen) for the major crop production activities.

However, the importance of livestock and actual numbers vary considerably with location. In general, livestock are more concentrated in the northern SMM at Mt. Elgon in Kenya given the high potential for livestock production in that district. The available land areas are ideal for dairy cattle and wool sheep. Other areas in the catchment have varying proportions of indigenous cattle, sheep, and poultry. The available data for selected districts are provided in Table 4.7. From the table, it can be seen that the Bungoma and Elgon districts have high numbers of grade or improved livestock, particularly cattle.

**Table 4.7: Livestock population in selected districts**

| | **LIVESTOCK (1,000's)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Districts** | **Cattle** | **Goats** | **Sheep** | **Pigs** | **Rabbits** | **Ducks** | **Turkey** | **Chicken** |
| Tororo | 134,272 | 88,010 | 15,060 | 24,217 | - | 46,787 | 40,000 | 829,232 |
| Pallisa | 101,820 | 97,981 | 15,151 | 13,848 | 6125 | 30,016 | 34,253 | 253,514 |
| Bungoma | 48,000*<br>247,000 | 180*<br>35,700 | 790 | 13780 | | 39,800 | 33,000 | 751,150 |
| Elgon | 14,755*<br>28,950 | 12*<br>8,190 | 11530 | | 6515 | 1460 | 590 | 121,835 |
| Busia | 131000 | | | | | | | |
| Teso | 39000 | | | | | | | |

***Grade or improved type***

*Source: Mt. Elgon District State of Environment Report, 2004*

On the Uganda side, there is no record of improved livestock. In general, the livestock management system is agro-pastoral. Farmers cultivate food crops both for subsistence and sale while keeping livestock at the same time. The herds feed on communally grazed land, fallow land or crop land after the crops are harvested. Agro-pastoral systems are common in the Tororo, Busia, Butaleja and Pallisa districts in Uganda and the Teso, Busia districts in Kenya. The farmers use their livestock for drought power, dowry, cash savings and milk production.

Water for livestock constitutes an important water use particularly in areas that experience long dry periods. In Uganda, the livestock population was estimated at 4.5 million and the demand for water for livestock was estimated at 81 million m3/per year. This water demand was projected to rise to 223 million m3 per year by 2010.  A total of 425 medium sized dams and valley tanks including several small tanks were provided in the semi-arid areas including Pallisa. Most of these water sources have since been silted up due to poor construction, poor maintenance, and poor animal watering methods.  Additional problems have been associated with soil erosion resulting from over stocking and overgrazing.

In some districts the presence of tsetse flies (Glossina spp) has restricted livestock production due to the presence of trypanosomiasis. The flies are common in parts of southern Tororo district and the neighboring district of Busia. Other common livestock diseases include foot and mouth, rinder pests, East Coast Fever (and other tick borne diseases), and many internal parasites. These diseases and parasites lead to loss in livestock productivity. In addition, the movement of animals across the borders encourages the spread of diseases, particularly foot and mouth.

## 4.4 Irrigation and irrigation potential

In general the population in the SMM catchment is largely dependent on rain fed agriculture. Table 4.8 shows that over 95% of the population in Uganda depends on rain fed agriculture. In eastern Uganda, large-scale irrigation for agricultural activities is only about 0.4%. Most of this irrigation is for rice production in Kibimba, Bugiri, Doho, and Butaleja districts.

Small-scale irrigation accounts for about 4% in eastern Uganda. Most of this irrigation is in the fringes of swamps or wetlands and is largely for rice and vegetable production in the Tororo and Bugiri districts. The use of swamps for crop production has been expanding. The 1994 population census estimated the total area under swamp rice production at 55,000ha.

**Table 4.8: Percent water source distribution by region for agricultural activities**

| | **Main Water Source** | | |
|---|---|---|---|
| **Region** | **Irrigation** | **Rainfall** | **Swamp/wetland** |
| Central | 2.0 | 95.6 | 2.4 |
| Eastern | 0.4 | 95.5 | 4.1 |
| Northern | 0.1 | 97.1 | 2.8 |
| Western | 1.1 | 96.6 | 2.3 |
| Average | 0.9 | 96.2 | 2.9 |

In general, little progress has been made on large-scale irrigation, although there is a great potential to increase agricultural production (Table 4.9). Analysis of rainfall and evapotranspiration data indicates that supplementary irrigation is needed even in areas with high rainfall. The rapid increase in population, the shrinking land holding, and the declining soil fertility all confirm and strengthen the need for supplementary irrigation to increase agricultural production.

On the Kenya side of the SMM catchment, minor irrigation schemes have been initiated as indicated in **Appendix 4.** However, the land topography is a major constraint to irrigation development.

**Table 4.9: Current Status of water use for crop production in Uganda**

| Irrigation project | District | Source of water | Main crop | Area (ha) |
|---|---|---|---|---|
| **A.** Large scale | | | | |
| 1. Kibimba | Iganga | Kibimba Reservoir | Rice | 600 |
| 2. Doho | Tororo | Manafwa River | Rice | 1,000 |
| **B.** Small scale | Tororo | Mpologoma Lumbika, Mpologoma | Rice | 24,500 |
| | Pallisa | | Rice | 10,800 |
| **Total** | | | | **36,900** |

## 4.5 Farming systems and their impact on land degradation

Improved land management in the catchment would result in an economic gain. In Uganda, land resource degradation accounts for over 80% of the annual environmental degradation costs. Estimates of these annual costs were approximately $157 to $480 million US dollars in 1991 (Slade and Weitza, 1991). When these values are capitalized at a government capital rate of 12% p.a., the environmental degradations costs represent $1 to $4 billion US dollars in 2007.

Land degradation is a complex process that lowers the quantitative and/or qualitative capacity to produce the desired goods and services. Degradation processes lead to a decrease in soil quality and can be generally divided into three interactive groups: physical, chemical, and biological (Lal *et al* 1975). Two types of land degradation can be recognized in the catchment, soil degradation and vegetation degradation.

Soil degradation involves partial or total loss of productivity and qualitative attributes. Soil degradation occurs as a result of erosion, surface crusting, compaction, water logging, and extreme acidification, loss of plant nutrients (fertility degradation), pollution and loss of soil structure.

Of these soil degradation mechanisms, the most prevalent in the catchment are nutrient depletion and soil erosion. Both have serious long-term implications because the processes cannot be reversed easily. Both water erosion (rill and gully) and nutrient depletion pose the greatest threat to land productivity in the catchment. Evidence of soil erosion and nutrient depletion is rampant particularly in the hill slopes. Although soil degradation problems (particularly erosion) are widely recognized, actual quantities of soil lost and off-site damage caused are not accurately known. According to Bekunda and Lorup (1994), rivers originating from South-Western Mountains and Mt. Elgon in Uganda carry massive amounts of sediment. Bagoora (1990) obtained high erosion values of $100 g/m^2$, which corresponded to a one ton per hectare soil loss in a single rain storm on an open lot.

In the Mt. Elgon district, annual soil loss is estimated at 750 tons per hectare per year. This erosion together with other forms of degradation can create serious limitations for food production if uncontrolled.

