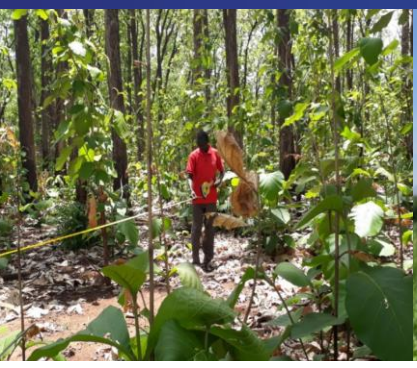
Nov 30, 2017

Kinaite Catchment

Environmental Risk Assessment & Ecosystem mapping
Protracted Crisis Horn of Africa (PCHA) – South Sudan

Synthesis Report

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Executive summary

This report, part of the Protracted Crisis Horn of Africa (PCHA) project, focusses on the Kinaite Catchment of Eastern Equatoria State in South Sudan. This area has been dealing with many problems over the last decades including civil war conflicts, floods and droughts. The overall goal of the project is to provide a baseline for water security, food security and future catchment management plans for disaster risk reduction for the Kinaite Catchment. For this purpose, environmental risk assessment is combined with ecosystem mapping. Natural ecosystems perform many services, such as food provision, climate regulation and flood and drought mitigation. Targeted use of ecosystem services can be an effective tool in disaster risk reduction.

To accomplish this, a literature study and a field study was performed to support two things: 1) development of an ecosystem map of the catchment with identification of according ecosystem services; and 2) an environmental risk assessment in which the main threats and hazards in the area were identified and ranked. Based on this, solutions to main threats and hazards were identified, coupled to ecosystem services, and recommendations were made.

It appeared that, besides the conflicts, most problems were a result of the expanding agriculture and deforestation, with the combination of bad land management practices. To combat these problems, a switch to good agricultural practices is necessary, like contour strips, soil bunds and mulching. A switch to agroforestry or ecosystem-based use of natural resources would be even better, as benefits of forest ecosystem services like flood and drought mitigation could also be exploited. Field-scale rainwater harvesting could significantly increase food and water security in the catchment as well. Strengthening of the institutional context and promotion of the value chain is however required to make such a switch feasible at catchment level.

Colophon

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1 Introduction

Kinaite Catchment is situated in the Eastern Equatoria State, Torit County, in South Sudan, a country established in 2011 after two decades of civil war and colonial occupation. Kinaite Catchment is an area with a high biodiversity of which the wetlands of Badingilo and the Imatong Central Forest Reserve are part. The catchment is prone to disasters and is typically characterised by food insecurity and low social and economic development levels leading to unsustainable natural resource use. Low development levels are largely attributed to chronic insecurity, droughts, floods and disease outbreaks, resulting in the displacement of populations, crop failure, loss of livestock and high mortality rates.

Acacia Water and Wetlands International Kenya are working together in Kinaite Catchment on the Protracted Crisis Horn of Africa (PCHA) Project (2014 – 2017). The aim of the project is long term community stability and resilience through strategic interventions for food security, water security and disaster risk reduction (DRR). Protecting and restoring ecosystems while optimizing ecosystem services and ecosystem-based catchment management planning contribute to sustainable livelihoods and resilience to disasters. Wetlands International will continue the work in Kinaite Catchment in the Partners for Resilience project (PfR) (2016-2020), which are implemented through strategic interventions targeting the challenges mentioned above. These programmes are implemented in partnership with the Netherlands Red Cross, South Sudan Red Cross, the Red Cross Climate Centre and Cordaid with the support of the Dutch Ministry of Foreign Affairs (MoFA). The programmes are implemented in close collaboration with key public and local stakeholders both at the Federal and State levels, and is expected to consolidate community participation in environmental conservation through capacity building and awareness raising directly linked to Water Resource

This synthesis report presents the baseline situation for the PCHA project including ecosystem mapping combined with an environmental risk assessment.

Approach

The two main objectives of this assessment were the identification of main environmental risks and mapping of the ecosystems and their services. To achieve these objectives, data and information from a literature study, remote sensing, GIS analysis, field surveys and interviews with stakeholders were combined.

Figure 1. Three different ecosystem services from Kinaite Catchment. Top photo: wild coconuts, middle: Bee hive for honey, bottom: grinding cassava on rocks.

There are several studies available that provide a good starting point for this report. The African Wildlife Foundation (AWF) was planning to implement a five-year program "Improving the Integrated Watershed Management of the Imatong Mountains", aiming to secure the forest reserves at the Imatong Mountains. This project contained a refined landcover map and a threat assessment for the Upper Kinaite Catchment (AWF, 2014). The Institute of Natural Resources carried out a study for AWF: 'Imatong forest and water consultancy report' which contains relevant information for the mid and upper Kinaite Catchment. (AWF, 2015). Future Water has built a water resources allocation model for Kinaite Catchment (Future Water, 2015).

To map the ecosystems, a landcover map was developed using Landsat8 satellite imagery and the FAO Land Use Land Cover map, which was then translated into an ecosystems map. The ecosystems were defined based on existing ecosystem classifications, field data collection and visual analysis of satellite imagery. The refinement (for example of the agricultural lands) was done using manually digitized land cover classes in Google earth, Landsat and NDVI images. The classes are based on the IUCN Habitats Classification Scheme (Version 3.1).

In March 2017 Wetlands International Kenya travelled to Kinaite Catchment to collect data and consult key stakeholders[1]. The field data collection was guided by Acacia Water and assisted by NIRAS International, Rural Action Against Hunger (RAAH) and six local research assistants:

- Dominic Andruga
- Mindraa Stella
- Isaac Oduho
- Libel Amos Ucwa
- Taban James
- Timateo

The biophysical field data of sample plots was used to calibrate the landcover and ecosystems map. The results of the stakeholder consultation were used to support the identification of ecosystem services. Scoring exercises were done with communities to identify key threats and hazards in the catchment.

[1] All photographs included in the report were made during the field visit by Wetlands International Kenya in march 2017

The results of the assessment were validated with stakeholders during a workshop in Torit in September 2017. The validation workshop was attended by twenty-six participants from diverse backgrounds and organisations from the Imotong State, government line ministries and local Civil Society Organisations (CSOs)

2 Background

Kinaite Catchment is situated in South Sudan (Figure 2) close to the border with Uganda. The catchment connects two protected areas, the Imatong Forest Reserve to the south and Badingilo National Park to the north. Administratively the catchment falls within the former Eastern Equatoria State and the payams of Pacidi, Burgilo, Kurumi, Imurok, Ifwotu, Kudo, Hiyala, Himodonge, Nyong, Iyire. The catchment comprises an area of 3891 km^2 and the main urban centre is Torit Township which is growing rapidly. There are different variations on the spelling of the Kinaite catchment. These include Kinnyeti, Kinneti, Kenneti and Hinaite. For purposes of uniformity, it was agreed to retain Kinaite Catchment.

