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Integrated Watershed Management for Urban Water Security

Integrated Watershed Management – a Tool for Urban Water Security Workshop Results from Mbale, Uganda

Authors:

Yazidhi Bamutaze	Makerere University	Uganda
Stefan Thiemann	IWM Expert GmbH & Freie Universität Berlin	Germany
Gerd Förch	Makerere University	Uganda

Contributors:

Akombo, Rose | Kenyatta University | Kenya

Amumpaire, Jane | Namutumba District Local Government | Uganda

Aluoch, Ochieng Austin | Technical University of Kenya | Kenya

Attibu, Philip | Kenyatta University | Ghana

Bagalwa, Jean Jacques | Research Center at CRSN/Lwiro | Congolese

Bisikwa, Sarah | Ministry of Water / Mbale Local Government | Uganda

Deme, Fred | Ministry of Water / Mbale Local Government | Uganda

Ebbu, Emmanuel | Ministry of Water and Environment | Uganda

Itanna, Fisseha | University of Namibia | Namibia

Kakaire, Joel | Kenyatta University| Kenya

Katusiime, Juliet | Makerere University, CAES | Uganda

Khatib, Mwadini | Kenyatta University | Tanzania

Kokulu, Halala Willie | Ministry of Agriculture Liberia | Uganda (Liberia)

Mangana, John Mathias | Tanzania Development Organization | Tanzania

Matsiko, Andrews | Uganda Civil Society Incubators | Uganda

Mohindo, Daniel | Université Catholique de Bukavu | Democratic Republic of the Congo

Mugabi, Thimoty | Ministry of Water and Environment | Uganda

Mukwaya, Paul | Makerere University, CAES | Uganda

Nakileza, Bob | Makerere University | Uganda

Namono, Marrion | Ministry of Water / Mbale Local Government | Uganda

Ng'hwaya, Charles Edward | Punch International | Tanzania

Ngonzo Luwesi, Cush | Kenyatta University, South East Kenya University | Kenya

Nkuba, Bossissi | Université Catholique de Bukavu | Democratic Republic of the Congo

Nyangara, Eric | National Water and Sewerage Corporation | Uganda

Othman, Ramadhan | Ministry of Agriculture and Natural Resources | Tanzania

Ott, Wibke | Freie Universität Berlin | Germany

Tayebwa, Mellon | Mbarara Univeristy of Science and Technology | Uganda

Tumuhimbise, Manasseh | Mbarara University of Science and Technology | Uganda

Wasige, Ejiet John | Makerere Univeristy | Uganda

Zizinga, Alex | Makerere University | Uganda

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Preface

This document is the outcome of a Workshop on "Integrated Watershed Management – a tool for Urban Water Security" from 10th to 16th March, 2014 in Mbale, Uganda within the project "Integrated Watershed Management for Urban Water Security". The workshop, funded by DAAD, was a joint project of Makerere University, Uganda, the Freie Universität Berlin, Germany, German International Cooperation GIZ RUWASS, Uganda, and the consulting company IWM Expert GmbH, Germany.

The workshop was designed to train at different stakeholder levels the topic "Integrated Watershed Management – a tool for Urban Water Security" in Manafwa Sub-Catchment of Kyogo Water Management Zone, Uganda. Introductory presentation on Integrated Watershed Management and Urban Water Security was followed by a visit to the catchment and group work to collate gathered information and data.

This document is a record of the deliberations of the participants at the workshop.

Content

Abbreviations

DWD	Directorate of Water Development
DWRM	Directorate of Water Resources Management
EIA	Environmental Impact Assessment
ES	Environmental Services
EWS	Early Warning Systems
FOM	Face of Malawi
FU	Freie Universität
GIZ	Gesellschaft für Internationale Zusammenarbeit
GWSP	Global Water System Project
HH	Household
IWM	Integrated Watershed Management
KWMZ	Kyoga Water Management Zone
MAR	Managed Aquifer Recharge
MWE	Ministry of Water and Environment Uganda
NWSC	National Water and Sewerage Corporation
PWS	Payments for Watershed Services
RDF	Recursive Digital Filter
SDG	Sustainable Development Goals
SEA	Socio-Economic Assessment
UWS	Urban Water Security
UWSRA	Urban Water Security Research Alliance

Figures

Tables

Boxes

1 Workshop Objectives

The workshop of Integrated Watershed Management (IWM) a Tool for Urban Water Security (UWS) in Uganda is composed by the following objectives:

1. Understanding of workshop approach and methodology
2. Development of common understanding of the terminology „Integrated Watershed Management (IWM)“, „Integrated Water Resources Management (IWRM)“ and „Urban Water Security (UWS)“
3. Assessment of the relation between IWM and UWS
4. Booklet on IWM for UWS

Based on the objectives the following learning targets shall be achieved:

a. Approach how to find a common understanding about IWM in Eastern Africa
b. Strategy how to assess IWM topics in the field relevant for UWS?
c. Understanding how to bring urban and rural water experts together?
d. Understanding how IWM can assist UWS?
e. Strategy that all stakeholder can benefit?

2 Introduction to Integrated Watershed Management

Integrated Watershed Management is a holistic and integrated approach for sustainable management of a watershed area. A watershed area is understood as an ecological system, which can only survive as a unit of:

- The individual components of the watershed (e.g. water resources, water user)
- The relationships between the characteristic forms of the landscape (e.g. slope, bedrock, vegetation, water body)
- And the process factors (e.g. precipitation intensity, human-environment dynamics)

Management of vital resources, available in the watershed, is to be carried out collectively and simultaneously to improve the living condition of the local population. Watershed based planning aims to balance environmental goals with socio-economic and political goals within the considered watershed.

Integrated Watershed Management is a process of rational decision making in successive steps. Systematically the available management options are compared, and a Watershed Management Plan is developed that is mainly a rural development concept.

The following management components, shown in Figure 1, need to be considered for a holistic approach. Furthermore, the points 2.1 till 2.3 list the objectives, principles and benefits of IWM.

Figure 1: Integrated Approach of Integrated Watershed Management
Source: Thiemann

2.1 Objectives of Integrated Watershed Management

- Conserve soil, rainwater, and vegetation effectively and harvest the surplus water to create water sources in addition to groundwater recharge
- Promote sustainable farming and stabilize crop yields by adopting suitable soil, water, nutrient, and crop management practices
- Cover non-arable area effectively through afforestation, horticulture, and pasture land development based on land capability class
- Enhance the income of individuals by adopting alternative enterprises
- Restore ecological balance
- Build capacity to appreciate economic value of ecologic functioning watersheds

2.2 Principals of Integrated Watershed Management

- Utilise natural resources according to its sustainable capability
- Secure adequate vegetation cover during the rainy season
- Conserve as much rainwater as possible at the place where it falls
- Effective utilisation of surface and groundwater resources
- Avoid gully formation and control soil erosion
- Increase groundwater recharge
- Ensure sustainability of the ecosystem services
- Improve infrastructural facilities with regard to storage, transportation, and marketing
- Prevent water pollution and increasing WASH (water and sanitation hygiene) facilities
- Solve water conflicts within the watershed
- Secure access to water

2.3 Benefits from IWM for UWS

Farmers:

- Increased productivity and higher profits
- Improved water availability
- Improved soil quality and better drainage
- Improved livelihoods

Local community:

- Reduced flooding and water logging

- Reduced soil erosion and land degradation
- Increased agricultural productivity
- Improved livelihoods options and land management
- Less socio-economic conflict

Larger society:

- Reduced risks from floods to downstream cities and farmlands
- Reduced sedimentation in agricultural productive areas and dams
- Better conservation of natural resources
- Higher resilience of communities

2.4 Conclusion

"Integrated Watershed Management is the implementing tool of Integrated Water Resources Management at sub-catchment level" (THIEMANN).

3 Urban Water Security

Water Security is an emerging concept and controversially discussed between the actors in the water sector because of their different backgrounds, positions and objectives. Urban Water Security in particular receives more and more importance because of the rapid urbanisation worldwide and the growing demands for safe and reliable water services. Consequently, UWS may be defined as the interaction of a wide range of factors, including technical, socio-economic, environmental and natural parameters as well as modern/good governance concepts.

UWS is aiming at securing the appropriate and reliable supply of (drinking) water to the urban population by looking at:

- Reliable and sustainable source from where the freshwater is taken
- Efficiency and effectiveness of water purification measures, transport and distribution of sufficient potable water to the end user
- Guarantee of high quality drinking water for personal hygiene and health
- Equitable access to potable water for all social groups
- Availability and provision of cost covering funds generated from the payment of users to the service providers
- Safe collection, effective treatment and disposal of used water (waste water) to the environment
- Consequent endorsement of the user and polluter pays principle as one of the key concepts introduced by IWRM worldwide.

The seminar aimed particularly at giving answers to the question, whether sufficient (quantity and quality) freshwater is available at the Manafwa Waterworks and supplied to Mbale town. The waterworks have a design capacity at the inception in the late 50ies of 9000 m^3/per day, about 50 % of which it is currently regularly produced.

The starting point of any assessment of UWS is to meet the demand of the consumers/users. Given the subjective, transient, and relative nature of demand, a locally derived measure of sufficiency is probably the most sensible route to take. Thus, for a selected system, water needs might be derived from its domestic, agricultural, and industrial functions, but validated against norms and standards taken from similar situations (or indeed with reference to international standards) (FALKENMARK 2013).

Water security by its volumetric definition is depending on various factors, described and summarised by LANKFORD ET AL. (2013) with the following graph (Figure 2).

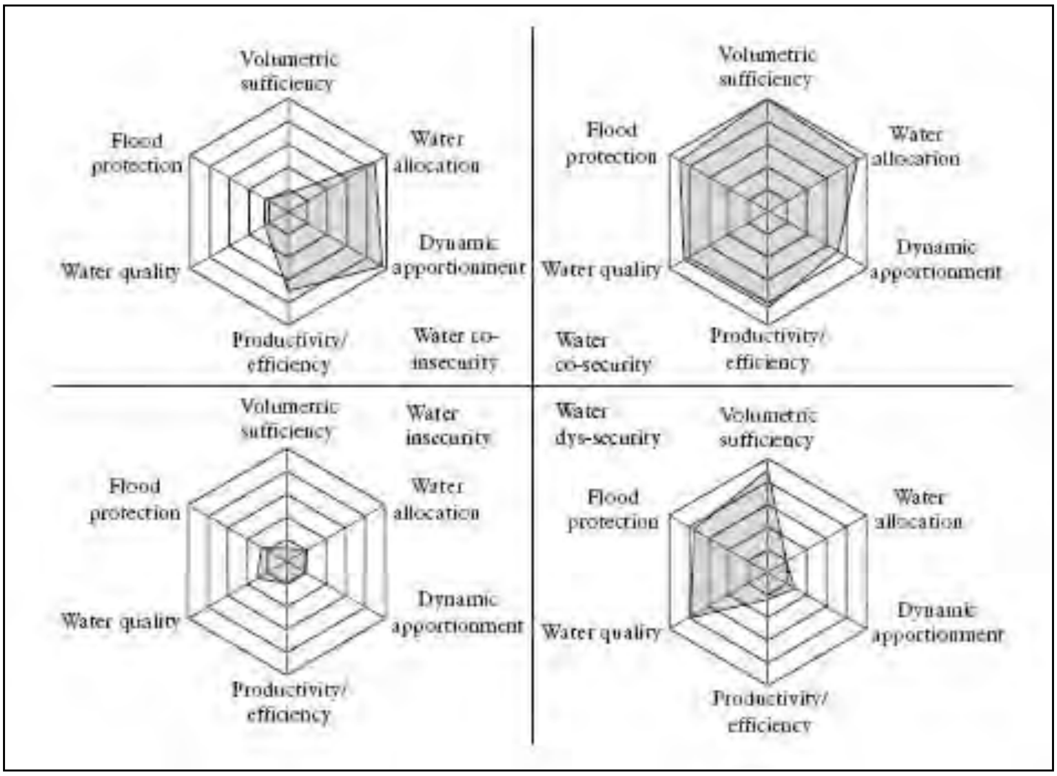

Figure 2: Four Conditions of Water Security depicted in the Radar Charts
Source: LANKFORD 2013

With respects to socio-economic water security outcomes, a number of authors identify outcome examples including: general health and poverty indicators (CHENOWETH ET AL. 2013), urban, industrial and economic activity associated with water (EARLE 2013) and impacts on other resources such as energy, land and food (FROGGATT 2013).