Even in the relatively flat districts of Iganga, Tororo, Busia and Pallisa, in Uganda, erosion continues to occur at a high rate largely through rill and sheet erosion. This erosion results in gradual but steadily increasing losses in soil productivity. The uncontrolled runoff of excessive rain water causes sheet erosion and eventually leads to gullies and land slides with corresponding decreases in soil productivity and increases in river, stream and lake siltation. As mentioned earlier, all the valley tanks have been silted through soil erosion.

## 4.6 Emerging issues

Farming systems in the catchment are largely traditional, and do not typically follow current environmental management practices. Inappropriate use of arable land including excessive cultivation, cropping too frequently, inadequate fertilization, and soil exposure through grazing or removal of crop residues have put considerable strain on the land. Excessive cultivation breaks the soil structure, may compact the soil below the plough layer, and may also cause crusting which reduces soil moisture retention and increases run off and erosion.

Generally, arable land is left bare for extended periods, thus making it more likely for soil degradation. In most areas there has been serious shortening of fallow periods, and in many cases fallow periods have been abandoned altogether because of the population pressure. This practice has led to repeated use of the same land year after year without adequate soil conservation measures. High population pressure has also led to land fragmentation and has pushed farming into marginal areas and steep hill slopes that are more vulnerable to soil erosion and nutrient loss. In addition, extensive cultivation is a common practice by converting ecologically fragile areas into farm lands. Forest land encroachment is particularly critical in some areas of the Mt. Elgon district (Cheptains and Kopsiro divisions).

As shown in Plates 4.2 and 4.3 farmers have cultivated steep slopes and river banks without soil conservation practices in place.

**Plate 4.2: Erosion on hilltops**

**Plate 4.3: Cultivation on river banks**

Crop production using a variety of chemicals (e.g. nitrogen fertilizers and herbicides) has intensified. Chemicals are largely used in plantation agriculture (sugar cane).

The most crucial issue is that most farmers have inadequate knowledge of improved farming methods and land degradation. Part of the reason is a shortage of extension staff. Other issues include uncontrolled forest clearing and widespread bush burning and over grazing which cause erosion and soil productivity decline. Land degradation due to over grazing has occurred largely because livestock populations per unit area have exceeded the safe stocking rate. In the Pallisa district, communal grazing areas like wetlands (which are the only places with water during dry seasons) are badly degraded. As explained earlier, valley dams have been silted. The high livestock concentration near watering points and feeding places also destroys vegetation.

In summary, the major causes of land degradation in the catchment include:

- High population densities
- Diminished farm sizes and land fragmentation
- Over cultivation and repeated cultivation
- Farming on marginal areas such as steep hill slopes and river banks

- Lack of fallow periods
- Lack of crop rotation
- Inadequate soil conservation measures
- Frequent bush and trash burning
- Inadequate advisory services
- Inadequate knowledge on degradation problems
- Inadequate knowledge of improved farming methods
- Land tenure issues particularly the Mailo district
- Inadequate use of soil amendments

## 4.7 Mitigation measures and investment issues

The history of mitigation and soil conservation measures in East Africa is a long one particularly in southwestern Uganda. Environmental concerns date back to 1911 with the colonial government. A historical summary is outlined below (Tukahirwa and Veit, 1992).

**1900** Population increased and the need for arable land forced the farmers to cultivate the steep hilltops. Animal husbandry gave way to cultivation.

**Mid 1928's** Population pressure was identified as the main cause for land resource damages; over cultivation and inappropriate farming methods were denuding the slopes, causing accelerated soil erosion and leading to productivity declines. Land fragmentation increased (Denoon, 1972; Tindituuza and Kateete 1971). Fuel wood shortages forced people to burn cow dung or purchase wood from neighboring areas.

**1935** Marked the beginning of organized land management courses for extension officers and chiefs. In the same year, the Kigezi District (present Kabale, Kisoro and Rukungiri) passed a series of soil conservation bylaws.

**1949** The region developed soil conservation measures (Uganda Protectorate 1949).

**1953** Initiation of the resettlement program by the British Government (Colonial Government) encouraging migration to other parts of Uganda. The incentives were that those migrating would receive 10 acres of land, free transport, subsidized food, and 6 months tax exemption. This program drastically reduced the region's population growth.

In general there have been many attempts to reduce or minimize land degradation. In Uganda various areas have received innovations in land husbandry and agro-biodiversity conservation. Both local and foreign innovators have developed strategies offering solutions to the widespread land degradation. Despite this, however, there are still many driving forces and pressures that need attention to develop sustainable land use and management systems.

Below is an outline of recommendations for mitigation measures. Further details of the various land degradation issues, their causes, and investment proposals are provided in Table 4.10.

**(i) Review and strengthen the soil conservation measures**

Soil conservation measures include terracing, contours, strip cultivation, ridge and tie ridging, grass strips, and bands. Some of these methods were introduced during the colonial times but have since been largely abandoned. In some areas like Mt. Elgon and Manafwa, farmers are destroying the terraces to expand their cultivation areas, and this has led to disastrous effects on soil erosion

Currently, there is also a problem in Uganda over responsibility for enforcing by-laws i.e. either the LCs or the Chiefs. The roles of LCs and Chiefs with regard to enforcing conservation measures should be clearly defined.

**(ii) Review and strengthen coordination**

In Uganda, there is a general lack of central authority to provide a coordinated policy for land resource use and improved soil conservation. The districts operate independently and plan and implement their own activities. As a result the MAAIF is becoming more removed from the districts, and technical oversight is inadequate. In Kenya, the situation is as decentralized.

**(iii) Strengthen capacity and facilitation**

Providing grassroots awareness is necessary. Farmers, civic leaders and government officials need to be educated on the dangers of land degradation. Facilitation of cross border meetings should be provided to improve awareness and ensure coordination and collaboration with neighboring countries and districts.

**(iv) Enhance efforts in service delivery**

In Uganda service providers have not been available as was originally planned. Many farmers have complained that they have never heard about NAADS.

**(v) Address land shortage/high population issues**

Currently the high population is causing serious land degradation. There is need to understand the dynamics involved in high population and land fragmentation. Investment proposals should consider population issues and assess land purchases or exchanges for consolidation.

**(vi) Crop rotation**

Well designed rotation is essential to minimize soil degradation and sustain productivity. Efforts should be made to ensure that farmers do not grow the same crop every year. Rotation should include nitrogen fixing legumes.

**(vii)** Integrate agro forestry practices which have proved viable. For example, implement alley cropping hedge rows in the Kigezi district. In addition, plant trees and other vegetation to cover the presently eroded slopes and prevent further erosion.

**(viii)** Minimize the cultivation of steep slopes outside the recommended slope range. Cultivation near river banks and lake shores should also be discouraged. Efforts should be made to enforce the 100m cultivation limit.

**(ix)** Formulate a policy ensuring that land users are also land owners. This policy will promote investment for long-term conservation.

**(x)** Conduct a national survey to map land according to its use capability and formulate a national land use policy which includes sound management guidelines.

**(xi)** Encourage a sustainable stocking rate for livestock. The high livestock density particularly in Mt. Elgon and Paliisa has caused extensive soil degradation.

**(xii)** Construct valley dams and valley tanks and improve maintenance of existing ones to minimize animal movement and reduce overgrazing.