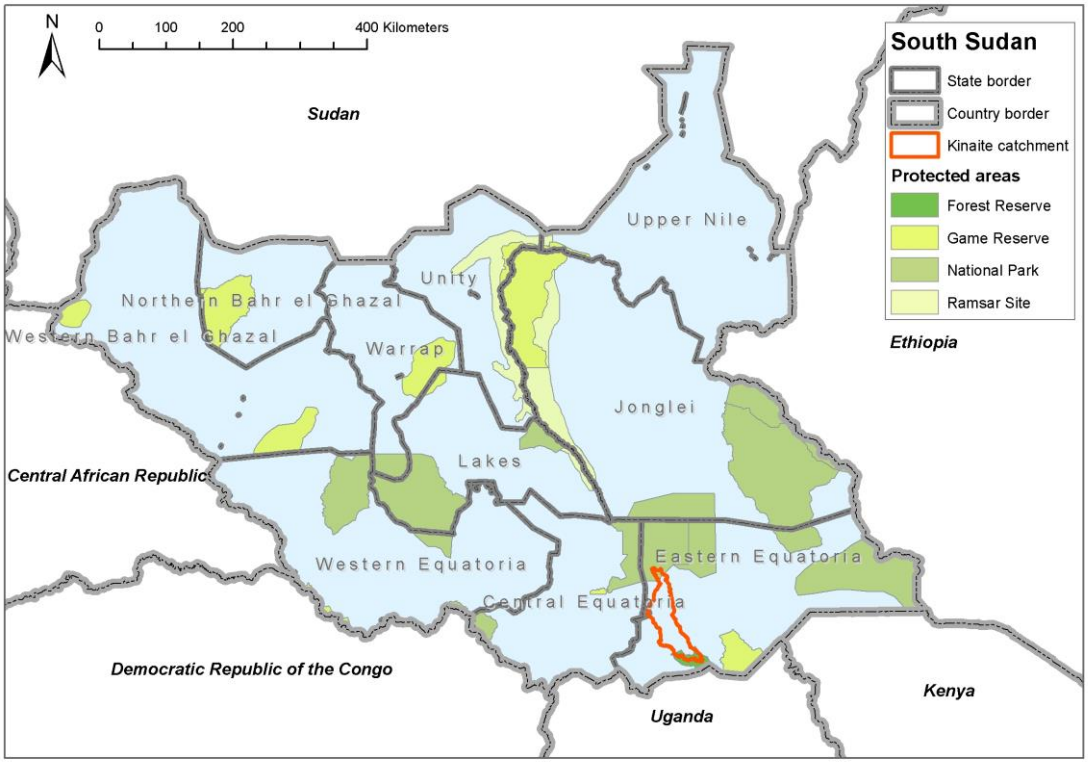

Figure 2. Map of South Sudan, with Kinaite Catchment illustrated in red.

2.1 Physical landscape

Topography

The main river of the catchment is the Kinaite River. It originates from the Imatong Mountains, which lie for a large part in the Imatong Central Forest Reserve, flowing northward eventually dispersing into the wetlands of Badingilo National Park. Kinaite Catchment has an atypical topography (Figure 3). The majority of the catchment is extremely flat and has vast areas of occasionally and regularly flooded lands. Yet, the elevation differences between the floodplains (Torit at 600 masl) and the highest point (Mt Kinyeti 3170 masl) are extreme for the limited size

of the catchment. The high biodiversity and high diversity of ecosystems in the catchment are strongly linked to these elevation differences through differences in biogeography and climate conditions.