- An array of interactions might exist between sufficiency and equity. One is that "sufficient" water quality, quantity, and flood protection might automatically "trickle down" into equity. Others viewed that these two dimensions need not be necessarily linked and that low levels of equity between parties might mark high levels of sufficiency. For example, a new large dam might generate greater benefits for more people (in absolute terms), but some members of society gain tremendously from this infrastructure compared to others.
- A model promotes the collection and analysis of metrics as paramount objectives to inform the deliberative and participatory process that then attempts to reconcile disparate user perceptions. But it is the lack of substantiated metrics that make many participatory workshops somewhat hollow affairs. It should be noted that participation itself is not part of the model set of physical metrics, but it may be recorded as a socio-economic outcome (LANKFORD ET AL. 2013).

- The collective use and distribution of water, and therefore equity, is central to successful water management (LANKFORD ET AL. 2013).

The Seminar itself focussed on the watershed upstream of the Waterworks at Manafwa-Bridge as a source for Mbale water supply. It was decided to let the discussion out about technical issues like limitations at the intake, limits of the treatment process, power cuts, aging and leaking conveyer pipes, insufficient distribution network, etc. Consequently, the results are insufficient for overall UWS for Mbale town on one side. On the other, they show quite some interesting results on protecting the water source (Manafwa Sub-Watershed) for improving quantities and qualities of the discharge of Manfwa-River (see chapter 6).

This "narrow" approach is needed for defining IWM measures within the watershed. Furthermore, it brings the "supply side" together with the resource protection in the long run. The following quotes from "Bonn Declaration on Global Water Security 2013" highlights the needs for this approach not only at global level but also at the national one and particularly for local measures, where stakeholders or end-users are getting involved (GWSP 2013). Water scientists are more than ever convinced that fresh water systems across the planet are in a precarious state. Mismanagement, overuse and climate change pose long-term threats to human well being, and evaluating and responding to those threats constitutes a major challenge to water researchers and managers alike. Countless millions of individual local human actions add up and reverberate into larger regional, continental and global changes that have drastically changed water flows and storage, impaired water quality, and damaged aquatic ecosystems. Research has produced several important results that inform a better global understanding of fresh water today:

- At a time of impending water challenges, it remains a struggle to secure the basic environmental and social observations needed to obtain an accurate picture of the state of the resource. We need to know about the availability, condition and use of water as part of a global system through sustained environmental surveillance. History teaches us that failure to obtain this basic information will be costly and dangerous.
- Humans typically achieve water security through short-term and often costly engineering solutions, which can create long-lived impacts on social-ecological systems. Faced with a choice of water for short-term economic gain or for the more general health of aquatic ecosystems, society overwhelmingly chooses development, often with deleterious consequences on the very water systems that provide the resource.
- Traditional approaches to development are frequently counter-productive, destroying the services that healthy water systems provide, such as flood protection, habitat for fisheries and pollution control. Loss of these services will adversely affect current and future generations.
- Sustainable development requires both technological and institutional innovation. At present, the formulation of effective institutions for the management of water lags behind engineering technologies in many regions.

The existing focus on water supply, sanitation and hygiene has delivered undoubted benefits to people around the world, but equally, we need to consider wider

Sustainable Development Goals (SDGs) in the context of the global water system. Ecosystem-based Sustainable Water Management, a pressing need that was reaffirmed at the Rio+20 Earth Summit, requires that solving water problems must be a joint obligation of environmental scientists, social scientists, engineers, policy-makers, and a wide range of stakeholders.

Given the development imperatives associated with all natural resources at the dawn of the 21st century, we urge a united front to form a strategic partnership of scientists, public stakeholders, decision-makers and the private sector. This partnership should develop a broad, community-consensus blueprint for a reality-based, multi-perspective, and multi-scale knowledge-to-action water agenda, based on these recommendations by GWSP (2013):

1. Consider ecosystem-based alternatives to costly structural solutions for climate proofing, such that the design of the built environment in future includes both traditional and green infrastructure.
2. Stimulate innovation in water institutions, with a balance of technical- and governance-based solutions and taking heed of value systems and equity. A failure to adopt a more inclusive approach will make it impossible to design effective green growth strategies or policies.

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4 Geographical Introduction to Manafwa Sub-Catchment

4.1 Location

The Manafwa Sub-Catchment is located in the Kyoga Water Management Zone (KWMZ), Eastern Uganda.

The KWMZ is one of four management zones, established by the Ministry of Water and Environment (MWE) under its Directorate of Water Resources Management (DWRM) as well located in Eastern Uganda. The Koya Catchment covers an area of 57.080 km² comprising rivers that drain into Lake Kyoga (Figure 3).

Figure 3: The four Water Management Zones in Uganda
Source: FOERCHE 2014 cf. DWRM-GIS-UNIT

Within the catchment, there are nine sub-catchments including Mpologoma under which the Manafwa Sub-Catchment is situated. In this booklet, to describe the Manafwa Sub-Watershed the term Sub-Catchment is used.

The study area of the workshop, the Manafwa Sub-Catchment on the Ugandan side of Mt. Elgon is based on the outlet at the Manafwa Waterworks, which is located at N 00.95806 & E 034.05716 (Figure 4).

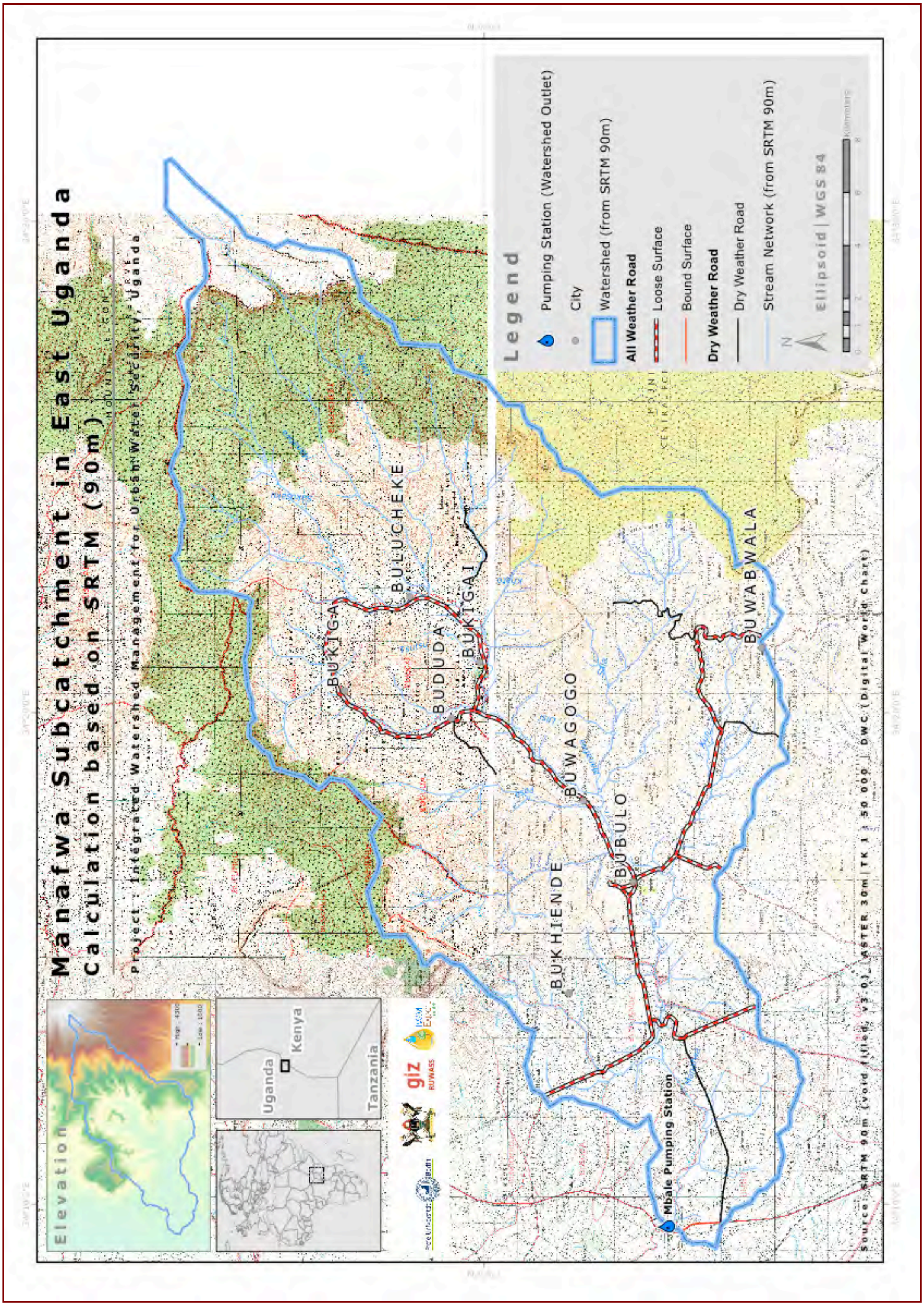

Figure 4: Manafwa Sub-Catchment
Source: Ott 2014

The study area is composed of the administrative entity Manjiya, Bubulo, and Bungokho Country including Sub-Countries, parishes and villages. To them count:

- The Bulucheke, Bubiita, Bumayoka, Bukighai, Bududa, and Bushika Sub-Country in Manjiya County
- The Bugobero, Buwabwala, Buwagogo and Kaato Sub-Country in Bubulo County
- And the lowlands of Bukhiende, Busoba and Bungokho Sub-County in Bungokho County

The forest of the Mt Elgon National Park is the main forest recharging the ground water within the catchment (MWE 2014 EXPERT INTERVIEW).

4.2 Geology and Relief

The geology in the Mt. Elgon region comprises of mainly Pre-Cambrian and Cainozoic rock formations. The Pre-Cambrian rock system is wholly granitised beside scattered medium metamorphosed formations. Cainozoic formations consist of Pleistocene to recent sediment alluvium, black soils and moraines (MBALE DISTRICT STATE OF ENVIRONMENT REPORT 2004).