**Table 4.10: Land degradation causes, mitigation and investment options**

| | LAND USE/DEGRADATION ISSUES/PROBLEMS | CAUSES | MITIGATION MEASURES/ INVESTMENT PROPOSALS |
|---|---|---|---|
| 1. | Unsuitable land use practice/fragile ecosystems<br>(i) Farming on marginal areas/steep hill slopes<br>(ii) Frequent bush burning<br>(iii) Over cultivation/repeated cultivation<br>(iv) Lack of fallow/shortened fallow periods<br>(v) Encroachment on wetlands/forest ecosystems<br>(vi) Farming on river banks | ➢ High population pressure and survival strategy<br>➢ Inadequate knowledge of degradation problems<br>➢ Inadequate knowledge of the dangers of farming on river banks | (a) Address land shortage/high population issues<br>(b) Strengthen capacity and facilitate improved grass root awareness.<br>(c) Facilitate cross border meetings to improve awareness and ensure coordination<br>(d) Investment proposals should target population control:<br>(i) Adolescent and adult reproductive health programs<br>(ii) Job opportunities and incentives to encourage migration away from fragmented areas<br>(iii) Invest in education for observing the 100m limit |

| | | | |
|---|---|---|---|
| | | | (iv) Promote consolidation programs |
| 2. | Unsuitable farming methods<br><br>(i) Lack of crop rotation<br><br>(ii) Use of unimproved technologies | ➢ Inadequate advisory services<br><br>➢ Unavailability of improved technologies<br><br>➢ Inadequate knowledge of improved farming methods<br><br>➢ Inadequate linkage/coordination between MAAIF and MOLG/NAADS in Uganda | (a) Design and encourage crop rotation which include N-fixing legumes and deep rooted crops<br><br>(b) Review and strengthen coordination of agricultural production by MAAIF<br><br>(c) Improve institutional arrangements e.g. NAADS to improve farming practices |
| 3. | Excessive land fragmentation and diminished farm sizes<br><br>(i) Land is owned in small parcels usually scattered<br><br>(ii) The parcels are rarely more than 0.5ha<br><br>(iii) Farm holdings are not able to sustain household requirements thus leading to increased poverty. | ➢ High population pressure<br><br>➢ Scattered settlements within the small family farms<br><br>➢ Excessive subdivision of land owing to traditional inheritance system<br><br>➢ Subsistence farming methods are exploitive and lead to soil degradation | (a) Address land shortage/high population issues (e.g. reduce rate of population growth in high populated rural areas) though<br><br>(i) Encouraging birth control<br><br>(ii) Creation of job opportunities and other incentives in urban areas that will encourage migration away from fragmented land<br><br>(b) Initiate research to understand the dynamics involved in high population/land |

| | | | |
|---|---|---|---|
| | | | fragmentation<br><br>(c) Strengthen institutional capacity to improve awareness of the dangers of land fragmentation.<br><br>(d) Investment proposals should target population control and assessments of land purchases or exchanges to encourage consolidation of fragmented lands. |
| 4. | Insecure land tenure system<br><br>(i) Weakly defined ownership of agricultural land undermines production and discourages investment for environmental protection. | ➢ The Land Act of 1998 recognizes four types of land ownership<br><br>(i) Customary tenure<br><br>(ii) Mailo tenure<br><br>(iii) Freehold tenure<br><br>(iv) Leasehold tenure<br><br>Customary tenure is dominant in the catchment and is associated with increasing fragmentation as the number of household members grows. Land farmers are unable to make | (a) Expedite the implementation of the land use policy recently proposed for Uganda.<br><br>(b) Review the land holding systems to discourage/minimize land fragmentation.<br><br>(c) Review the present tenure system with the objective to adopt a uniform tenure system that is easily understood by both land owners and land users.<br><br>(d) Formulate land policy that ensures land users are also land owners and promote long-term investment in soil conservation. |

| | | | |
|---|---|---|---|
| | | long-term investments on fragmented land. | |
| 5. | Extensive rill and sheet erosion:<br><br>(i) contribute to soil degradation. Soil degradation is associated with:<br><br>• Soil erosion<br>• Soil compaction<br>• Development of crust<br>• Soil acidification<br><br>(ii) cause increased losses in soil productivity<br><br>(iii) cause silting and blocking of watercourses, reservoirs, lakes, valley dams and valley tanks. | ➢ Destruction of vegetation cover<br><br>➢ Over exploitation of the land/cropping too frequently<br><br>➢ Inadequate soil conservation measures<br><br>➢ Poor farming methods e.g.<br><br>(i) Low plant population<br><br>(ii) Late planting<br><br>(iii) Use of unimproved varieties/cultivars<br><br>➢ Poor recycling of organic matter<br><br>➢ Over grazing<br><br>➢ Excessive cultivation<br><br>➢ Inadequate use of fertilizers<br><br>➢ Weak law enforcement mechanism | (a) Educate farmers to adopt and use improved farming technologies.<br><br>(b) Improve capacity for technology transfer<br><br>(c) Strengthen the law enforcement mechanism<br><br>(d) Encourage research on soil, land forms, vegetation, land use and agro-ecologies to ensure that conservation measures are implemented.<br><br>(e) promote and encourage improved land use and management practices that will minimize run off e.g.<br><br>▪ Deep cultivation<br>▪ Use of organic manure<br>▪ Use of contour bands<br>▪ Use of appropriate crop rotation e.g. |

| | | | |
|---|---|---|---|
| | | for soil conservation measures. | include deep rooting crops and N-fixing<br>▪ Use of appropriate intercropping<br>▪ Use of terraces<br>(f) Encourage the use of optimum plant densities for various crops<br>(f) Promote the use of optimum stocking rates to avoid overgrazing<br>(g) Create awareness of the dangers of soil erosion and soil degradation in general. |
| 6. | Agro-biodiversity<br>(i) Present land use practices lead to loss of bio-diversity in addition to environmental degradation.<br>(ii) Traditional varieties e.g. bananas, cassava, potatoes, are declining | ➢ Introduction of improved varieties may neglect of local cultivars<br>➢ Lack of market<br>➢ Diseases and pests because traditional varieties may be less resistant. | (a) Reintroduce the economically profitable traditional varieties<br>(b) Educate farmers, NGOs, CBOs on the benefits of rich biodiversity<br>(c) Promote the use indigenous knowledge (IK) with respect to collection, utilization, management and conservation of plant genetic resources.<br>(d) Promote farm conservation of crop |

| | | | |
|---|---|---|---|
| | | | cultivars at district and village level. |
| 7. | Deforestation<br><br>(i) Extensive deforestation on private, communal, and public lands has led to massive land degradation. | ➢ Expansion of agricultural production<br><br>➢ Lack of alternative sources of domestic energy<br><br>➢ Weak policies and inadequate enforcement of by-laws. | (a) Educate the public on the benefits of forest conservation<br><br>(b) Strengthen and update policies which handle forested areas<br><br>(c) Strengthen implementation/enforcement of forest resource utilization under different ownership categories.<br><br>(d) Encourage tree planting as a source of energy and income generation through agro-forestry and forestation practices.<br><br>(e) Promote the use of high yielding disease resistant crop varieties to achieve higher yield per unit area and minimize agricultural expansion.<br><br>(f) Promote the use of energy saving cooking stoves.<br><br>(g) Create incentives for the protection of forests outside protected areas. |