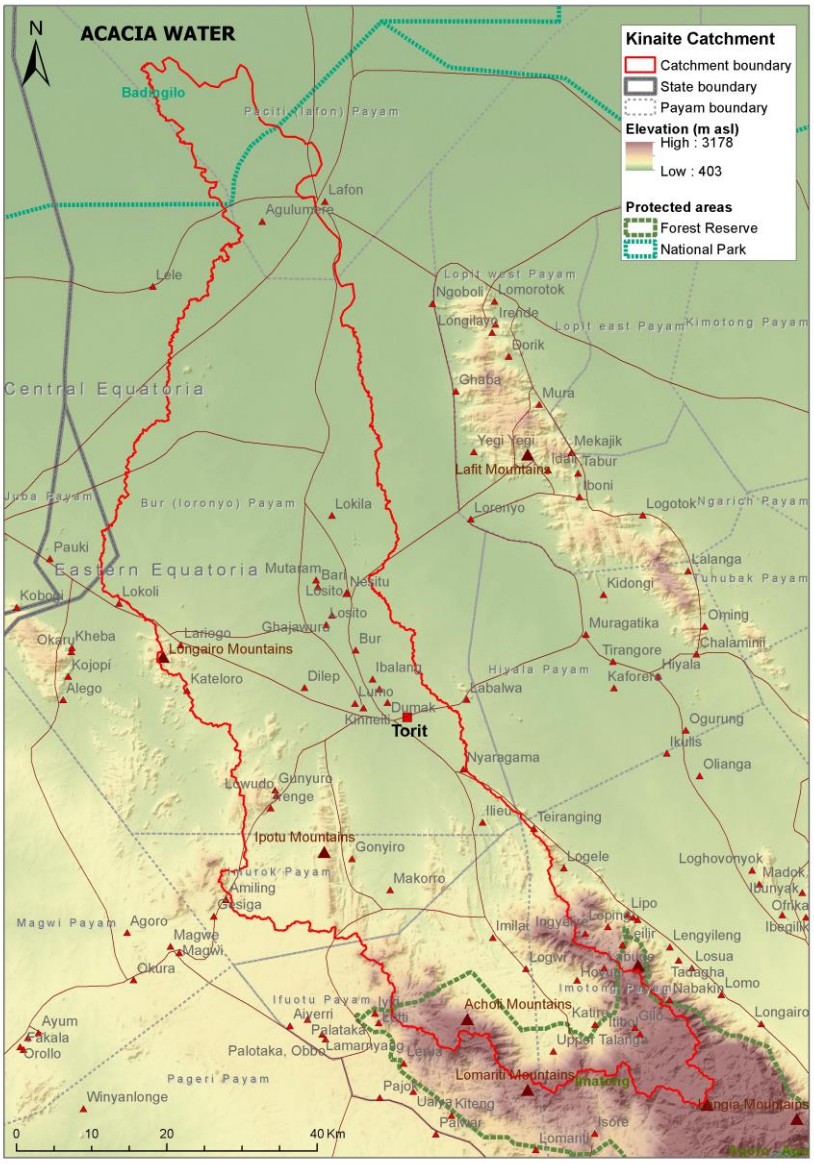

Figure 3. Topographic map of the Kinaite Catchment

Geology and soils

Geologically, the area can be divided into three areas. The middle and largest part of the catchment is underlain by the basement complex, a vast formation of Precambrian metamorphic rock. The depth of the basement rock is variable. In the southeast, the basement complex is overlain by intrusive rocks, which form the Imatong Mountains which stand out high above the landscape. In the North, more recent material is present, such as Quaternary sandstones and alluvial deposits. A geological map can be found in Annex 1.

Six major soil types can be distinguished in Kinaite Catchment (Figure 4). The Imatong Mountains are predominantly covered by leptosols, which are very shallow soils with depths of less than one

meter over hard rock. The field assessment indicated stones and boulders in the topsoil. These soils are very sensitive to erosion, and hold low potential for agriculture.

At lower elevations, leptosols are replaced by nitisol and later on lixisols. Both nitisols and lixisols are characterized by a high degree of weathering, but nitisols have a higher fertility. Lixisols have a strongly developed layer of clay accumulation, inhibiting drainage. This layer is much less developed in nitisols. Altogether, nitisols present a high and nitisols a medium potential for agriculture.

In the river and flooding areas fluvisols predominate, associated with recent alluvial deposits. Soil moisture capacity is high in these regions, and drainage can be good as well depending on texture of the local material. Potential for agriculture is medium to high in these areas. Field assessment shows clay soils and loamy-clay soils in the flooding areas. Site assessments with the loamier soils showed signs of cultivation and encroachment.

Beyond the floodplains, of which only a small part falls within catchment borders, cambisols and vertisols are present. Both soil types generally have a high fertility and are quite well suited for agriculture, but vertisols require intensive management to control soil erosion due to the high clay content. Vertisols are prone to develop deep wide cracks upon drying. This process causes the soil to mix or churn, which is good for fertility, but when unmanaged can destroy crops.

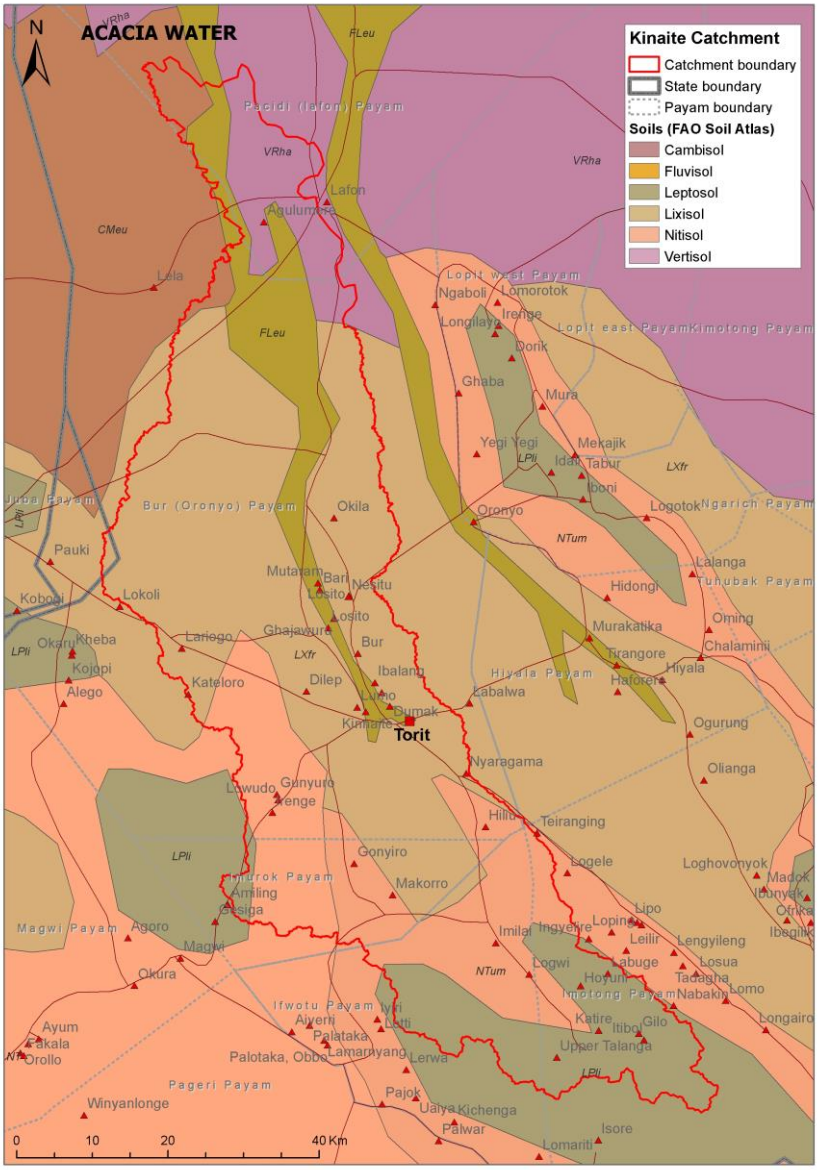

Figure 4. Soil map of the Kinaite Catchment (data: FAO Soil Atlas of Africa).

Land cover

Figure 5 depicts a refined landcover map, which was developed based on Landsat8 Imagery, FAO landcover data and Google Earth satellite images. The Imatong Mountains are primarily covered by broadleaved deciduous forest with woodland in the lower ranges and some patches of closed herbaceous vegetation. Most of the middle and lower catchment is covered by shrubland, with some large areas of open woodland and herbaceous vegetation (grasslands). The floodplains are mostly covered with closed herbaceous vegetation. Some patches of rainfed herbaceous crops are present as well, for instance around Torit which forms the largest patch of built-up area.