The rocks on Mt. Elgon include volcanics, granitites and sediments. In Mukoto, the rocks include mudflows and agglomerates of Mt. Elgon as well as tuffs and lava. These rocks on the slopes have been deeply weathered into black cotton soils riche in montmorrillonite (clay mineral with a very high swelling/shrinking capacity and high water retention). The top of the mountain has scarps of agglomerates in linear pattern, which could be an indicator of faulting. In Bupoto, the volcanic landscape covers granitoits, which are classified by higher rock hardness (NEMA 2008).

The relief is relatively undulating and hilly with the highest catchment elevation at 3,616 m.a.s.l. and the lowest at 1,083 m.a.s.l.

4.3 Climate and Hydrology

Manafwa Sub-Catchment is located in the Mt. Elgon climatic zone, which lies in the tropical region and experiences a bi-model rainfall pattern. The average annual rainfall is about 1,500 mm with rainy seasons occurring in the months of April - June and August - November. The mean annual maximum temperature is by 27 °C and annual minimum temperature by 15 °C (ECO TRUST 2012 CF. VAN HEIST 1994).

Water resources in the Manafwa Sub-Catchement comprise of surface water (e.g. rivers and streams), and ground water (e.g. shallow and deep aquifers, springs). The Mt. Elgon forest is important for the surface- and groundwater runoff to guarantee a continuous hydrological cycle. Studies found out higher infiltration rates in some parts of the Manafwa Sub-Watershed because of deeper soils. Due to BAMUTAZE ET AL. (2010), the water infiltration rate vary from 1,2 cm/h to 363 cm/h.

Drained by the Manafwa system, River-Manafwa is the main river in the catchment served by eight permanent tributaries, which include Sakusaku, Ukha, Tsutsu, Sala, Kufu, Pasa, Liisi, and Kaato. The river covers a distance of 43 km from the source to the Manafwa water works in Mbale (Figure 4).

Based on the outlet at the waterworks the computed catchment size is 483 km^2.

4.4 Soil

The catchment is highly influenced by past volcanic activities. The soil of the area is highly variable. Due to NEMA (2010) and BAMUTAZE ET AL. (2010 CF. ISABIRYE 2004), soils in this area have a sequence where the central carbonatite dome is covered by Rhodi andic Nitisols and the surrounding areas by Rhodi andic Luvisols, Haplic lixic Ferralsol, and Humic andic Nitisols. The impermeable nature of most of these rocks makes the adjacent areas of Mt. Elgon susceptible to landslides during wet seasons. Furthermore, some parts of the catchment especially around the Mt. Elgon National Park have shallow topsoils. Generally, the soils in the highlands have clay properties, while those in the midlands and the lowlands are clay loam and sandy (ECO TRUST UGANDA 2012).

4.5 Land Use and Land Cover

The land uses in the region is characterized by crop, livestock, and fish farming as well as agroforestry. Others include bee keeping, mushroom growing, increased settlement due to urbanization as well as quarrying and mining activities (i.e. sand, stones and phosphate/vermiculite). Brick making is the recent activity with high economical value in the region.

The undulating land is widely cultivated with subsistence farming. The main crops include banana (plantain), cassava, rice, potato, maize, beans, nuts and coffee. Cotton is the major cash crop. Crop diversification and intercropping practices are characteristically for the Sub-Watershed.

The vegetation in the Mt. Elgon region is represented by forest, cleared areas and savannah. Many of the forests have remained as patches due to population growth and increased agricultural activities. The forest is categorized into tree protected areas (Mt. Elgon National Park, Namatale Central and Local Forest Reserves). Some farmers also cultivate wooded areas of especially Eucalyptus sp., while others are increasingly practicing coffee agroforestry. In general, the subsistence farms cultivate the mentioned crops.

4.6 Population

The population rate of Mbale district is growing, estimated at 3,4 % (UBOS 2012) to 4 % for Mbale town (ECKART ET AL. 2012), which is the case for the Manafwa Sub-Catchment as well as whole country. Currently, the environmental consequences are serious land pressure leading to land degradation. The population development is summarized in Table 1.

Table 1: Population 2002 and 2005 as well as Number of HH in 2011 | 12
Source: UDOS 2012 & ECKART ET AL. 2012

District	2002		2005		2011|12
	Population	**Density [person/km²]**	**Population**	**Poverty [%]**	**HH**
Mbale	332571	594	428800	34,9 %	99070 HH
Manafwa	262566	493	367500	33,6 %	84640 HH
Bududda	123102	450	180600	32,8 %	39140 HH

4.7 Socio-Economic Activities

The population growth takes influence on the socio-economic situation as well. The socio-economic information are gathered through the field assessment, but further and more precise knowledge would be needed for a sustainable IWM for UWS:

The majority of the people speaks Gishu and belongs to the Bantu ethnicity. Circumcision ranks to a predominant cultural practice called Imbalu done once in every two years. The villagers and communities in the catchment are organized through religious and community based organizations.

In the catchment exist a network of institutions, but the service facilitation is inadequate. Schools and health care centres are present on local level, located mainly in the lowlands. The upland settlers are affected by shortage of infrastructural and service facilities. An active separation between female and male villagers is indicated during the first assessment.

The main income sources are agriculture, trade, mining, brick making, and forestry (Eucalyptus) (see captor 4.5).

The population is relying on firewood and charcoal as energy for cooking. Therefore, people encroach on the park to look for firewood.

The characteristically high population growth in Mbale town and the sub-catchment is influencing the economical activities to a great extend. Till the beginning of the 2000th the surrounding hills were densely covered by forestry. Among others, the high demand of firewood regarding brick production leads to a complete deforestation resulting in a non-wood covered area. Unfortunately, to resist the increasing moister of agricultural fields and living areas, Ecalyptus sp. was planted due to its features (Box. 1).

4.8 Administrative Division of the Sub-Catchment

The Manafwa Sub-Catchment is embedded in three administrative districts namely Bududa (upper zone), Manafwa (mid zone) and Mbale (lower zone).

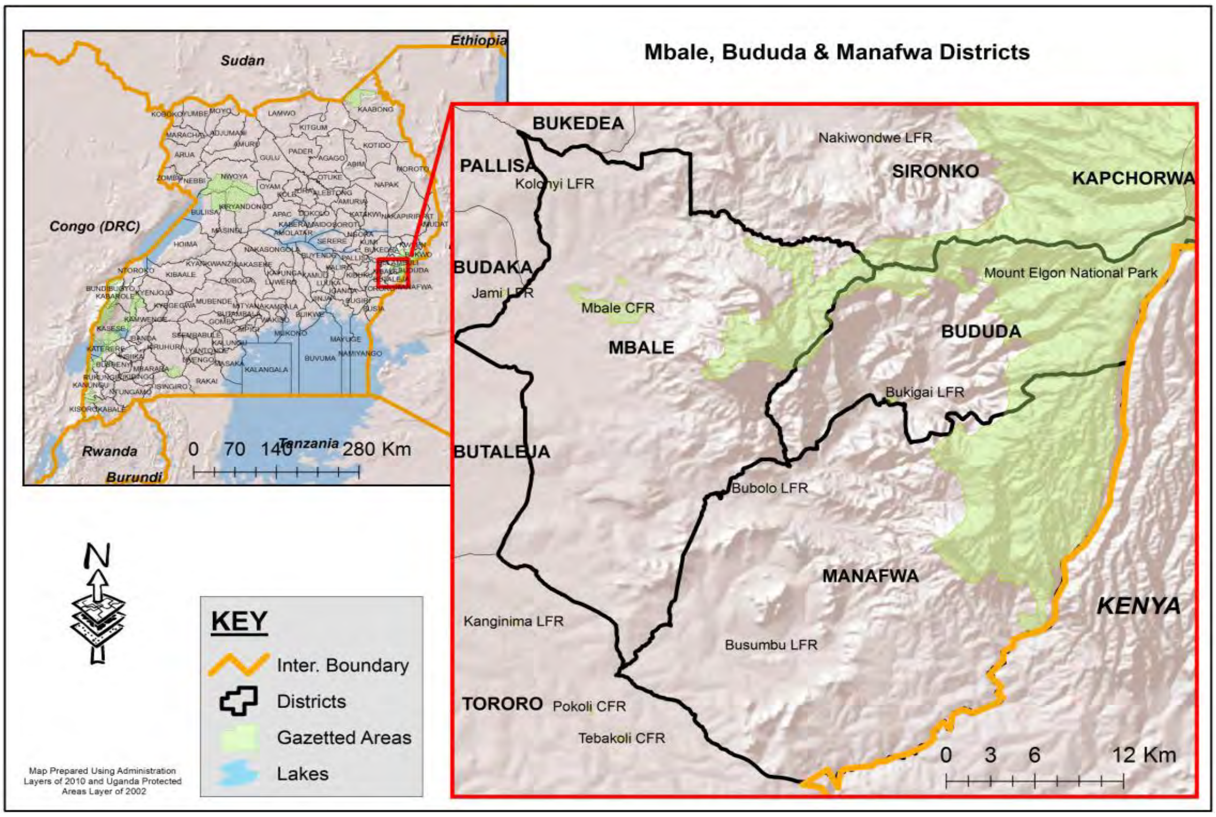

Figure 5: Administrative Boundaries for Manafwa Sub-Catchment
Source: ECO TRUST 2012

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5 Resources Challenges in the Catchment

Manafwa Sub-Catchment is endowed with a number of resources, which include biomass, human, water, soil and energy. However, there are a number of challenges affecting the use and accessibility of these resources.

5.1 Biomass

1. Increased Demand for Firewood:

Firewood is the main source of fuel in the catchment. In addition, firewood is used for brick making which has taken its toll in the area. Along the road to Manafwa district at least each second household produces bricks. This has increased deforestation uphill as far as Mt. Elgon reserve area. The capacity of the trees to capture rainfall is reducing.

2. Low use of natural residues

The use of animal residues is low and of human sewage not at all adopted. Mainly artificial fertiliser is used, which is cost-intensive. To make a point about the quality and quantity of used artificial fertiliser further assessments are needed. The flipside is, the infiltration of human sewage in the river stream and even back to the individual via drinking water is high due to neglecting of protection zones (see chapter 5.3 point 4).

5.2 Human Resource

1. Settlement & Migration:

The settlement patterns are linear alongside the road and near various water sources in study area. Most of the trading centres are close to water streams. Several activities in the rivers (e.g. car washing) take negative impact on the water quality. Additionally, the majority of the residents have constructed pit latrines close to the water streams, which leads to water pollution.

2. Population Growth:

The average household size is seven members (HH INTERVIEWS 12.03.2014). Based on the field assessment, the age difference of children is less than one year for parents between 25-35, which correlates with the high national population growth (see chapter 4.6).

3. Increased Demand for agricultural Land and Settlements:

The main economic activity for the growing population in the Manafwa Sub-Catchment is agriculture. The residents of the Sub-Catchment have cleared forest to acquire more land for cultivation and commercial use of wood. Farming practices on the steep slopes of Manafwa hills have exacerbated land degradation and decline of soil fertility resulting into erosion hence reducing land productivity (see chapter 5.4).

4. Information Access:

Access to information concerning natural resource management as watershed management, soil conservation and among others is still low (HH INTERVIEWS 12.03.2014). Only one mobile network (MTN), by the villagers described as expensive compared to networks (as Warid and Airtel) available in other areas is used yet. Hence, the mobile communication is limited adopted. The use of radios could be a further source of information, but out of ten interview partners only two own a radios.