| | | | |
|---|---|---|---|
| 8. | Intensification of agriculture leads to pollution.<br><br>The effects of agro-chemical/pesticides are becoming wide spread, but relatively unstudied. | ➢ Great emphasis on crop diversification particularly high value export crops likely to lead to greater use of agro-chemicals.<br><br>➢ Majority of present farmers have little knowledge of agro-chemicals.<br><br>➢ Residual effects of agro-chemicals on the catchment environment are relatively unstudied. | (a) Promote the use of agro-chemicals in quantities that will minimize pollution.<br><br>(b) Promote research that will monitor pollution levels in the soil and water around horticultural farms, industries and mines<br><br>(c) Conduct environmental impact assessments for all planned large scale farms to ensure potential impacts are mitigated.<br><br>(d) Promote organic farming in the major agricultural enterprises in the catchment.<br><br>(e) Investment proposals should emphasize intensification of educational programs on the dangers of pollution arising from improper use of agro-chemicals. |
| 9. | Dependence on agriculture and rainfall conditions<br><br>(i) Farming in the catchment is almost 100% dependent on rainfall conditions<br><br>(ii) Unreliability of rain leads to risks in production. | ➢ Variability in climate is the cause of drought and diversification<br><br>➢ Climate change has had devastating effects on agricultural production in Uganda. | (a) Intensify the use of early warning systems to prepare the farming communities for possible droughts.<br><br>(b) Improve long-term weather forecasting to predict and respond to drought and general crop water deficits. |

| | | | |
|---|---|---|---|
| | | | (c) Investment proposals should include:<br><br>(i) Research to identify drought resistant/tolerant crops<br><br>(ii) Comprehensive assessment water demands for different crops and different agro-ecological zones.<br><br>(iii) Conduct a comprehensive study to determine the feasibility of intensified irrigation agriculture in the catchment.<br><br>(iv) Conduct education and extension programs on soil degradation, conservation, and water harvesting techniques. |
| 10. | Severe degradation on rangelands and other grazing areas<br><br>(i) Rangelands (also called cattle corridors) occupy about 43% of the total land area but are significantly degraded. | ➢ Overgrazing due to over stocking<br><br>➢ Communal grazing<br><br>➢ Growth in human population<br><br>➢ Poverty and lack of knowledge of animal management<br><br>➢ Shortage of water | (a) Promote the use of more productive weeds<br><br>(b) Control stocking rate and provide farmers with incentives to destock.<br><br>(c) Provide effective extension services<br><br>(d) Investment proposals should include; |

- Shortage of pastures
- Seasonal bush burning
- Inadequate extension services
- Invasion and proliferation of cultivation into areas only suitable for grazing.

(i) Identification and promotion of cost-effective practices in the management of ranges and pastures.

(ii) Provision and improvement of watering points including the construction of valley dams and valley tanks.

(iii) Planting of trees, fodder and grass in degraded land areas.

(iv) Development of techniques for water harvesting

(v) Improvements through cross breeding.

# 5.0 Fisheries and Aquaculture

This section presents fish types in the rivers and lakes within the Sio-Malaba-Malakisi (SMM) catchment; the fish catches and trends; fisheries management frameworks; community involvement in fisheries management; aquaculture production; fish processing; and exports.

## 5.1 Fisheries

### 5.1.1 Fish species in Lake Victoria

The fish species found in Lake Victoria are shown in Table 5.1. Many of these species for example, *Clarias spp, Synodontis, Labeo victorianus, Barbus spp, Normyrus, Gnathonemus, Marcusenius sp, Petrocephalus, Schilbe mystus* swim up river to breed but live and feed in open lake waters through a process called "anadromesis". The Sio River is one of the important breeding rivers as demonstrated by several studies (Whitehead, 1959, Okedi, 1965, Welcomme 1974, Cadwallader 1965, 1969, and others). If fish are prevented from swimming upstream to breed, then spawning will not be possible. Not only could the fishery industry suffer, but these species could also die out.

There are other fish species which live comfortably both in Lake Victoria and rivers. These include the tilapiines (such as *O. Esculentus*, *Oreochromis niloticus, O. Variabilis, O. Leucosticus, T. Zillii)* and the Haplochhhromis species flock (such as *Lates niloticus, Protopterus aethiopicus and Rastrineobola argentea).* These species are endemic to Lake Victoria. Only *Lates niloticus and Oreochromis niloticus* are exotic to the lake and were introduced in later years from other water bodies.

**Table 5.1: Fish species of Lake Victoria and Lake Kyoga**

| **Species** | **Lake Victoria** | **Lake Kyoga** |
|---|---|---|
| *Bagrus docmak* | P | P |
| *Lates niloticus* | P | P |
| *Brynicinus jacksonii* | P | P |
| *Brynicinus sadleri* | P | P |
| *Oreochromis niloticus* | P | P |
| *O. leucostictus* | P | P |
| *O. variabilis* | P | P |
| *Tilapia zillii* | P | P |
| *Haplochromines* | P | P |
| *Clarius gariepinus* | P | P |
| *Barbus altianalis* | P | P |
| *Labeo victorianus* | P | P |
| *Rastrineobola argentea* | P | P |
| *Aplocheilicthys pumilus* | P | P |
| *Protopterus aethiopicus* | P | P |
| *Synodontis afrofischeri* | P | P |

| | | |
|---|---|---|
| *S. victoriae* | P | P |
| *Marcusenius grahami* | P | P |
| *Mormyrus macrocephalus* | ? | P |
| *M. kannume* | P | P |
| *Petrocephalus catastoma* | P | P |
| *Gnathonemus longibarbis* | P | P |
| *Gnathonemus victoriae* | P | P |
| *Schilibe intermedius* | P | P |
| *Astatoreochromis alluadii* | P | P |
| *A. "kyoga astato"* | | P |
| *A.nubila* | | P |
| *H. serranus* | | P |
| *Lithochromis sp* | | P |
| *Mbipia sp* | | P |
| *M.* "scarlet" | | P |
| *Neochromis sp.* | P | P |
| *N. nigricans* | P | P |

| | | |
|---|---|---|
| *N.*yellowfish | P | P |
| *N.* redfin | P | P |
| *N.* "20416" | P | P |
| *N. simotes* | P | P |
| *Paralabidochromis* "blackpara" | P | P |
| *P.* "bluepara" | P | P |
| *P.* "earthquake" | P | P |
| *P.* rock cribensis | P | P |
| *Psammochromis* "shovelmouth" | P | P |
| *Ptyochromis sp* | P | P |
| *Pundamilia sp* | P | P |
| "Haplo" orangefin | P | P |

**"P"** denotes that the fish species is present

### 5.1.2 The Lake Victoria fisheries

The Lake Victoria fishery is extremely important for Kenya, Uganda and Tanzania. For the three countries, the Lake Victoria fishery is estimated at 500,000 metric tons valued at about $500 million USD annually. Fish exports from Lake Victoria from the three countries are estimated at $250 million USD annually. In Kenya and Uganda, fisheries contribute 0.5% and 1.5%, respectively, to the GDP. The Lake Victoria fishery also offers direct employment to approximately 180,000 fishers and 600,000 fish traders. About 7 million people depend directly or indirectly on the Lake Victoria fisheries in Kenya, Uganda and Tanzania. Furthermore, many more people both within and out of the basin depend on fish for food. Fish catches from the Ugandan part of Lake Victoria and from Lake Kyoga are shown in Table 5.2 and are illustrated in Figure 5.1. As shown, fish catches rose from 25.5 to 136.1 metric tons in this period. However, Lake Victoria has been reduced to a three species fishery of the Nile perch, Tilapia and Rastreneobola, as shown in Figure. 5.2.