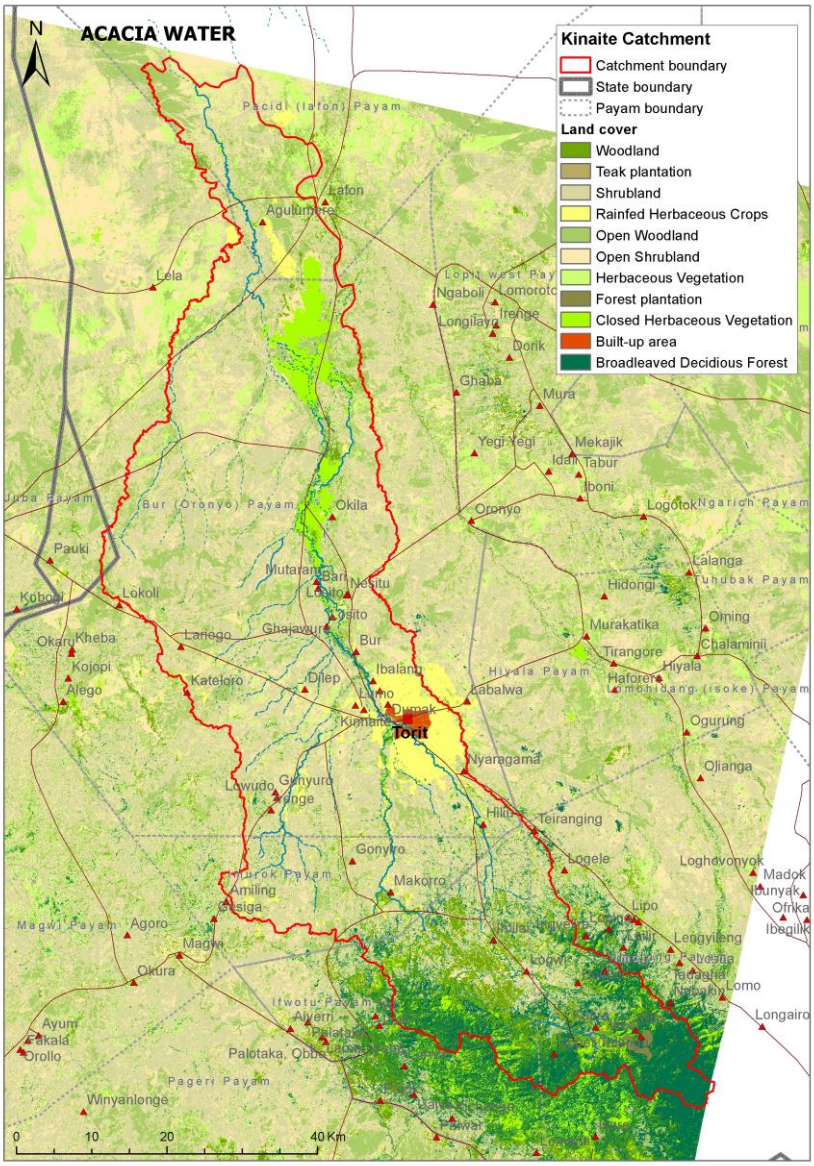

Figure 5 Refined landcover map of the Kinaite Catchment

2.2 Climate

Kinaite Catchment has a unimodal rainfall pattern with average precipitation of about 900-1,300 mm per year. The highest values of precipitation occur in the upper catchment, especially around the Imatong mountains. Precipitation decreases gradually northward. There are two distinct seasons; a rainy season from April to November and a short dry season from December to March. Two small precipitation peaks occur at the beginning of the rainy season and at the end. Inter-annual variation in precipitation is moderate, with highest values in the upper catchment of about 1700 mm and lowest values in the lower catchment of about 600 mm per year.

Temperatures in the area are high. Om average, maximum temperatures go up to about 42˚ Celsius in February and minimum down to 30˚ Celsius in December to January (FEWS-NET, 2013).

Evapotranspiration follows a pattern similar to that of precipitation, with values ranging from 300-1,000 mm per year. Values are highest in the upper catchment around the Imatong mountains and gradually decrease northward (Figure 7). A dry and wet season are observed as well, with an even clearer unimodal pattern.