5. Gender Disparity:

Gender differences in resource management are prevalent in the catchment area. Men own land, property and take community decision. Therefore, integration of resource management becomes a challenge due to gender inequality. For example, meetings take place separated by men and women. At this stage, it seems that objectives based on gender agreements cannot be achieved in the Sub-Watershed.

6. Education:

The residents rely mostly on government schools and training institutions. Children have to walk long distance to attend schools. However, awareness on natural resource management and training of it is limited on soil and water conservation.

7. Institutional Framework:

Institutional arrangements aim to protect and preserve the Manafwa Sub-Catchment but resources are not well established. Social groups and community-based organizations do not work hand in hand toward catchment protection. A conflict of interests exists among farmers between conserving the forest and increasing the farmland.

8. Inefficient Law Enforcement:

Existing laws related to protection of the Manafwa Sub-Catchment are not well implemented by authorities. Normally, 100 m are meant to be reserved from the riverbanks as a riparian area to protect the river and allow various hydrological functions like flood control, filtering, etc. However, activities such as farming, settlement, livestock keeping and others are continuously practiced in the area. The settlements and over-cultivation on the fragile Manafwa ecosystems has led to increased soil erosion, sedimentation and gully formation.

5.3 Water

1. Change in Vegetation Cover:

The vegetation cover is changing from forest to farmland accompanied by settlements due to population growth over the last decades and deforestation since 2000. Those takes tremendously influence on the hydrological cycle in the area.

2. Reclamation of Wetland:

Wetlands are being reclaimed for farmland due to their favourable terrain (not subject to soil erosion). The water for irrigation can easily be available for crops. These wetlands play a crucial role in water purification, which is affected by the human intervention.

3. Eucalyptus Trees:

The local population has planted eucalyptus trees (see Box 1) for wood and timber production. This species has been preferred because of its rapid growth (35 m^3/ ha/ year) and timber produce. Unfortunately, eucalyptus consumes a lot of water (90 l/ day for a three years old tree) (ALBOUGH ET AL. 2013). It seems that this is one of the major factors, which reduces the base flow of Manafwa tributaries and the Manafwa River.

4. Location of Pit Latrines:

People dig pit latrines very close to watercourses (Figure 6). This short horizontal (less than 10 m away from the stream) and vertical (up to the water table) distance affects the water quality in the stream and groundwater.

Figure 6: Pit Latrine close to the River

5. Mining within the Streambed:

Stone quarrying and sand mining all over the streams' disturbs the natural riverbed and exposes it to erosion.

6. Waste Management:

The waste management in the catchment is poor. Waste as plastic bags stuck in rivers. Rivers are uses as public cleaning place for instance for cars and motorbikes which affects the water flow and quality.

Box. 1: Features of Eucalyptus Trees
Source: SOTOMAYOR 2002

There exist more then 700 species of eucalyptus. For the in the Sub-Catchment planted Eucalyptus sp. the following features can be summarised:

Long lived & evergreen | Hardwood | Fastest growing woody plant | Renewable biomass crop for energy production | Deep rooting | Oily leaves | Eucalyptus displaces the natural fauna | Soil becomes prone to degradation | Low possibilities to reduce the negative impacts of eucalyptus

5.4 Soil

1. Brick Making:

The brick making as economic activity is done mainly by the youth. It has devastating effects on the soil. The bricks are dug from the fertile top layers and burnt on the topsoil layer, which is subjected to high temperatures. This leads to soil nutrient losses, death of microorganisms, and destruction of the organic material. Brick making is an important income source with devastating consequences for the soil conditions and deductive hydrological circle in the Sub-Watershed and those for the UWS in Mbale.

2. Farming along the Slopes:

To generate income, farmers practice farming along the slopes in the hilly areas and use ox–ploughs in the down slopes. Both leave the soils bare and result into erosion, which is an obstacle for further agricultural land use in the long run.

3. Use of Agrochemicals:

In attempts to increase on the productivity of the soils, some farmers are using artificial fertilizers (as NPK, DAP, SSP) and a spectrum of pesticides (e.g. Dimethioate and Ambush) on horticultural crops as sukumawich, Irish potatoes, onions, and tomatoes. It is to assume that all of them are applied in wrong quantities, which can lead to change in the soil PH, nutrient toxicity, and nutrient antagonism (see chapter 5.1 point 2.)

4. Settlement:

The housing structures in the catchment can be described as semi-permanent and raising. This can affect the soil by building new settlements and leave the previous spot compacted, which can interfere with infiltration rate and runoff.

5.5 Energy

1. Wood Fuel

The community depends on wood fuel as a major source of energy for cooking and brick burning. In this attempt, they cut down trees to harvest wood, which affects ground water recharge in the long run, and the water pattern in the Manafwa Sub-Catchment. Therefore, relying on tree cutting hampers groundwater charge and increase surface discharge. This also increases run off, siltation and sedimentation. Alternative energy sources could be solar, biogas and briquettes, but these are underutilized until now.

2. Illegal Connection to the national Power Grid

Illegal connections to the national Power Grid affect the power supply of the Manafwa Water Works and the urban water supply. In case of missing access to water in the Sub-Catchment, illegal water abstraction occurs from the streams, which ends up in lower water levels resulting into 4-5 mm^3/s in a day. The users of the illegal and self-made power resources are exposed to accidents and health risks. The power is unmetered by a legal distributor, Umeme.

3. Mini hydro-electricity Dam

In the process of Uganda�
s Rural Electrification Programme, a mini hydro-electricity dam is in the pipeline to be established on one of the streams in the Manafwa Sub-Catchment.

4. Renewable energy

In general, forms of renewable energy in the Sub-Catchment are hampered by the high cost.

Literature

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6 Request on IWM for UWS

Based on the preceding information, this chapter focuses on the request tasks of IWM for UWS in the Manafwa Sub-Catchment. Before considering the tasks a short summary of Integrated Watershed Management as holistic approach is given to recall the principles for a sustainable implementation. Afterwards the sub-chapter 6.1 gives a short introduction to base, average and peak flow. The sub-chapters 6.2, 6.3, and 6.4 present recommendations elaborated in the workshop to secure the base and average flow as well as reduce the peak flow for the UWS of Mbale subjected to all IWM principles.

IWM is based on knowledge of the respective catchment. The global IWM principles (chapter 2.2) have to be considered in the context of the location and target group, it is not a pre-built panacea. Therefore, initially it calls for a multi-dimensional assessment of the ecological, economical, social and political circumstances as well as their interpenetration to finally use IWM as a context-specific tool for sustainable UWS.

To secure the water supply in Mbale as well as the availability in the Manafwa Sub-Catchment, it is essential to stabilize the base flow, which is the fresh water source for the city supplied by the NWSC waterworks. Alike, the average and peak flow has to be considered under the holistic IWM principles for sustainable and efficient UWS.

After the first field observation at the 12th March 2014 and cooperation work with local stakeholders during the workshop, further assessments under the holistic perspective of IWM for UWS are necessary to concretise the preliminary recommendations of the booklet.

PLEASE NOTE: The implementation should be done alongside a sustainable chain where everything is feeding into everything else.

6.1 Introduction Base Flow, Average Flow and Peak Flow

To gain a conjoint comprehension, this chapter presents a short introduction to base, average and peak flow which all contribute to a stream flow (Table 2).

Stream ecosystems in general are stressed by urbanisation as appearing in the Manfwa Sub-Catchment. The health of streams is affected by disturbances to flow regimes, alteration of water quality, and direct habitat modifications (Walsh et al. 2005a; Wenger et al. 2009).

The base flow is important to manage the water supply (Linsley et al. 1988) low flow hydrology, flood hydrology, contamination investigation and stream ecology (Li 2014). There are various definitions of base flow, including groundwater discharge (Chapman 1999; Freeze 1972), slow flow and sustained flow (Hall 1968). In this booklet concerning the Manafwa Sub-Catchment, the base flow is considered as groundwater discharged from aquifers, which contribute continuously to the Manafwa stream flow. The base flow and groundwater are influenced by natural features (as geology, topography, vegetation and climate) and anthropogenic factors (as impervious patches and external water inputs) (Hamel et al. 2013). The alterations of base flow by urbanisation can affect the water quality and may accentuate the impact of pollutant inputs to the stream because of higher concentrations (MENCIÓ & MAS-PLA 2010, HAMEL ET AL. 2013).

It is difficult to measure the base flow in the field (DUKIC 2006; MCCALLUM ET AL. 2010, LI ET AL. 2014). Nevertheless, LI ET AL. (2014) argues, that one of the most commonly used method for estimating base flows in practice is Recursive Digital Filters (RDF) due to their simplicity and ease of implementation. This could be as well a method to determine exactly the base flow in to the Manafwa River.

Both the base flow as well as the peak flow can have serious economic consequences (ROBINSON ET AL. 2003).

The peak flow, as well named storm flow stands for the decreasing infiltration and increasing direct run-off during a storm, less groundwater recharge, and increased variability especially if storm water is routed directly to streams. The storm water is untapped water source in urban as well as in rural areas (UWSRA 2011). Storm water runoff can contain a huge amount of pollutants and may cause relevant impact to the aquatic system (BARBOSA 2012). The magnitude and frequency of peak flows are needed to design hydraulic structures, delineate flood- hazard zones, minimize property damage, and reduce the loss of life caused by floods (AHEARN 2003).

The average flow describes an individual period of stream flow record. Beyond, the inter flow is briefly mentioned which describes the part of precipitation not reaching the aquifer but infiltrating into the soil surface and travels by means of gravity to the stream channel. The origin of base, inert, and peak flow are illustrated in Figure 7.

Table 2: Definition of Base, Average and Peak Flow
(Source: HALL 1968; CHERKAUER & ANSARI 2005)

Base Flow	Average Flow	Peak Flow
• Portion of stream flow coming from groundwater, subsurface or delayed sources • Maintains the river flow during the period of low precipitation	• Mean flow of an individual period of the Manafwa-River	• Caused by storm events • Time of high flow concentration • Influenced by decreased infiltration and groundwater recharge as well as increasing direct run-off

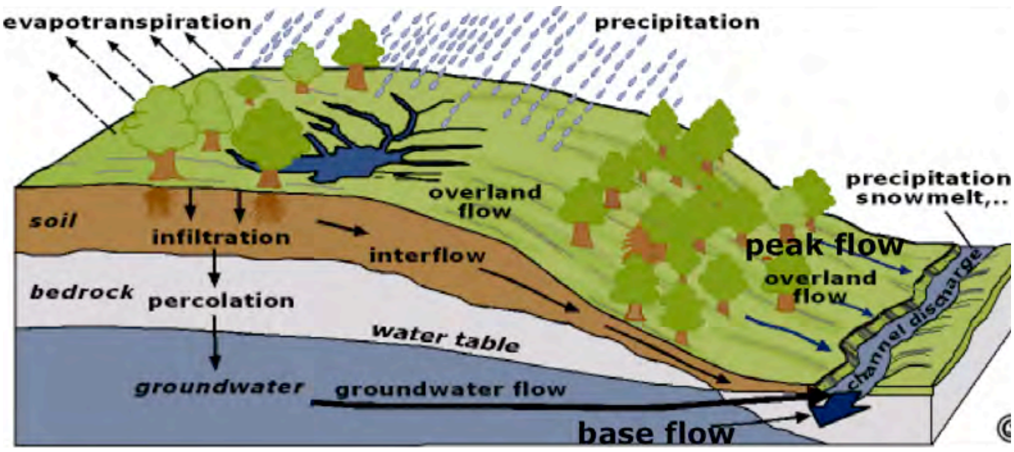

Figure 7: The Hydrological Cycle
Source: ADAPTED AFTER FU BERLIN 2007

6.2 Base Flow in the Manafwa Sub-Catchement

The Manafwa River base flow is decreasing, which results in a minus water extraction of 4,000 m^3 per day (NWSC 2014, FIELD ASSESMENT 12.03.2014). In the Sub-Catchment the base flow is dropped. Several studies, reviewed by HAMEL ET AL. (2013) suggest that change in base flow is correlating with degradation of the stream ecosystems. To secure the urban water supply of Mbale in a sustainable manner, the focus is to increase the water infiltration and groundwater recharge.