**Table 5.2: Ugandan fish catches in Lake Victoria and Lake Kioga (metric tons)**

| **Year** | **L.V.** | **L.K.** |
|---|---|---|
| 1961 | 25.5 | 12.5 |
| 1962 | 23.4 | 12.1 |
| 1963 | 24.4 | 12 |
| 1964 | 24.4 | 10.2 |
| 1965 | 24.4 | 12.6 |
| 1966 | 28 | 10.9 |
| 1967 | 38.2 | 12.9 |
| 1968 | 40.5 | 13 |
| 1969 | 46.3 | 11.8 |
| 1970 | 41.7 | 10.5 |
| 1971 | 38.1 | 11.7 |
| 1972 | 33.9 | 12.3 |
| 1973 | 32.5 | 11 |

| | | |
|---|---|---|
| 1974 | 24.5 | 10.5 |
| 1975 | 16.9 | 13.2 |
| 1976 | 11.1 | 12.5 |
| 1977 | 15.7 | 12 |
| 1978 | 14.2 | 11.8 |
| 1979 | 12 | 9.6 |
| 1980 | 10 | 7 |
| 1981 | 17 | 5 |
| 1982 | 13 | 6.9 |
| 1983 | 17 | 6 |
| 1984 | 44.8 | 6.5 |
| 1985 | 54.6 | 6 |
| 1986 | 56.8 | 6.3 |
| 1987 | 93.2 | 6.2 |
| 1988 | 107.1 | 5.9 |
| 1989 | 132.4 | 5.6 |
| 1990 | 119.94 | 5.5 |
| 1991 | 118.04 | 10.93 |
| 1992 | 120.4 | 10.6 |

| | | |
|---|---|---|
| 1993 | 111.5 | 10.7 |
| 1994 | 103.04 | 10.8 |
| 1995 | 103 | 9 |
| 1996 | 106 | 5 |
| 1997 | 106 | 6 |
| 1998 | 105.2 | 5.6 |
| 1999 | 104.2 | 7.43 |
| 2000 | 133.4 | 5.22 |
| 2001 | 131.8 | 6.4 |
| 2002 | 136.11 | 5.22 |

*Source: (Adapted from Reports of the Fisheries Resources Department of Uganda)*

**Figure 5.1: Annual fish catches from Lakes Victoria, Albert, Kyoga, and Victoria**

1961 **YEARS** 2002

VICTORIA ALBERT KYOGA LAKE LEVELS

Source: *(Adapted from Reports of the Fisheries Resources Department of Uganda 1961-2002)*

In the Kenyan part of Lake Victoria, the Busia district is the only riparian area of the SMM catchment where capture fisheries are undertaken. This district covers a surface area of approximately 137 $km^2$, extending from Sio Port at the border with Uganda to Osieko Beach in the Budalangi division. Open water capture fisheries are undertaken in the Funyula and Budalangi divisions of the Busia district. In 2006, the district had 21 operational landing sites. During the same year, 4,177 fishermen and 1,450 fishing boats were estimated within the Busia waters of Lake Victoria. Based on the 2006 surveys, fishing boats were propelled by paddles (50%), sails (41%) and outboard engines (9%). The main fishing gear included gill nets, long lines, hook and line, small seines, beach seines and cast nets although they are proscribed. The monthly fish catches for 2006 in Busia District is shown in Table 5.3.

**Table 5.3: Fish catches from Busia District, Kenya, 2006**

| Month | Weight (Kgs) | Value (Kshs.) |
|---|---|---|
| January | 573,601 | 50,038,430 |
| February | 484,504 | 41,287,000 |

| | | |
|---|---|---|
| March | 545,269 | 39,047,460 |
| April | 253,499 | 21,207,025 |
| May | 294,239 | 25,734,371 |
| June | 528,374 | 29,377,900 |
| July | 451,908 | 28,701,490 |
| August | 287,311 | 19,797,340 |
| September | 470,783 | 31,897,333 |
| October | 399,382 | 28,425,150 |
| November | 335,843 | 18,317,415 |
| December | 423,948 | 22,041,460 |
| Total | 5,048,661 | 355,872,374 |

The percentage fish species caught in the Busia district of Kenya is shown in Table 5.4. Figure 5.2 shows the three major commercial fish species caught in Lake Victoria.

**Table 5.4: Percentage of fish species caught in Busia, Kenya**

| | |
|---|---|
| Lates Niloticus (Nile Perch) | 44% |
| Rastrineobola | 31% |

| | |
|---|---|
| Tilapia | 24% |
| Others* | 1% |

**Figure 5.2: Major commercial fish caught in Lake Victoria (% of total in 2000)**

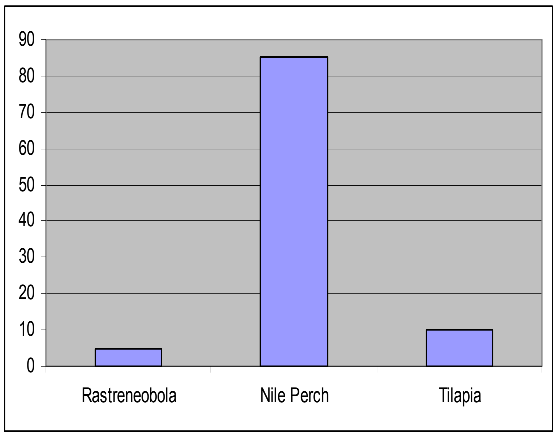



**Plate 5.1: *Rastreneobola* dagaa being dried on the shores of Lake Victoria**

(Photograph near Majanji in Uganda, near the Sio River.)

On the Uganda side, there is not much fish production information from the Lake Victoria riparian districts in the SMM catchment. In the Busia District in 2000, there were four un-gazetted fish landing sites. In 2002, there were three in Busia and one in Majanji. In 2001 and 2002 there were four fishing boats with engines; in 2002 and 2002 there were 177 and 210 boats without engines, respectively. There is one fish market with permanent handling facilities. Some 16 fish markets have temporary fish handling facilities. There were 143fishermen in 2001 (Fisheries Department, Busia 2003).

Fish landing facilities on both the Kenyan and Ugandan sides of Lake Victoria are being considered for rehabilitation through the Lake Victoria Fisheries Management Project, Phase 2. The second phase of this project is scheduled to start early in 2008. Similarly under the EU Project in Uganda, some 30 Fish landings will be upgraded to include provisions for fish handling and washing facilities, safe clean water, power, cooling, storage facilities, and road network improvements.