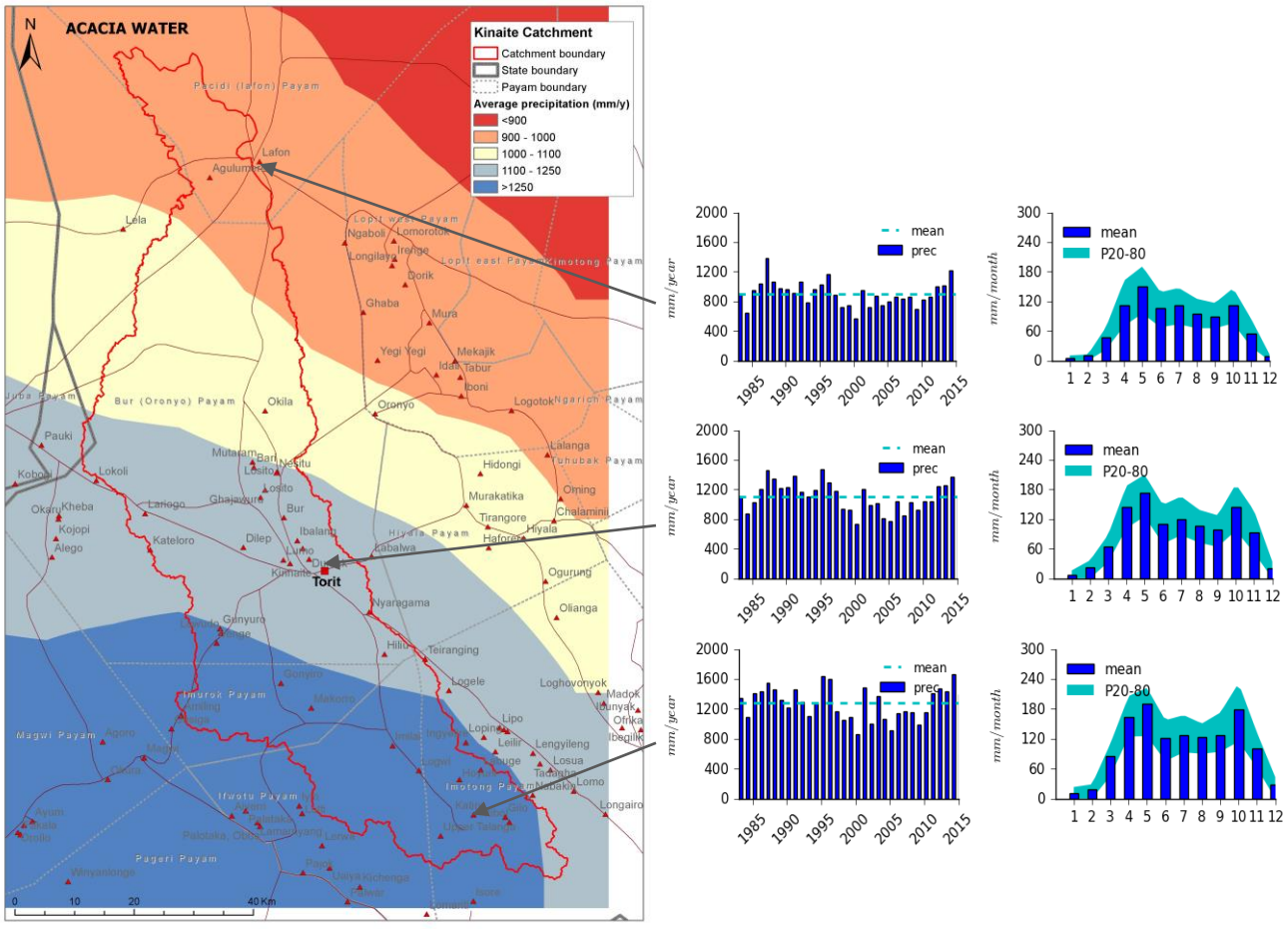

Figure 6. Average yearly precipitation based on ARC2 data (left); and average yearly and monthly ARC2 precipitation data Lafon, Torit and Katire respectively. P20-80 refers to the percentile falling within the given range (20% below, 20% above) (right)

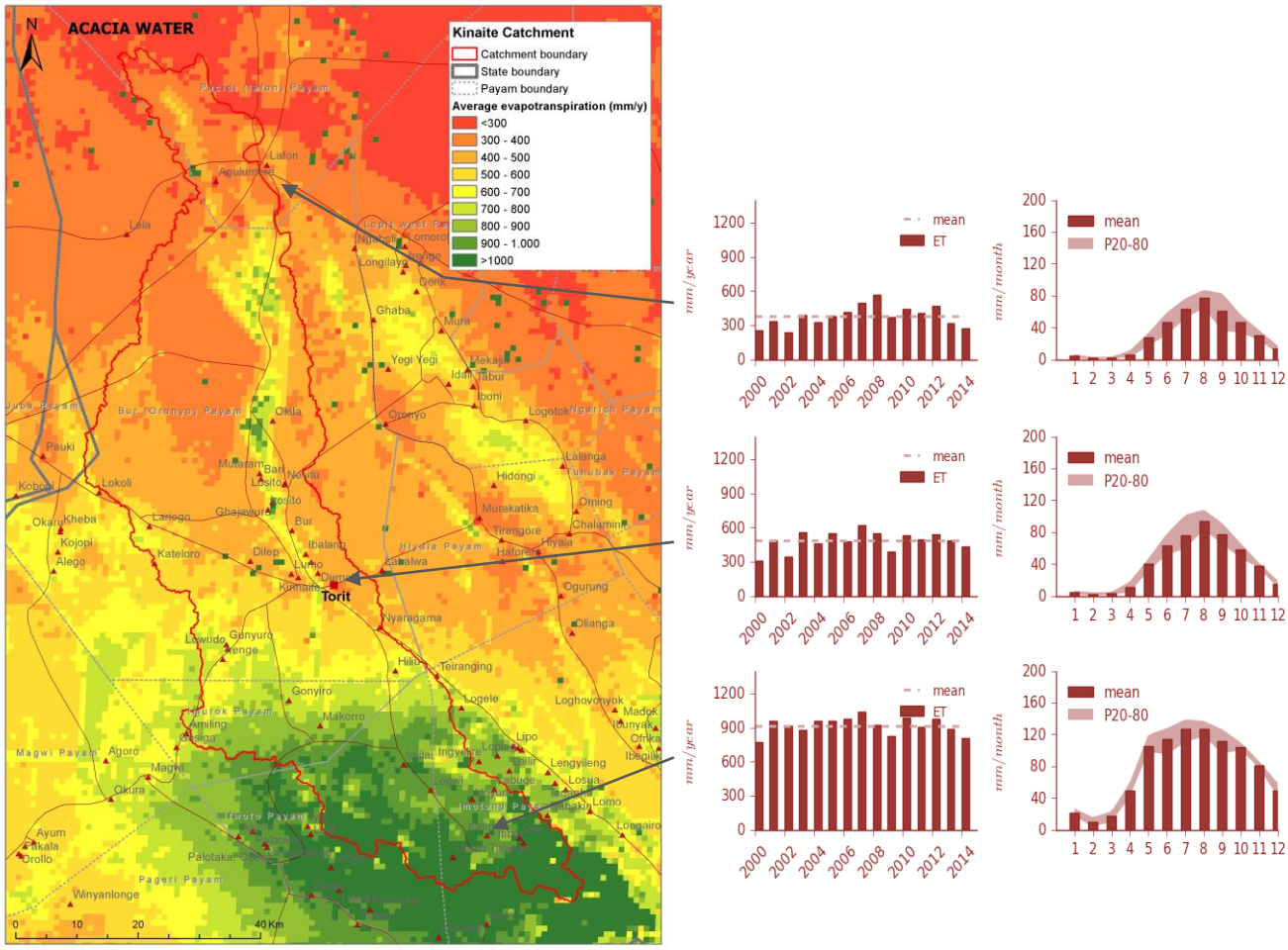

Figure 7 Average yearly MODIS evapotranspiration for the Kinaite catchment (left); and average yearly and monthly MODIS evapotranspiration data near Lafon, Torit and Katire respectively. P20-80 refers to the percentile falling within the given range (20% below, 20% above) (right)

2.3 Water resources

Surface water

The Kinaite river has many tributaries. The different sub-catchments are displayed in Figure 8. Different stream types and flooding areas were classified.

Although some boreholes are present in Torit County, the river and streams form the major source of water for domestic water use (IOM, 2013). The majority of the water originates from the Imatong Mountains. The discharge of the river and streams is strongly influenced by the seasons, rendering many of them dry from April onwards.