6.2.1 Influencing Factors

A strong impact on the environmental and hydrological circumstances regarding all discharge forms has the growing population including consequential effects of socio-economical change (see chapter 4.6 and 4.7). The increased surface and groundwater demand as well as usage in the Sub-Watershed result in decreased base flow discharge into the Manafwa River and deductive unsecured fresh water provision for Mbale. In the Sub-Catchment exists an upstream-downstream disparity. Siltation and deteriorating water quality is increasing. Furthermore, the following elaborated points influence the base flow but also the average and peak flow of the Sub-Watershed:

- Grown number of customers connected to the distribution network from 1,800 to 11,400 (date information missing) (NYANGA 2014)
- Increased water supply service in the urban area from original 2,400 ha to 42,000 ha (date information is missing) (NYANGA 2014)
- Increased illegal water leakage from sewers since the water supply lacks behind the demand; Results are sewer blockages and silt settlement at the ponds
- Increased groundwater extraction
- Complete deforestation since 2000 because of:
    - High demand of firewood as economical income generator
    - Increased demand of fertile agricultural land
- Completely deforestation resulting in:
    - Decreased infiltration
    - Change of micro-climate (which has influence on the base flow (PRICE 2011; HAMEL ET AL. 2013))
- Planting of eucalyptus as new timber species to secure the availability of firewood with negative environmental impacts (soil salinization, degradation and arid lands)
- Anthropological contamination of water (e.g. car washing in the rivers, livestock farming, and pit latrines in protected areas close to the river) lowers the water quality

6.2.2 Recommendations to secure the Base Flow

Based on the IWM and UWS principles as well as the first assessment results in the Sub-Catchment the following recommendations are given to secure the base flow in the

Manafwa River and study area. Nevertheless, the recommendations have to be adapted after the execution of further fieldwork assessments.

For all recommendations it is important to consider beside the topographical, soil, hydrological, and environmental consideration of circumstances also: a) the farming systems of the community, b) the financial capabilities of the farmers, c) the cultural behaviour together with religious belief of the people, d) the attitude of farmers towards the introduction of new farming methods, e) the farmers knowledge about irrigated agriculture, f) the land tenure and property rights and g) the role of women and minorities in the communities as crucial issues.

Please NOTE: Some of the recommendations to secure the base flow are also useful for average and peak flow management.

1. Rainwater Harvesting:

Rainwater harvesting is a method to induce, collect, store and conserve local surface run-off. For the Sub-Catchment as well as for the UWS the particular advantage of rainwater harvesting is from the public water supplier independent water provision and access to water even during drought periods. It can be roughly distinguished between the following three forms whereby the consideration of socio-economic conditions is always important (PRINZE ET AL. 2003):

- Water collection from rooftops
- Micro-catchment harvesting
- And macro-catchment harvesting

For the Manafwa Sub-Watershed, practices from the first two water-harvesting forms can be taken into account. This ability and practice could be extended since it is an efficient and affordable method.

Beside the water harvesting methods the kind of storage is crucial as well. To secure the base flow groundwater-harvesting methods have to be applied. But there are also surface storages, which are already adapted by the villagers due to low cost technology among others (Figure 19).

Furthermore the applied methods are relative to: rainfall, land use or vegetation cover, topography, soil type and depth, hydrology as well as socio-economic and infrastructural conditions (PRINZE ET AL. 2003).

Benefits of rainwater harvesting can be: declaration of run-off, increase of infiltration, base flow level contribution, erosion protection, increase of agricultural productivity (FOM 2013).

The following recommendations are related to rainwater harvesting concerning water for base flow increase and agriculture purposes:

- In (macro- and) micro-catchments the run-off from a nearby slope could be used for agricultural purposes (Figure 8).
- Water partitioning points at the soil surface and in the soil increase infiltration and storage of water in the soil (Figure 8). This has some short-term advantages (based on a single rainfall event). It slows the flow of water, which reduces soil erosion, minimizes flooding, and limits damage to built

structures by storm water flows (UNDP 2009). Furthermore, more water infiltrates into the aquifer and can contribute to the base flow recharge

- Roof run-off can be diverted into a well, sump, or caisson filled with sand or gravel and is allowed to percolate to the water table where it is collected (by pumping) from a well (Figure 9). The advantage, if water is stored underground, this may not impact increasing malaria incidence (UNDP 2009)
- Field technologies like small farm ponds and infiltration pits (Figure 10) support the water infiltration and are of low cost compared to the construction of water tanks

PLEASE NOTE: The given recommendations need more precise information about the aquifer in the region as well as further socio-economic and environmental assessments

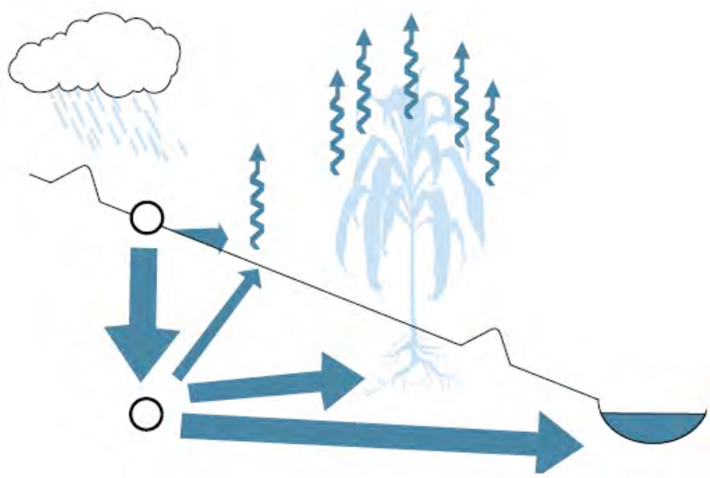

Figure 8: Flow Paths with Rainwater Harvesting
Source: UNEP 2009

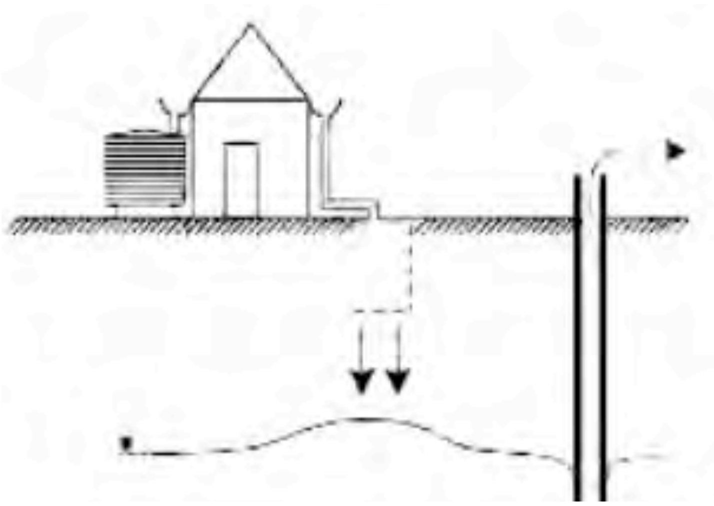

Figure 9: Rainwater Harvesting from Roof for Aquifer Recharge. Infiltration Gallery
Source: Dillon et al. 2009

Box 2: The Eight Principles of Successful Water Harvesting
Source: LANCATER 2014

1. Long and thoughtful observation
2. Starting from the top (highpoint) of the watershed and working downwards
3. Small & simple (many small strategies are far more effective than one big by trying to infiltrate water into the soil)
4. Slow, spread, and sink (slowly and the water infiltrates)
5. Plan of overflow route and management of overflow resources
6. Maximize living and organic groundcover (creating of a "living sponge" so the harvested water is used to create more resources, while the soil's ability to infiltrate and hold water steadily improve)
7. Maximize beneficial relationships and efficiency by "stacking functions."
8. Continually reassess of the system ("feedback loop")

2. Aquifer Recharge Management:

Managed Aquifer Recharge (MAR) stands for the purposeful recharge of water to aquifers for subsequent recovery (DILLON ET AL. 2009). Aquifers, a permeable geological stratum that contains water, can infiltrate base flow into the stream.

- Infiltration basins close to a well or a stream (Figure 10)
- Buried trenches (containing polythene cells or slotted pipes) in permeable soils that allow infiltration through the unsaturated zone to an unconfined aquifer (Figure 9)
- Furthermore, sand dams are useful to trap sediment when flow occurs and prevent high sedimentation of the Manafwa River.

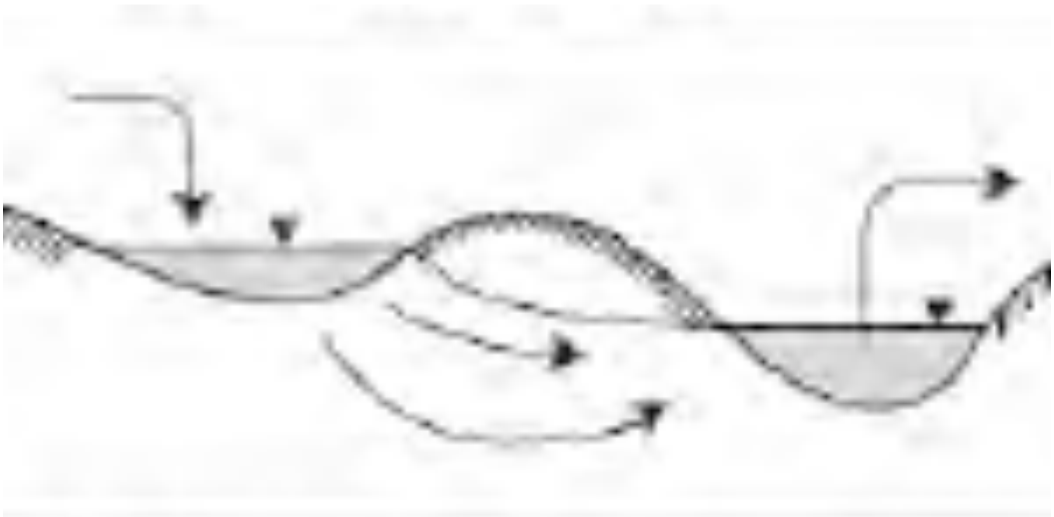

Figure 10: Infiltration Pond/Dune
Source: DILLON ET AL. 2009

3. Agroforestry:

Agroforestry stands for a combination of agricultural land or livestock use with integrated forestry operations (KRÜGER ET AL. 2008). The aim is to create a more diverse and resistant ecological stability by securing the agricultural production for local stakeholders. Agroforestry could help to:

- Reduce the soil degradation and enhance the water infiltration

- The (planted) deep-rooted vegetation can contribute to the recharge of the water aquifer

It has to be point out that after eucalyptus is planted it takes time and effort to rehabilitate the natural fauna since eucalyptus destroys the soil beside its positive features (timber production) (Box 1).