### 5.1.3 The Lake Kyoga fish species

The fish species found in Lake Kioga are shown in Table 5.0. Plate 5.2 shows *Protopterus aethiopicus,* the African lung fish, a common inhabitant of Lake Kyoga and its wetlands.

This fish is an aerial breather, aestivates in drying wetlands, and is an extremely important food source for the local communities.

**Plate 5.2: *Protopterus aethiopicus*, the African Lung Fish from Lake Kyoga**

### 5.1.4 The Lake Kyoga fisheries

Lake Kyoga is a very shallow flooded river basin whose level oscillates between 2.5 to 3.5 meters. Because the Lake Kyoga shoreline is primarily a wetland, fertilizing has a significant effect. Further, the enormous wetland vegetation performs well as a fish fry habitat. The average fish catch after 1962 floods is 93 metric tons per year as shown in Table 5.1, where the fish catch has been estimated from 1961 to 2002 (Source: Fisheries Resources Department of Uganda Reports). These figures are also plotted in Figure. 5.1. The fish catch from Lake Kioga was much greater than Lake Victoria in the 1970s and 1980s as shown in Figure. 5.1.

### 5.1.5 Riverine and floodplain fisheries

Rivers and their associated floodplains have characteristic fisheries. Many of the fish species swim up rivers to breed during the spawning period. Others live in the rivers and associated wetlands. These species often have mechanisms that help them survive in relatively anaerobic conditions, such as accessory breathing mechanisms that enable them to breath in air. Example species include the African lung fish, *Protopterus aethiopicus* and the *Clarias* species. These fish are very important in riverine and floodplain fisheries found along the Malaba, Sio, Manafwa and Mpologoma Rivers. A floodplain fishery is illustrated in Plate 5.3 and some of the species are illustrated in the Plate 5.4 below.

**Plate 5.3: Fisherman in the flooded banks of the Malaba Tributaries**

**Plate 5.4: Catfish caught in the Malaba flood plain**


### 5.1.6 Trout farming

Trout farming in the SMM catchment is unexploited but has good potential particularly in the Mt. Elgon district in Kenya and Uganda. Trout needs fast flowing clear water, without silt and an optimal temperature of 12 degrees centigrade. These conditions prevail in the upper catchment districts. Trout also already exist in local rivers having been introduced during colonial times. Trout farming and sport fishing were viable industries in Mt Elgon until the 1960s, but they are now virtually nonexistent in both countries. The predominant species is rainbow trout. A significant trout market still exists in the hotel and tourism industries where trout is a delicacy and the most expensive fish available in East Africa.

In Kenya, the Trout Development Project received government funding in 2000. However, the project was stalled due to technical and administrative problems. The project had the following objectives:

- To promote trout farming in the district both for local consumption and sale outside the district;

- To promote tourism through sport fishing, fishing camps, hotels, and curio shops;
- To provide a cheaper and readily available trout supply for the Mt. Elgon district and other areas in Western Kenya;
- To reduce the import of trout eggs by constructing a hatchery; and
- To act as a training facility for farmers and students on trout farming.

There are still good prospects for commercial trout farming in the Mt Elgon district both in Kenya and Uganda where the rivers have suitable temperatures and very clear water. A high demand for trout exists in the region's hotel and tourism industries. Therefore, investment projects to develop trout farming in the upper SMM catchment have good chances for success.

## 5.2 Institutional arrangements for fisheries management

### 5.2.1 Fisheries departments

In both Kenya and Uganda the Departments of Fisheries are responsible for management and control of fisheries activities. These departments operate under the Ministry of Agriculture in Uganda and the Ministry of Natural Resources in Kenya.

The Fisheries Departments in both countries have responsibility for the sustaining the fishery resources at optimal economic levels and maintaining their availability for both present and future generations. These departments formulate government policies in the fisheries sector, develop national plans and strategies to achieve set goals within the policy guidelines, and monitor the fisheries sector performance. Both countries have decentralized fisheries management activities to the district level.

The Fisheries Department in Kenya is headed by a Director assisted by Deputy Commissioners. In Uganda the Department is headed by a Commissioner assisted by several Deputy Commissioners in charge of Fisheries Production and Fisheries Regulation and Control. In both countries, the Fisheries Departments are responsible for the following:

- Drafting and reviewing policies and standards governing the fisheries sub-sector;
- Preparing fisheries regulations and guidelines and reviewing fisheries legislation;
- Drafting national and zonal plans and strategies for the fisheries sub-sector;
- Advising on improved fish handling techniques, processing, preservation, storage, transportation and marketing;
- Advising for more efficient and effective production techniques for fish farming, e.g. site selection, pond design, pond construction, stocking, cropping and management;
- Co-coordinating fishing activities with neighboring countries;
- Inspecting the activities of fish processors to ensure compliance with national and international standards;
- Providing technical guidance and assistance, including capacity building to the district fisheries extension personnel.

A number of these duties have been decentralized to districts, for example, providing advice on fish processing and handling; collecting, processing and maintaining district data and on the fisheries sub-sector; and monitoring, inspecting, evaluating and co-coordinating fisheries extension activities in the district.

There are three major cadres of technical staff in the Fisheries Department at the district level. These are a Fisheries Officer, who is normally a graduate; an Assistant Fisheries Development Officer, who is usually a diploma holder; and a Fisheries Assistant, who is normally a certificate holder.

### 5.2.2 Fisheries research

Both Kenya and Uganda have Fisheries Research Institutes located in Kisumu (KEMFRI) and Jinja (FIRRI). FIRRI was established in 1948 by the British colonial administration as a regional organization responsible for fisheries research throughout East Africa. It subsequently evolved into the regional East African Freshwater Fisheries Research Organization (EAFFRO) under the East African Community (EAC). After the break up of EAC, EAFFRO evolved into the Uganda Freshwater Fisheries Research Organization (UFFRO), which became FIRI and later NAFIRI following the creation of NARO. KEMFRI was established for freshwater fisheries research in Kenya in the 1960s but later evolved to a full fisheries research institute after the break up of the EAC in 1977.

### 5.2.3 Beach management units (BMU)

In the past, fisheries management in both countries was with the central government and was based on a command and control approach. However, management problems were encountered due to enforcement difficulties, lack of compliance, poor fishery resource utilization, and lack of ownership. Among the riparian measures implemented to control fishing were Beach Management Units (BMUs). Under the various Fisheries Acts, the Beach Management Units were established in selected gazetted fish landing sites. On the Sio River, there is a BMU on the Kenyan side and there is another on the Ugandan side. Under this arrangement, fisheries are co-managed. The BMU concept is popular with communities on both sides of the Sio River and in the Lake Kioga fishery. The BMUs have the following advantages.

- They move from a command and control management system to a participatory approach, and they provide an avenue where citizens and government (local and central) share responsibility in fisheries planning, development, and management as active partners.
- They empower communities, in partnership with local governments, to control fishing and how to share fisheries benefits.
- They provide the institutional structure at the grass roots to improve planning and sustain fisheries resources.
- They are legally empowered.

- They include fisheries stakeholders, are gender sensitive, and include poor stakeholders.
- They provide transparent and free elections.
- They are empowered to collect and manage funds.
- They are empowered to make by-laws.
- They are empowered to collect data and other relevant information on fisheries management.
- They improve control and monitoring.