The wetlands downstream are heavily exploited by people and wildlife during the dry season (e.g. Badingilo National Park). As a consequence, the mouth of Kinaite River also dries up in April (Bilateral Programme in the Water Sector, 2012).

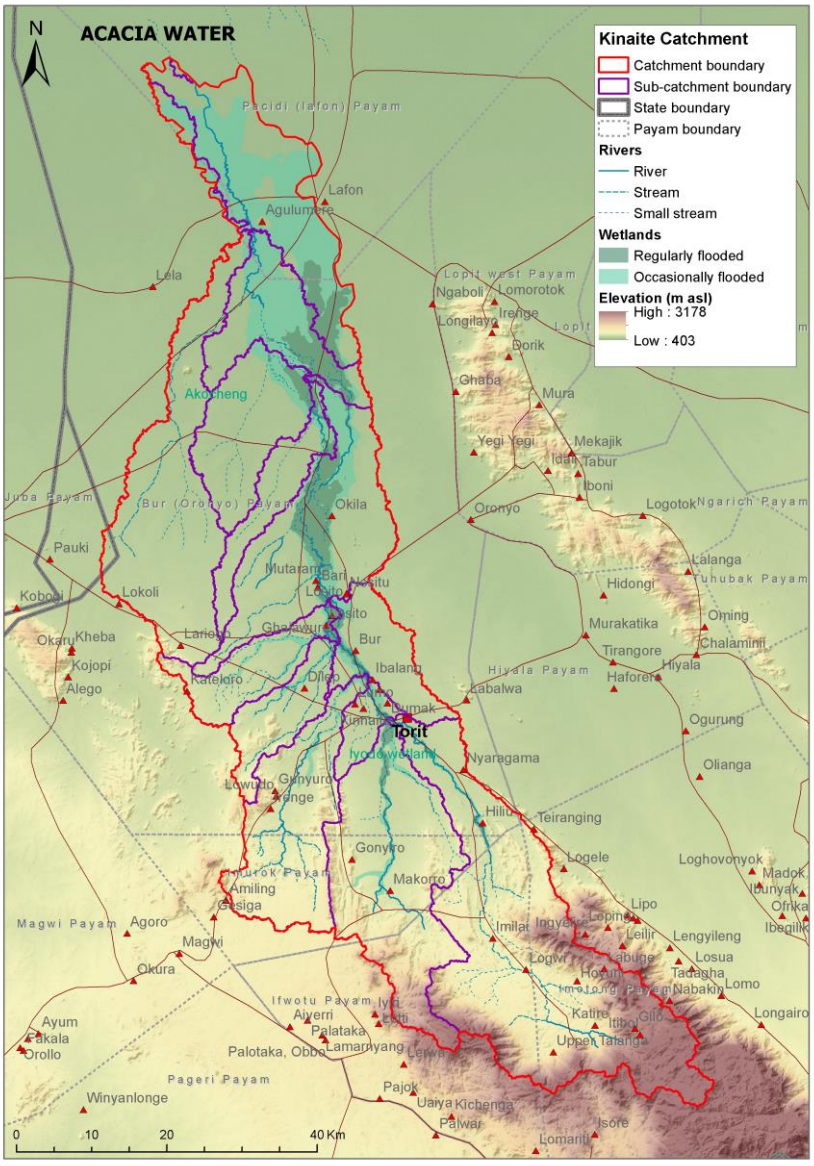

Figure 8. Hydrologic map including streams and sub catchments of the Mid-Upper Kinaite catchment.

The study of the Bilateral Programme in the Water Sector (2012) made estimations of the streamflow of the Kinaite river on the Juba-Torit main road. At the 23th of September, 2011, thus in the middle of the rainy season in an average year, the discharge rate was estimated at 4.0 m^3/s. A monitoring system of gauging stations was recently set up by NIRAS through its Water for Eastern Equatoria project. Nine gauging stations are included in this monitoring network in different Payams (see Table 1). Rating curves are used for the relation between the water level in the stream and the discharge in m^3/s.

Table 1. Overview of recently set up monitoring stations by NIRAS

nr	Payam	Station site	Type of stations	Latitude	Longitude	Altitude (masl)
1	Katire	DPK1_Katire	Staff gauge and cable way	4.267151	32.66431	665
2	Katire	Ottese	Staff gauge and cable way	4.033125	32.80091	1009
3	Torit	MoPI	staff gauge	4.401125	32.57251	606
4	Torit	Kiwa River	Staff gauge and cable way	4.20787	32.68032	734
5	Torit	Halihoi River	staff gauge	4.332394	32.64273	644
6	Imurok	Iyodo River (Imokoru)	Staff gauge and cable way	4.202214	32.54679	708
7	Imoruk	Gunyoro bridge	staff gauge	4.279357	32.54882	657
8	Imoruk	Lerere River (Magwi road)	staff gauge	4.298827	32.41858	707
9	Imoruk	Lerere River (Juba road)	Staff gauge and cable way	4.436792	32.48371	593

Groundwater

The main groundwater flow goes through fractured rock, the so-called secondary porosity. The permeability of these fractured rocks is highly variable. Yield of boreholes in the region is on average in the order of 1 to 3 m^3/h (Bilateral Programme in the Water Sector, 2012), which is reasonable in such areas. Water levels change over the season and many boreholes in the region have reduced yields or dry up in the dry season.

The study of the Bilateral Programme in the Water Sector (2012) concludes that "the fractured rock aquifer is not considered sufficiently reliable to supply all Torit's raw water needs, based in the current level of information".

Water quality

Poor sanitation was observed, with 60.0% of households not having basic pit latrine while by 67.2% of the households are sharing pit latrines. Pit latrines that were available were of the traditional type (not VIP). Women (82.8 %) were responsible for water collection. Only 36.4 % of the households are between 1-3 km away from their source of water and 66.7% of households' main source of drinking water was public boreholes (INR, 2014). Drinking water is often polluted with coliform bacteria. Locals apply different methods to make water safe for drinking. They add bleach/chlorine or boil the water.

2.4 Livelihoods, land use and land management

Most of the catchment is classified as livelihood zone 'Highland forest and sorghum', with a part of the lower catchment as 'eastern semi-arid pastoral' (FEWS NET, 2013). Throughout the catchment people rely on both farming and livestock. In most of the upper catchment farming is especially important, while the floodplains downstream from Torit form a large seasonal grazing area (SSCCSE, 2011). Locally near rivers, people rely additionally on fishing (IOM, 2013a). The most grown farming crops are maize, sorghum and vegetables, often combined with sesame, groundnuts, millet and/or cassava, and some use of beans, bananas and mangoes as well (IOM, 2013a).