4. Alley Cropping:

Alley cropping (Figure 11) means planting of trees or shrubs in rows with agronomic, horticultural, or forage crops cultivated in the alleys between the rows of woody plants (USDA 1997).

PLEASE NOTE: The alley cropping has to be balanced with the high deforestation rate in the area. It is a possibility on micro-level.

The benefit for the catchment can be:

- Reduced surface water runoff and erosion; reduced wind erosion; increased water infiltration; enhanced or diversified farm products, and improved utilisation of nutrients. It can lead to modification of the microclimate for improved crop production and improvement for wildlife and livestock (USDA 1997)
- It can result in increased baseflow. Deductive it can lead to urban water security and economical income generation due to sustainable and efficient farming and agriculture

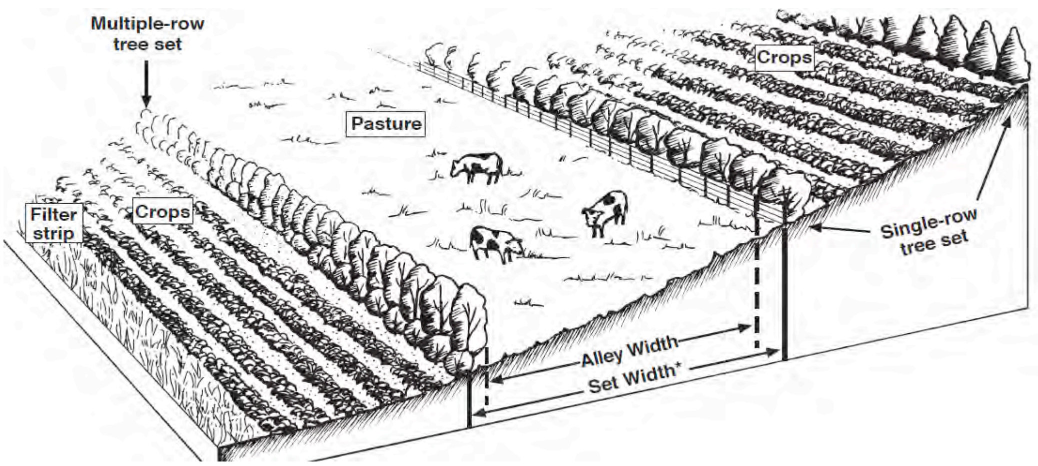

Figure 11: Alley Cropping
Source: USDA 1997

5. Alternative Energies:

For the economical security of the population as well as the Mbale Waterworks the demand of energy has to be secured in efficient, equal and sustainable way. In the Sub-Catchment alternative energy resources should be implemented by increasing the use of non-timber resources.

- Solar energy: For cooking and drinking water treatment, solar energy could be an alternative to firewood

- Solar energy: For the Manafwa Waterworks, it can be a solution to secure the daily energy demand
- Biogas: Out of human and animal excreta could be an alternative energy resource, which is for the moment not at all considered and appreciated by the local community. In this case a high engagement of capacity building concerning biogas would be necessary. It can save labour of gathering wood for cooking, minimise harmful smoke in homes, and contain deforestation and greenhouse gas emissions. Biogas plants can also improve sanitation, and the residue is useful as a fertiliser (Figure 12, Figure 13) (ASHDEN 2014)
- Biogas: For the Mbale Waterworks could be an alternative energy source to secure the water treatment and finally provision

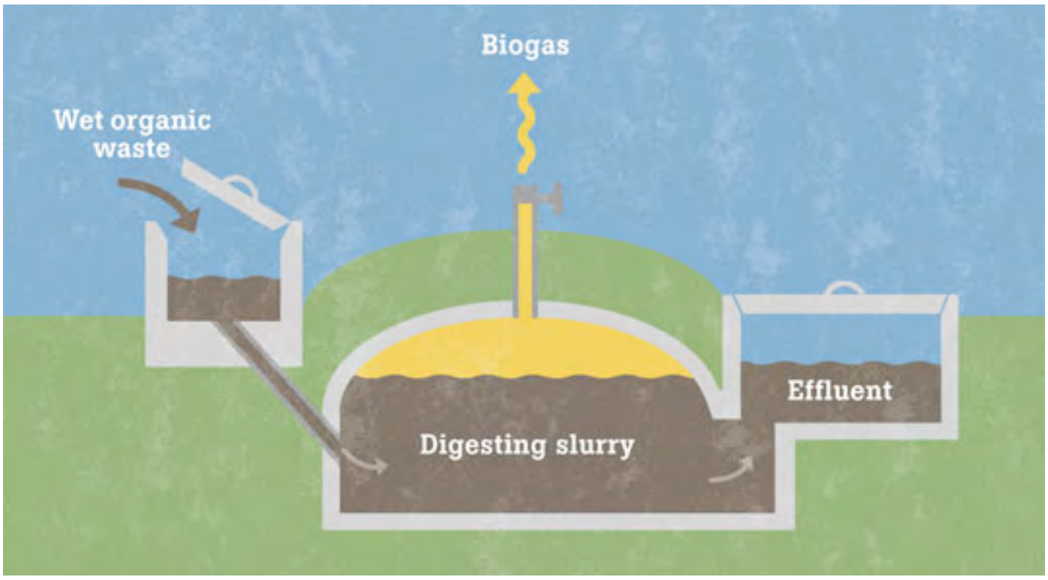

Figure 12: Delineation of Biogas Construction
Source: ASHDEN 2014

Figure 13: Indian Farm Women profiting from Biogas
Source: ASHDEN 2014

6. Capacity Building and Training:

- Sensitization about indigenous trees should be promoted to farmers (EXPERT INTERVIEW, MWE 2014)
- Community sensitization and involvement in the upcoming IWM activities
- Promotion of family planning: The population growth will continue increasing pressure on the groundwater demand and the Manafwa River's base flow.
- Promotion of ecosan toilets: To improve the water quality of Manafwa River. At the same time, the faecal matter can be used as raw material for biogas production
- Promotion of sustainable and alternative agricultural methods: Alternatives have to be elaborated and implemented in cooperation, active participation, and responsibility of the local effected community.

7. Methods for NWSC Mbale:

- The area of NWSC has the spatial potential for rainwater harvesting methods to collect and increase the store of water for water provision
- Usage of satellite images could determine soil erosion, geomorphological classification, vegetation change and finally suitable water harvesting areas
- Biogas can be an alternative to secure the electricity demand for the water treatment and provision (Figure 12, Figure 13)
- Collaboration with the villagers in the Sub-Catchment as provision of water tanks for rain water harvesting could lead to decreased pipe tapping

6.3 Average Flow in the Manafwa Sub-Catchment

According to NWSC Mbale regional station (2014), the monthly average flow of the Manafwa River is by 8,7 m^3/s with varying degree of flow ranging from 0,775 m^3/s (min) to 35.003 m^3/s (max) in the duration of 1948 - 2011. The most extreme flows occurred in 1997 and 2010 during the El Niño. According to NWSC (2014) there have been fluctuations in the amount of average flow ranging between 4 m^3/s and 30 m^3/s (Figure 14).

The mean flow at 12th March 2014 is at 4 m^3/s compared to a required average flow of around 8 m^3/s. The Manafwa River has potential to produce the required average flow (IBID 2014). In order to do so, some measures/strategies have to be undertaken as suggested in chapter 6.3.2.

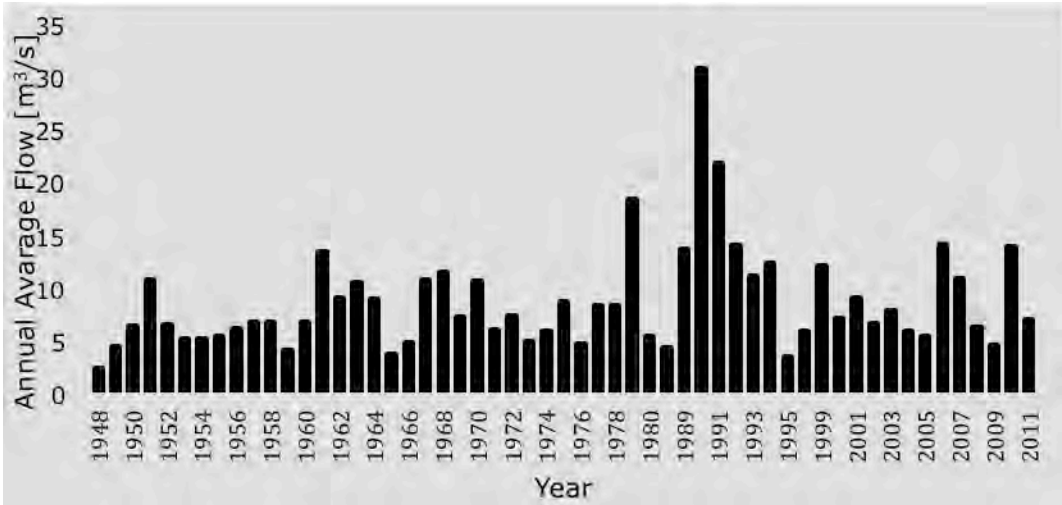

Figure 14: Annual Avarage Flow at the Gauging Station
Source: DWD 2011

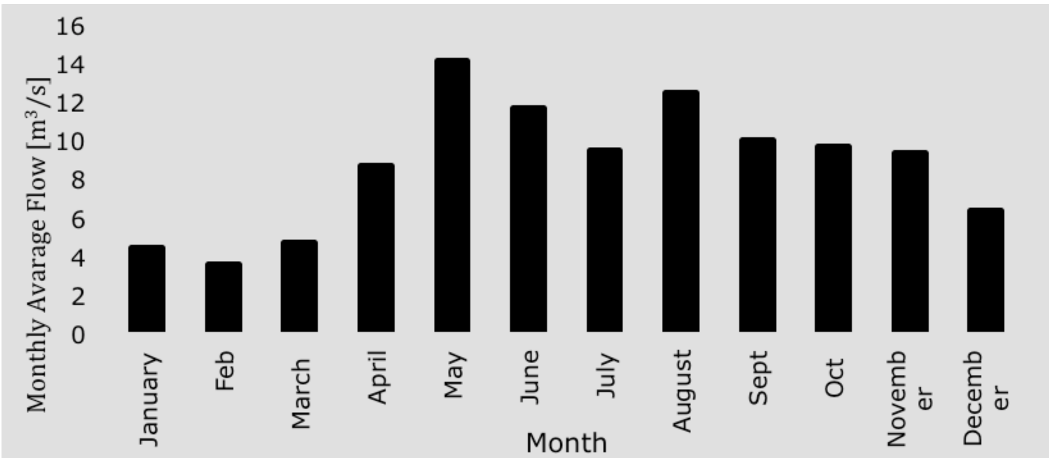

Figure 15: Monthly Average Flow at Manafwa Gauging Station
Source: DWD 2011

6.3.1 Influencing Factors

The average flow influencing factors are similar to those for the base flow listed in the sub-chapter 6.2.1. To them count among others solid topsoil, dismissed vegetation due to urbanisation, deforestation, oily eucalyptus leaves and augmentation of agricultural effective areas.