As a new innovation, BMUs need strengthening to eliminate some of the following shortcomings:

- The roles of the local and central government in relation to BMUs are not clearly defined.
- The BMUs have a weak legal base and hence limited power.
- BMU committees are not legal entities or autonomous bodies.
- BMUs lack political clout.
- BMU assets, although acquired from the funds they generate, belong to government.
- Delegation of authority is at the discretion of the BMU chairperson.
- Liabilities for losses associated with the BMU are not specified.
- Revenue sources are limited.
- Tenured positions are too short and no provision is made for continuity.

- The communities were not fully informed on the roles of BMU committee members and as a result did not necessarily elect the best candidates.
- Penalties were low and ineffective.

## 5.3 Issues of concern in fisheries

The major fisheries issues of concern in SMM are:

- About 200 fish species have disappeared from Lake Victoria over the last 40 years, and now the commercial fishery has been reduced to a three species-Nile perch, the Nile tilapia and *Ratrineobola* (Mukene) as shown in Figure 5.2;
- In spite of economic benefits accrued from the fishery resources, most fishermen have remained poor;
- The Lake-side infrastructure and sanitation facilities have remained in dilapidated states;
- Certain equipment and methods, especially beach-seines, cast nets and gill nets of small mesh size, weirs and basket traps, have destroyed breeding grounds and catch immature fish;
- There is continuing deterioration of water quality, wetlands and fish habitats;
- Trans-boundary conflicts in the fishing grounds and in fish trade are rampant;
- There is high incidence of disease such as HIV/AIDS, malaria, water borne diseases, and Bilharzia among fishing communities;
- There is low investment in fishery technologies;
- There is poor access to financial resources for indigenous fishermen and fish traders;
- There are inadequate credit facilities for community level fishermen and craft makers; and

- Gold mining in the Busia District of Uganda uses mercury and arsenic as cleaning substances to concentrate gold from rock and soil deposits. These substances can be released to the air, streams, rivers, water table and the lake. These substances are extremely toxic and are currently not monitored. There is, therefore, need to monitor these contaminant levels.

## 5.4 Aquaculture production

### 5.4.1 Aquaculture in the SMM Districts of Kenya

In both Kenya and Uganda, aquaculture contributes only about 1% of the total fish landed. Aquaculture was vibrant in the 1940-1970s, but it has stagnated due to a variety of reasons. The main fish species for aquaculture in the two countries are *Oreochromis niloticus, Tilapia zillii and Clarias gariepinus.* Aquaculture in the SMM is not well developed. Aquaculture potential in Kenya is estimated at 50,000 m.t. p.a. but only 1,103 m.t. was produced in 2000.

### 5.4.2 Aquaculture in Mt. Elgon District of Kenya

In the Mt. Elgon district there are approximately 67 fish farmers with 120 ponds earning on average 13,000 annually. Most ponds are below the standard size of 300m$^2$ and the majority are between 100-200m$^2$. Table 5.5 gives fish farming statistics in the Mt. Elgon District for 2006.

**Table 5.5: 2006 fish farming statistics in Mt. Elgon District, Kenya**

| DIVISION | KAPSOKWONY | KAPTAMA | KOPSIRO | CHEPTAIS | TOTAL |
|---|---|---|---|---|---|
| No. Farmers | 24 | 8 | 13 | 13 | 58 |
| Operational Ponds: | | | | | |
| Number | 19 | 9 | 1 | 24 | |
| Area ($m^2$) | 4,643 | 1,061 | 200 | 2,002 | 8,006 |
| Inactive Ponds: | | | | | |
| Number | 11 | 1 | 17 | 7 | 36 |
| Area ($m^2$) | 1,672 | 200 | 1,399 | 546 | 3,817 |
| New Ponds: | | | | | |
| Number | 5 | 5 | - | 1 | 11 |
| Area ($m^2$) | 627 | 387 | - | 150 | 1,164 |
| Stocked Ponds | | | | | |
| Number | 4 | 7 | - | 2 | 13 |
| Area ($m^2$) | 1038 | 863 | | 220 | 2,121 |
| No. of fingerlings stocked (Tilapia) | 500 | 1,300 | - | 450 | 2,250 |
| Value of fingerlings (Ksh) | 3,000 | 5,200 | - | 1,200 | 9,400 |
| Harvested Ponds: | | | | | |
| Number | 4 | 7 | - | 2 | 13 |
| Area (m2) | 1038 | 863 | | 170 | 2071 |
| Weight of fish harvest-Kgs (Tilapia) | 115 | 55 | - | 24 | 194 |
| Value of harvested fish | 7,600 | 4,400 | - | 3,010 | 15,070 |

*Source: District Fisheries Office, Mt Elgon, 2006*

### 5.4.3 Aquaculture in the Bungoma District of Kenya

Aquaculture projects in the Bungoma District include approximately 700 fish farmers. However of these farmers, only about 50% are active along the rivers. The average fish pond size in this district is 400 sq. m. Among the key collaborators with fish farmers in Bungoma are: the Lake Basin Development Authority (LBDA) which is helping to provide aquaculture seed; Moi University which is assisting in training farmers; Kenya Agricultural Productivity Project (KAPP); National Agricultural and Livestock Extension Program (NALEP); and Nja Marufuku Kenya (NMK).

Through collaboration of these entities, the Chwele Area Project has established the Chwele Fish Farm with generators, infrastructure for residences, stores, and fish breeding facilities valued at over 10 million Kenya shillings. There is also potential to stock dams. The most prevalent aquaculture production system is the earthen fish pond. There is potential to culture other fish species including *Oreochromis esculentus, Lates niloticus,* Mirror Carp *Cyprinus carpio, Labeo victorianus*, the catfish *Bagrus docmac* and *Barbus altianalis* (which have been demonstrated as suitable candidate species by the Lake Victoria Environmental Management Project). Current aquaculture production is assessed at between 500 and 1,000 Kg/ha/annum with *Oreochromis niloticus*, and *Clarias gariepinus*.

In the Bungoma district aquaculture is mainly for Tilapia. Some aquaculture training occurs at the Chwele Fish Farm in the Western Province. However, aquaculture development district wide has been constrained by a lack of training. For example, by 2006 there were only three field staff covering the Bumula, Webuye and Kanduyi dvisions. This limited staffing explains the lack of aquaculture information in the Sirisia, Kanduyi and Central divisions. Fish farming data for the Bungoma district in 2006 are shown in Table 5.6.