Women dominate the agricultural production sector. It was revealed that sociocultural obligations not only limit their productivity, efficiency and effectiveness but also affect the growth of agricultural sector within the region. Men, especially the youth see agriculture as an unprofitable profession and are interested in trades that generate quick income such as charcoal burning, timber sales, and fishing. Women were responsible for food provision with >70% of the households reported to having two cooked meals each day. Although maize is the most commonly grown, cassava is the most consumed food and greens are the least consumed in the study area. The households experienced inadequate food supply mostly during the months of June, July, August, and December (INR, 2014).

Households depend on rain fed agriculture yet the area is characterized by erratic rainfall patterns. Other factors that limit agriculture production include

- the difficulty to access capital, labour, agricultural inputs and land
- the poor management practices
- poor fertility of soils,
- pest and diseases,
- insecurity,

Approximately 67 % of the households had been severely affected by natural climatic events such as droughts, floods and landslides in the last 5 years (INR, 2014).

Large areas, including steep slopes, are cleared for agriculture through slash and burn. This practice perturbs the hydrological cycle and soil retention capacity and therewith the water cycle and soil fertility in the medium to long term. (Bilateral Programme in the Water Sector, 2012).

A study by INR (2014) shows that land ownership in the area is very high, with around 90% around the major towns reported to own the land they use or live in. However, the landownership report by respondents refers to the settlement plots in urban centers rather than land for agriculture. It is worth nothing that agricultural lands in South Sudan are not yet registered.

3 Ecosystems and their services

3.1 Ecosystems

An ecosystem is defined as a biological community of interacting organisms and their physical environment. Each ecosystem has its own characteristics and provides their own set of ecosystem services. Variation in soil types, (micro)climates, vegetation and wildlife create different ecosystems. Mapping ecosystems helps to identity the main challenges relating to disasters, their causes, and possible solutions.

A refined ecosystem map was developed using Landsat8 satellite imagery. The classes are based on the IUCN Habitats Classification Scheme (Version 3.1). During field visit, the ecosystem type was visited and a detailed habitat assessment was made in sample plots[2]. The following natural ecosystems were identified:

- Tropical Swamp Forest
- Tropical Moist Montane Forest
- Savanna
- Tropical Dry Shrubland
- Tropical High Altitude Shrubland
- Tropical Dry Lowland Grassland
- Tropical Seasonally Wet/Flooded Lowland Grassland
- Tropical High Altitude Grassland
- Shrub Dominated Wetlands

And several anthropogenic ecosystems were identified:

- Arable land
- Plantations
- Urban areas

The ecosystems map is given in Figure 9. A short description of the different ecosystems is given below.

[2] The data collection forms for the field validation were based on the Field manual for describing terrestrial ecosystems – 2nd edition. British Columbia (2010).

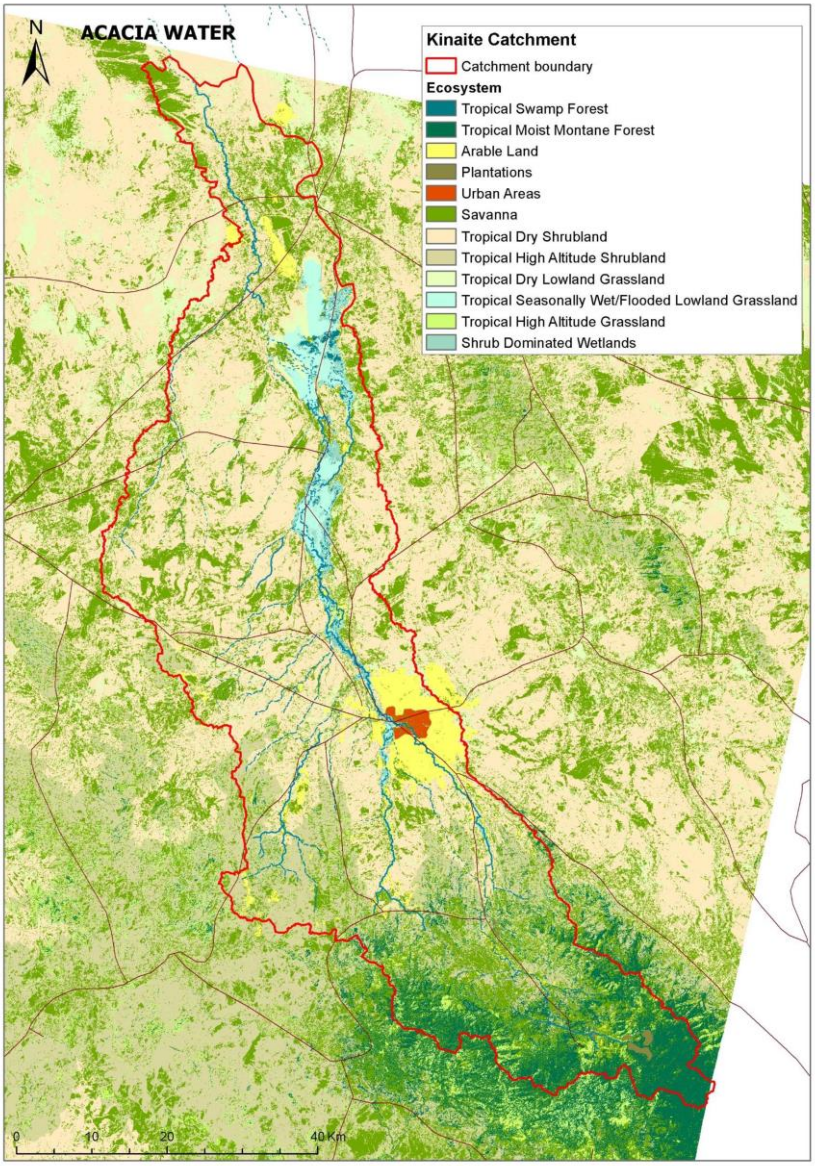

Figure 9 Ecosystems map. Classification based on IUCN Habitats Classification Scheme (Version 3.1).

Tropical Swamp Forest

Tropical swamp forest only covers some small patches in the lower floodplain area. These patches are the most densely vegetated parts of the floodplains and act as a refuge for animals living in the other ecosystems of the floodplains.