6.3.2 Recommendations to secure the Average Flow

During the workshop the following management options are elaborated to secure the average stream flow.

PLEASE NOTE: The water cycle has to be considered as a whole therefore the following recommendations have to be considered in combination with the recommendations to secure the base flow and limit the peak flow:

1. Soil Cover Maintenance through:

- Mulching which is already applied in the Manafwa Sub-Catchment is useful to improve moisture in the soil, water retention, and reduces soil erosion (Figure 16)
- Cover cropping (planting local typical cover crops as sweet potatoes or grass) to increase the vegetation cover that could reduce the impact of raindrop erosion and runoff. This would also improve the soil biodiversity and soil structure within the catchment area
- Intercropping to increase water infiltration and retention

Figure 16: Mulching with Banana Leafs

2. Soil Production:

- Afforestation
- Agroforestry (see chapter 6.2.2)
- Minimizing of soil compaction and erosion (through afforestation, adapted cultivation methods, and grazing)
- Vegetative filter strips for example through planting grass along the riverbanks to prevent drainage of polluted surface runoff into the stream system (see chapter 6.4 point 6)

PLEASE NOTE: All Recommendations should be considered with the cross-cutting recommendations in chapter 6.5)

6.4 Peak Flow in the Manafwa Sub-Catchment

Peak flows can cause damages as evidenced in Manafwa Sub-Catchment where flooding affected severe structural damage of private and public facilities and infrastructure (including the NWSC), extensive crop loss, and wider environmental degradation (NYANGA 2014B).

Current data from DWD (2011) indicates a low increase of the annual peak flow from 1949 to 2011 (Figure 17: Peakflow at Manafwa Gauging Station). Due to NANA (2013) this comes along with increased human settlement and encroachment into the Manafwa Sub-Catchment and flood plains/buffer zones. The effects of flood will be probably more devastating. In this regard, there is need to introduce interventions/measures to regulate the damaging effects of the peak flow.

Figure 17 shows the distribution of annual peak flow in the duration of 1949 to 2011. The maximum peak flow was at 56,5 m^3/s in 1990 and the minimum peak flow is reported with 7,85 m^3/s in 2009.

PLEASE NOTE: The lowest peak flow was reached in 2009 and at the workshop calculated trend of the peak flow over the last 62 years shows just a low increase. Therefore to make a point about the development and impact of peak flow further information as annual precipitation data, peak flow frequency and recurrence interval (RI) have to be consulted (AHEARN 2003).

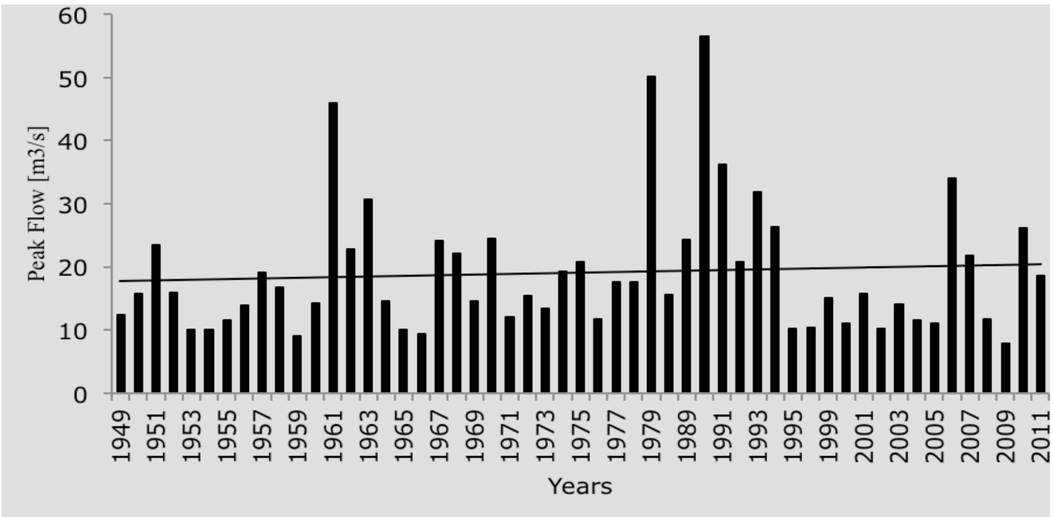

Figure 17: Peakflow at Manafwa Gauging Station
Source: DWD 2011

6.4.1 Influencing Factors

A peak flow occurs in case of a high storm event and low rainwater infiltration into the soil, which comes along with low soil coverage and unhampered runoff. Please see chapter 6.2.1

6.4.2 Recommendations to cheque the Peak Flow

In this section management peak flow options are proposed for implementation in the Manafwa Sub-Catchment. As with the base and average flow, the here considered recommendations are envisaged to implemented at local level through the cooperation of the local community, NWSC, and further stakeholders. These interventions are subject to the Environmental Impact Assessment (EIA) and Socio-Economic Assessment (SEA).

The vision is to make use of storm water by hampering peak flow.

1. Flood Plains:

- The flood plain is that land around the Manafwa River that may be covered by floodwater during a storm regional flood event. The floodplain should include the floodway and flood fringe area. The floodway is the most dangerous part of the floodplain. The flood fringe is the portion outside of the floodway associated with standing water rather than flowing water. Development in the flood fringe is allow according to the management agreements (Figure 18)
- Inhabitants of the Manafwa Sub-Catchment would need to be discouraged from settling on flood plains, especially in the portion of floodway. Those who have already settled on these plains can be requested to move to alternative land
- Specific recommendations concerning floodplain need précised information about precipitation, peak flow frequency and RI, as well as environmental and socio-economic assessment

PLEASE NOTE: Apriori, the cost-benefit analysis should be conducted. The collaboration of local and regional level is required

- See point six riparian grass

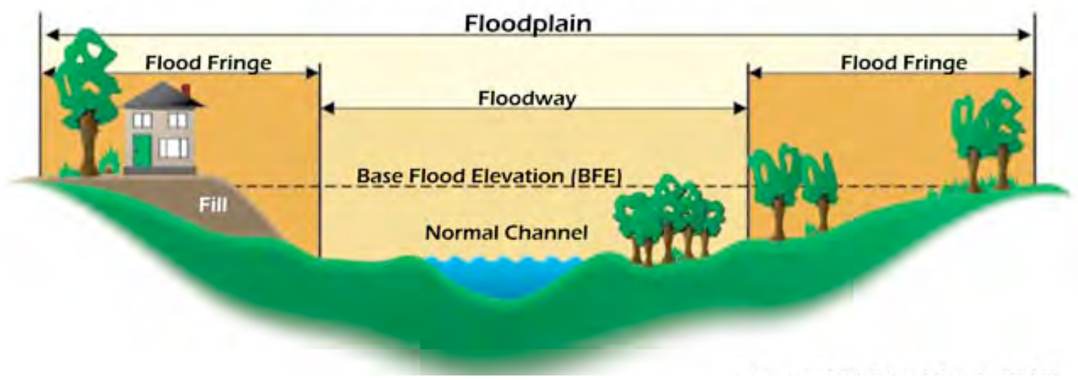

Figure 18: Characteristics of a Floodplain.
Source: NFIP Gauidbook, FEMA

2. Rainwater Harvesting:

- Rainwater harvesting can be implemented as a measure of reducing peak flow
- See chapter 6.2.2

Recommendations of rainwater harvesting concerning limited peak flow and water for domestic use:

- As a general proposition, NWSC could get into partnerships with the local community and provide water tanks (e.g. 10,000 litre tanks per three households). This would benefit the community as an alternative source of potable water, eliminating the need to move long distances to get water, decrease the groundwater withdrawal, and limit peak flow. The advantage, the villagers are already familiar with rainwater harvesting methods as water collection from rooftops (Figure 19)

Figure 19: Rainwater Harvesting in the Sub-Catchment

3. Weirs on Micro-Level:

- Weirs at selected locations of tributaries could be an effect means in reducing peak flows. Inexpensive technology can be used to construct weirs (e.g. the use of locally available materials such as boulders and sand). NWSC has successfully implemented weirs in other projects (NWSC 2011).

4. Mini-Dams/Water Ponds:

- Construction of mini-dams (Figure 10) can be used to slow down flow velocity during peak flow
- Used in lower elevations of the catchment, difficult at higher elevations because of possibility of landslides
- Collected water in the dams/ponds could be used during dry seasons and for the base flow recharge
- Subject to further EIA, SEA, and risk analysis

5. Early Warning System for Peak Flow:

- Early Warning Systems (EWS) during peak flows could be established between NWSC and the local community
- This may involve the installation of remote systems and training of the locals both in the Sub-Catchment as well as at NWSC on how to take readings, which may then be reported to the NWSC via text message. Beyond, there are apps on the market to facilitate EWS for peak flow. Innovative

approaches as this would require further assessments since the villagers already mentioned high costs and bad mobile phone connection in the area (see chapter 5.2 point 4)

6. Grow Riparian Grass:

- The populace in Manafwa Sub-Catchments may be encouraged to grow riparian grass (especially Vetiver sp.) as a instrument to reduce peak flow and degradation of the riverbanks because the runoff is mitigated
- Reports (NYANGA 2014) indicate that previous attempts to get the populace to grow Napier Grass were not very successful. The locals did not realize much economic benefits of Napier Grass. Vetiver grass (Figure 20) on the other hand has several possible economic benefits, which includes income gaining activities as making handcrafts, perfumery and also mulching
- The effect of introducing the riparian vegetation should not interfere with the river ecology. Monitoring that it does not reduce the size of the river channel, which may have counter effect

Figure 20: Vetiver Grass

7. Afforestation:

- In general, forest is associated with reducing peak flow, which not necessarily is applicable for all species of threes (ROBINSON 2003). Alternatives to Eucalyptus need to be planted to limit unhampered runoff in the Sub-Catchment At the same time the wood production as economic resource has to be considered.
- Methods can be agroforestry and alley cropping as discussed in chapter 25 production at the same time. See chapter 6.2.2. point 3 and 4. Additionally see Box 1.

8. Mulching:

- See chapter 6.2.2.
- Especially through the use of banana leaves

9. Energy Based Options:

- In the Manafwa Sub-Catchment the main source of fuel is charcoal or firewood (Figure 28). Therefore introduction of alternative sources of energy would minimize the cutting down of trees. Increased tree cover would lead to increased water infiltration

Suggest alternative energy sources include the following:

a) Use of energy efficient stoves that use briquettes instead of charcoal (Figure 29)

b) Use of biogas plants. In the Manafwa Sub-Catchment inhabitants practices zero grazing. Community projects can be organised to teach the residents on the development of biogas plants as an alternative source of energy

c) Micro-hydroelectric power stations, which can produce up to 100kW of electricity using natural water flow. These can be used to provide power to isolated homes or community and reduce the consumption of wood fuel, improve wetland retention, and may also reduce the peak flow.

d) Solar energy is very limited use in the Manafwa Sub-Catchment but could be an alternative energy source even at the household level

10. Soil Based Options:

- Soil interventions to minimize peak flow are numerous. Some key examples include: a) terracing, b) mulching, c) grass bunds, d) trash lines, e) Micro basins

6.5 Cross-cutting Recommendations

1. Consideration of Human Resources:

- Multi-dimensional approach to address and interlink the local and regional level
- Community involvement in the upcoming IWM activities
- Consideration and contacting of projects which are already active in the Manafwa Area (e.g. some are listed by NECODAG 2010)
- Capacity building on pit latrine issues, cultivation along the riverbanks, and gender issues
- Payment for Ecosystem Services (PES)

PLEASE NOTE: MWE has come up with guidelines on water source and environmental protection and a special environmental police to enforce the established law. See chapter 7

- Implementation, involvement and sensitization of a water user association

PLEASE NOTE: This needs intimated knowledge of the Sub-Catchment

- Alternatives to sand mining, which is a recent economic activity that has destroyed the riverbed and riverbank

- Enforcement of the law on settlement and relocation plan especially in the Bududa district.