**Table 5.6: 2006 fish farming statistics for the Bungoma District, Kenya**

| DIVISION | KIMILILI | WEBUYE | BUMULA | TONGAREN | TOTAL |
|---|---|---|---|---|---|
| No. Farmers | 307 | 281 | 31 | 152 | 628 |
| Operating ponds: | | | | | |
| Number | 462 | 375 | 76 | 329 | 1,240 |
| Area (m2) | 67,870 | 56,400 | 12,580 | 49,350 | 186,200 |
| Stocked ponds | | | | | |
| Number | 20 | 11 | 2 | 22 | 55 |
| Area (m2) | 4910 | 2400 | 1,770 | 4,980 | 15,515 |
| No. Fingerlings | 7,290 | 3,800 | 3,063 | 4,980 | 34,648 |
| Value of fingerlings | 15,170 | 8,000 | 9,189 | 10,060 | 42,419 |
| Harvested ponds: | | | | | |
| Number | 48 | 4 | 4 | 41 | 97 |
| Area (m2) | 5,970 | 530 | 1,000 | 7,812 | 15,312 |
| Wt. of fish harvested | 610 | 130 | 217 | 401 | 1,358 |
| Value of fish harvested | 98,730 | 15,650 | 27,765 | 28,050 | 170,195 |

*Source: District Fisheries Office, Bungoma, 2006*

### 5.4.4 Aquaculture in Busia District of Kenya

The Busia district in Kenya has established a fish hatchery at the Wakhungu Fish Farm Demonstration and Training Center. Fish farming data for the Busia district in 2006 are shown in Table 5.7.

**Table 5.7: 2006 fish farming statistics for the Busia District, Kenya**

| Division | Funyula | Nambale | Butula | Matayos | Township | Budalangi | Total |
|---|---|---|---|---|---|---|---|
| No. Farmers | 34 | 103 | 19 | 25 | 12 | 4 | 197 |
| Operating Ponds: | | | | | | | |
| Number | 76 | 71 | 33 | 13 | 14 | 5 | 212 |
| Area (m2) | 17,860 | 14,161, | 2,600 | 3,808 | 2,700 | 800 | 41,929 |
| Inactive ponds | | | | | | | |
| Number | 10 | 20 | 44 | 10 | - | - | 84 |
| Area (m2) | 27,250 | 2,610 | 9,760 | 750 | - | - | 40,370 |
| Stocked Ponds | - | 15 | - | 6 | 1 | - | 22 |
| No of fingerlings | | 3,230 | 1,200 | 1,281 | 90 | - | |
| Harvested ponds | 7 | | | 6 | | - | |
| Wt. fish harvested | | 162 | 120 | 93 | - | - | |
| Value of harvested fish | | 5,920 | 6,000 | 6,600 | - | - | |

*Source: District Fisheries Office, Busia 2006*

### 5.4.5 Aquaculture in Teso District of Kenya

Fish farmers in the Teso District mainly rear Tilapia and the *Clarias gariepinus*. Fingerlings are supplied by the Lake Basin Development Authority hatchery at Alupe and local streams. Fish farming data for the Teso District for 2006 are shown in Table 5.8.

**Table 5.8: 2006 fish farming statistics for Teso, District, Kenya**

| **Division** | **Amagoro** | **Ang'urai** | **Chakol** | **Amukura** | **Total** |
|---|---|---|---|---|---|
| No. of Farmers | 20 | 40 | 20 | 20 | 100 |
| No. of Self Help Groups | 1 | 1 | 1 | 2 | 5 |
| Operational Ponds: | | | | | |
| Number | 11 | 17 | 132 | 12 | 53 |
| Area ($m^2$) | 1,100 | 1700 | 1,000 | 1,100 | 4,900 |
| Non-operational Ponds: | | | | | |
| Number | 9 | 23 | 7 | 8 | 47 |
| Area ($m^2$) | 900 | 2300 | 700 | 800 | 3700 |
| Stocked ponds | | | | | |
| Number | 7 | - | - | - | |
| Area ($m^2$) | - | | | | |
| No. fingerlings | 3000 | | | | |

(Source: Fisheries Department, Teso, 2006).

## 5.5 Fish farming in the lower riparian districts in Uganda

In the lower riparian SMM districts, there is huge potential for aquaculture. In Uganda, by 1957, there were 2,000 fishponds. In 1967, there were 290 hectares of fishponds. By 1996 there were 6,200 fishponds owned by 4,100 fish farmers. In 2004, there were 4,500 fishponds producing 5,500 tons of fish from an area of 180 hectares. In the Busia district, the number of stocked fishponds increased from 30 in 2001 to 40 in 2002. In 2002 there were 20 unstocked fishponds and 20 were abandoned. (Source: Fisheries Department, Busia 2003).

In the Busia District there is a nucleus aquaculture project integrating fish culture, poultry and vegetable farming. This project produces mainly *Clarias* catfish fingerlings for bait that are then sold in Kenya (for 5 Kenya shillings each). Revenues were estimated to be 20 million Uganda shillings per month. The Mirror Carp (*Cyprinus carpio)* production is about 10,000 kg/ha/annum. There are 40 private fish fry producers who sell to fish farmers (at Shs.200 per fry). In the Tororo and Busia districts, a yield of 10,000kg/ha/annum has been obtained with a stocking rate of 10,000 Mirror Carp fry/ha and cropping 0.5kg fish after six months of growth. A group of fish farmers in Busia produce *Clarias* fingerlings which are reportedly sold to capture fishermen in Kenya at Uganda shillings 20,000,000 weekly. In the Mukono district, there are 45 commercial fishponds ranging from 1,000 to 3,000$m^2$ each. One fish farmer reported earnings of 26,000,000 Uganda shillings in one year. The fish were cured and sold in the Democratic Republic of Congo and to Rwanda. In addition, there is potential for the following aquaculture projects:

- Aquaculture can breed mosquito eating fish, *Lebistes sp,* to reduce mosquito larvae that spread malaria;
- Aquaculture can breed snail-eating fish *Astatoreochromis alluaudi* to reduce bilharzia parasites which harbor in snails;
- Aquaculture can breed rare and endangered species to restock Lake Victoria. These species include: *Oreschromis esculentus*, *Oreochromis variabilis*, *Brycainus jacksoni, Schilbe mystus, Mormyrus spp* and *Barbus altianalis*.

- Aquaculture can breed ornamental fish for export. Possible species include: *Haplochromis multicolour* and *Aplochelichthys* sp.

- Aquaculture can breed fresh water crayfish (*Procambarus clarkii*) for commercial purposes. A production of 2000 kg/ha/annum is possible at the farm gate price of $1 to 2 USD per kg (unshelled).

- Aquaculture can intensified commercial trout farming for the local tourist industry and export. Rainbow Trout (*Salmo gairdneniridens*) are highly priced and have been successfully stocked in some Mt. Elgon rivers in both Kenyan and Ugandan.

- Aquaculture can breed the fresh water prawn (*Macrobrachium rosenbergii)* that has been successfully cultured in a number of countries including Zimbabwe and Mauritius. The average price of this species is $7 USD per kilogram, and it could be farmed largely for export.

## 5.6 Key issues in aquaculture

The following have been identified as constraints to aquaculture production in the SMM districts:

- There is poor accessibility to funding from banks and other institutions;

- Technology for feed development is weak;

- Machinery and equipment for pond construction is expensive and often not readily available;

- Market prices for aquaculture fish is low compared to captured fish;

- Aquaculture fish tend to stagnate in growth;

- The aquaculture fish are frequently attacked by parasitic diseases, worms, fungus and bacteria;

- There is a huge problem of predators like birds, reptiles, amphibian and thieves;
- Livestock often damage pond embankments;
- Drought, de-oxygenation and high temperatures are a problem during the dry seasons;
- The technology for breeding high value captive fish is still not readily available.