2. General Water Management Options:

- Source protection and mitigation measures
- Maintaining water ways
- Water level monitoring & data collection at local level
- Proper waste management practices especially the management of used polythene bags by recycling to get products like bags and ropes

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7 Contribution of UWS for IWM

Water availability, reliability, accessibility, affordability and sustainability are major concerns of Urban Water Security. In best case, sufficient and undisrupted quality water is provided to an intended user community in an urban setting, at the shortest possible distance, time, and cost. However, for the available water to be accessible to both present and future generations UWS shall aim at achieving water sustainability.

That effect, UWS and IWM are interlinked and are mutually dependent. Some linkage examples are shortly listed below (BARBOSA 2012):

- Missing storm water measures in the urban Mbale can have devastating effects even to surrounding rural areas as the Manafwa Sub-Catchment
- On-going urbanisation of Mbale includes removal of vegetation, which results in a change of surface runoff. In case of missing UWS measures, urban storm water runoff can impact up to the surrounding Sub-Catchments
- Anthropogenic generated waste and pollutants can be washed out to water bodies of a watershed during a storm
- Missing maintenance of water pipes creates losses of transported water, deductive water demand in urban areas and extraction from Manafwa River increases. Maintenance of watershed services is just as crucial as maintenance of other types of infrastructure
- Institutional development can affect both the urban demand and rural supply side

It calls for protraction and sustainable and efficient possible use on both sides the urban population as well as the surrounding watershed inhabitants.

7.1 Recommendations for UWS as a Tool for improved IWM

Different from chapter 6, the recommendation for UWS as a Tool for improved IWM refer soely to Payments for Watershed Services (PWS).

1. Payments for Watershed Services

Localized IWM compensation mechanisms such as Payments for Watershed Services may enable enhanced delivery of Environmental Services (ES) by “poor” upstream stakeholders (Inhabitants in the Manafwa Sub-Watershed) to “rich” downstream waters users (Partly inhabitants in the Manafwa Sub-Watershed but mainly located in Mbale). Though successful UWS has been achieved in many areas through PWS (MALESU ET AL. 2006; DENT & KAUFFMAN 2007), other studies have shown that some of these schemes are not economically efficient and financially sustainable in many developing countries (FONAFIFO ET AL. 2012; LUWESI ET AL. 2012). Hence, caution shall be taken when designing and implementing PWS schemes.

The Ministry of Water and Environment (MWE 2012A&B) has provided a framework and guidelines, through its Ministry of Water and Environment, for designing and implementing PWS schemes between upstream farmers (ES sellers) and downstream water users (ES buyer). A special emphasis is put on the protection of water sources by the NWSC and major irrigation schemes (e.g. Doho Rice Scheme). The operationalization of this water source protection based watershed management includes eight critical steps, namely: (1) initiation and preparation; (2) awareness raising and sensitization of stakeholders; (3) detailed catchment problem analysis; (4) detailed catchment stakeholder analysis; (5) targets, monitoring and regulation; (6) identification of control measures; (7) preparation and financing of water source protection plan; and (8) implementation, review and updating.

In a nutshell, the process of designing and implementing a PWS scheme in Manafwa Sub-Catchment needs an assessment to determine hotspots and map key stakeholders and available resources. Then community members may be involved in the process of water source protection planning by signing of a Memorandum of Understanding (MoU). Finally, the development, implementation, monitoring, evaluation, and regulation of water source protection shall be done by all the stakeholders using a participatory approach (LUWESI & BADR 2013).

Targeted Hotspots for Manafwa PWS Scheme:

- A prospective implementation of a PWS scheme in Manafwa Sub-Catchment shall focus on Nakatsi Sub-County, Bulucheke Sub-County (Nametsi village), and the sources of river Tumbu, Busano and Sala, which are affected by frequent mass movements as well as riverbank and soil erosions.

Preliminary Stakeholders Mapping:

- Local stakeholders (as farmers; brick makers; sand and stone miners; wood loggers; Water User Committees; children and women as persons mainly responsible for water provision; and many more)
- Urban Domestic Consumers
- Industry (as cottage and beer industry)
- Schemes (as Gravity Flow Schemes for Rural Water Supply; Major Irrigation Scheme|Doho Rice Scheme)
- Water Supplier
    - Small Towns Water Supplier (as Manafwa; Bududa; Bwagogo; Busano; Bosolwe; and Buteleja Town Councils)
    - Large Urban Water Supplier (NWSC)
- Institutions (hospitals; schools; faith based organizations)
- Government
    - Regional Government (as district technical officers of water; forestry; environment; agriculture; wetland; veterinary; Kyoga Water Management Zones)
    - National Government as Ministry of Land, Water and Environment (NEMA, Technical Support Unit, Directorate of Water Development (DWD): Directorate of Water Resource Management (DWRM) and Directorate of Water Development Facility; Uganda Wildlife Authority; National Forestry Authority)
- Donors (as USAID, ADB, IFAD, DANIDA, EU, GIZ)

- NGOs (IUCN, World Vision, Africare, Food for the Hungry, Water Aid).
- Academic Institutions (Makerere University, Islamic University in Uganda, Mbale School of Clinical Officers)

Stakeholders' Involvement in the PWS Scheme:

For sustainable management of the water sources there is need for upstream and downstream stakeholders to co-operate with the facilitation of the local government and other stakeholders. The following institutions shall facilitate the design and implementation of the water source protection plan in Manafwa Sub-catchment:

- "Water source protection forum" involving all key stakeholders interested in the PWS
- "Water source protection committee" are elected by the above stakeholders' forum
- "Water source protection secretariat" consisting of technical personnel in charge of daily administrative issues related to the implementation of the PWS scheme

Developing and Signing of PWS Agreement:

- For effective design and implementation of a PWS scheme in Manafwa Sub-Catchment an agreement shall be made on various issues depending on the needs expressed by local stakeholders. These include a) hydrological concerns (water quality and quantity), b) upstream ecosystem managers' and downstream water users' benefits and c) environmental impacts on their livelihood.
- A legal contractual agreement shall be signed between upstream sellers and downstream buyers. The upstream stakeholders shall be considered as the ecosystem stewards and thus entitled to payment for their Environmental Services (ES) by their downstream counterparts (beneficiaries).

Developing and Implementing Water Source Protection Plans:

- Payments to upstream farmers shall be equitable and based on the nature and importance of interventions to be implemented in the catchment, especially on the above hotspots identified for the PWS scheme in Manafwa Sub-Catchment.
- The targeted interventions shall include both institutional activities (regulation, advisory, monitoring and evaluation) and engineering measures (soil and water conservation) through sustainable soil, forestry and biodiversity conservation, landscape rehabilitation and livelihood improvement. This PWS scheme shall address policy and land tenure issues, secure nature based business potential, improve rural poor livelihoods, secure investment; and protect and restore riparian lands of the catchment.
- Kyoga Water Management Zone shall be deeply involved in behaviour change and land use transformation for catchment conservation through partnership with Makerere University and other academic institutions of Uganda.
- Awareness shall be created on environmental changes and conflict resolution, tree planting, grasses striping, terracing, runoff cut off, increased biomass and reduced usage of fertilizers and pesticides.

- By the end of the year 2015, the Makerere University and Water Resources Department shall provide an evaluation of the outcomes of capacity building activities on Integrated Watershed Management in Manafwa Sub-Catchment.

Monitoring and Evaluation of Water Source Protection Plans:

The following key results are expected from this process:

- In less than two years, twelve Water Source Protection Forums are busy creating awareness on the water sector reforms, majority shall be having water source protection plans
- Kyoga Water Management Zone shall have developed tools for implementing IWM rules, water use charges and effluent discharge control plans based on participatory approaches
- Reduced Illegal water abstractions in the upper parts of the catchments,
- Strengthen water permitting system
- Reduced water rationing to enable 24hours water supply to downstream water users
- NWSC as a major water extractor to significantly contribute to on-going catchment conservation activities in the upper Sub-Catchment
- Kyoga Water Management Zones should empower water source protection committees to fence off and protect water sources, discourage planting of water intensive trees species (Eucalyptus sp.)
- Discourage pit latrines, open defecation, burial grounds, livestock pens or sheds, and cultivation near riparian areas

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8 Way Forward

This workshop on "Integrated Watershed Management – a tool for urban water security" collated challenges of IWM and UWS for Manafwa Sub-catchment and the NWSC for Mbale town and gave management options for different purposes of UWS. The workshop did not capture all aspects due to time limitations and thus this report is not a final product. The way forward for reaching this tasks is summarized below:

- Conduction of three more workshops on monitoring and modeling, capacity building for local communities, dissemination and networking (FU Berlin and IWM Expert GmbH)
- Engaging students from the Makerere University IWM MSc programme in further field work and thesis research (MAK)
- Developing joint proposals for projects and seminars to supplement the workshop activities and dissemination of results (FU Berlin, MAK, IWM Expert GmbH)
- Liaising with the Kyoga Water Management Zone and the GIZ RUWASS team (MAK)

9 Impressions from Manafa Sub-Catchment Area

Figure 21: NWSC Water Works for Mbale Town (at Outlet of Sub-Catchment)

Figure 22: Lower Part of the Sub-Catchment

Figure 23: Sand Mining, Car Washing and Cloth Washing in Tributary of Manafwa Sub-Catchment

Figure 24: Agriculture next to the River Bank

Figure 25: Stakeholder Participation during Excursion

Figure 26: Water Pollution

Figure 27: Brick Macking Oven

Figure 28: Fuel Wood for Brick Making

Figure 29: Making of Brickets

Figure 30: Vetiver Grass for Stabilisation of Terraces

Figure 31: Upper Part of the Sub-Catchment/ Land Slieds

10 Description of implementing Project "Integrated Watershed Research for Urban Water Security"

The international university project "Integrated Watershed Management for Urban Water Security" is an interdisciplinary capacity building project of Freie Universität Berlin, Makerere University, GIZ RUWASS, and IWM Expert GmbH.

These days Integrated Watershed Management (IWM) is a widely accepted concept for the sustainable management of human and natural resources of a watershed in order to keep and increase livelihoods of the local population. Management and development competences in the sector of IWM are lacking, not only due to missing capacity building opportunities, but due to a severe communication gap among the different IWM stakeholder: researchers, regulatory authorities, water resources users associations and other community based organisation.

The overall objective of this project aims at strengthening information and knowledge transfer among the different stakeholder groups with regard to IWM. Thus, the project contributes to reach the MDGs 7 (ensure environmental sustainability) and MDG 1 (eradicate extreme poverty and hunger) and supports international exchange in research and education.

Freie Universität Berlin

Project Applicant and Management

Makerere University

Project Partner

GIZ – RUWASS

Project Partner

IWM Expert GmbH

Project Management

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