Tropical Moist Montane Forest

Most of these forests start where elevations start to increase rapidly (i.e. approximately 1000 metres) and extend up to the highest peaks, which coincide with the areas of highest rainfall. The vegetation is dominated by species of *Vernonia, Hagenia, Albizia, Podocarpus* and *Erica*, forming zones from the grassland to the Afro-Alpine dominated by *Erica* shrub (South Sudan National Report, 2011). Common large animals include bush pig, bushbuck, Harvey's duiker, blue duiker, buffalo and many primates. Birdlife is rich with species occurring nowhere else in South Sudan and some being endemic to the region. Plant life in this ecosystem is also known for its high diversity, with multiple endemic species. More than 50% of all recorded plant species in South Sudan occur in this ecosystem. Around Katire in the upper catchment, the Tropical moist montane forest is cleared and in use as a teak plantation. Also, bamboo dominated forest has been noted during fieldwork.

Top photo shows a teak plantation, middle photo: Albizia, Bottom photo: pig weed and bamboo dominated forest.

Savanna

This ecosystem covers the more vegetated areas of the dry, lowland and midrange part of the catchment. It forms a patchy landscape alternating with tropical dry shrubland. The dry savanna consists mainly of trees, like acacia, tamarind and ebony, and shrubs. Species found in this ecosystem include white-eared kobs, gazelle, antelope, wild pigs elephants and lions.

Savanna together with tropical high altitude shrubland and moist tropical montane forests, a gradient of ecosystems is formed: with increasing elevation, precipitation and greenness of vegetation, tropical shrubland is replaced by savanna, which is in turn replaced by montane forest. Effectively, savanna consists of a combination of grasses, shrubs and trees..

Tropical Dry Shrubland

Tropical dry shrubland is the ecosystem covering the largest area in the catchment, although it is restricted to the dry, lowland part of the area. The vegetation is mostly mixed grasses and shrubs. Larger patches of shrubs and trees in this landscape are considered dry savanna, while larger patches of grasses are considered tropical dry grassland, together forming the non-flooded lowland landscape. Species found in this ecosystem include white-eared kobs, gazelle, elephants and lions.

Tropical High Altitude Shrubland

Moister than the tropical dry shrubland, this ecosystem generally develops a lusher and denser shrub vegetation, with fewer patches of grasses. The boundary between these two biotopes exists around 750 meters above sea level. In increasingly moister conditions, the shrubland is replaced by moist savanna. Species found in this ecosystem include white-eared kobs, gazelle, antelope, wild pigs and lions.

Tropical Dry Lowland Grassland

Also existent as wide grassy plains in the areas further downstream, the dry lowland grassland is formed in patches between savanna and dry shrubland within the Kinaite catchment. It effectively exists as open areas in an otherwise moderately vegetated area. In some cases, dry lowland grassland is a result of deforestation or burning. Bottom photo shows the Combretum tree.

Tropical Seasonally Wet/Flooded Lowland Grassland

This type of ecosystem is dominated by grasses (upper photo), Elephant grass being the most common species. Some solitary trees like palms or acacias and small shrubs can occur but are limited (lower photo). This ecosystem covers the largest part of the floodplains, which are mostly very open. Near populated areas, particularly near Torit, encroachment occurs combined with burning.

Bottom photo shows a so called sausage tree, Kigelia tree in a floodplain area.

Tropical High Altitude Grassland

Also used to refer to large tropical alpine meadows, this ecosystem covers mostly small grassy patches on high elevations in the study area. Similarly as tropical dry lowland grassland, it represents the open areas in an otherwise moderately to densely vegetated area. On steep slopes facing north, receiving less sunlight and precipitation, some larger

- No picture available

patches exist. Bare rock outcrops are also included in this ecosystem.

Shrub Dominated Wetlands

The shrub dominated wetlands exists as patches in the seasonally wet/flooded grasslands, which generally sharp boundaries. The grass present is the floodplains is mainly elephant grass. These patches exist mainly on slightly higher elevations in the floodplain landscape, where the root system of the vegetation is less affected by the anaerobe conditions of inundation. Where such patches become very densely vegetated, tropical swamp forests occur. The photo on the top right shows thorny burnt shrub. Bottom right photo shows and Aravai shrub.

3.2 Ecosystem services

Each ecosystem provides its own set of ecosystem services. These services constitute anything that the ecosystem offers from which the inhabitants of the area can profit. Ecosystem services can be classified into provisional, regulatory/supporting or cultural.

Provisional services include all nutritional, material and energetic outputs of an ecosystem. Examples include any type of natural food and wood for building or cooking. These services are the most obvious, clearly recognizable by a community, and thus more likely to gain support in land use planning.

Figure 10 Provisional services: Dried grass used for thatching roofs, preparation of poles for construction, wild fruits and fish caught by local youth.

Regulatory and supporting services are more abstract to users than provisional services. Examples are flood prevention, microclimate regulation, water purification and mitigation of soil erosion. The functioning of regulatory services is relatively difficult to measure and often a large area of coverage is needed to contribute significantly. The importance of these ecosystem services is often underestimated. When proper institutional regulation is missing, these services tend to be ignored in land use planning.

Cultural services are much dependent on the socio-economic and religious contexts. They include any spiritual value, religious value or value of heritage of an ecosystem, but they can also be recreational (like ecotourism or swimming). To fully recognize these services, an in-depth understanding of the socio-cultural context is required.

Some ecosystems provide many services, some very little. Some ecosystems provide similar services or provide them together. In order to keep a clear overview that suits land use planning and management practices, four main ecosystem groups were identified based on their characterization, location and the (relation between the) services provided.

- Imatong Forests comprising montane forests, plantations and moist savanna;
- Drylands, including both dry savanna and dry shrubland;
- Wetlands, which covers all wetlands areas, from swamp forest to flooded grasslands, and the adjacent lowland grasslands;
- Arable lands, which is made up of all the patches of rain fed croplands.

Imatong Forests

Provisional services are abundant in the Imatong Forests. A wide variety of wild food plants are available in the hills and mountains including herbs, fish, honey, nuts, roots, fruits, berries and vegetables (FEWSNET, 2013 and village assessment), but also animals to hunt. The major advantage of forest foods compared to agriculture is the year-round availability. In periods of extreme drought, the main diet of local people switch to these natural forest foods, sustaining them through the hardest of times.

Provision of (hard)wood is also an important ecosystem service. The Imatong Forests are known for the extensive coverage of *Albizia*, *Terminalia* (tropical almond), *Khaya*, *Podocarpus* (plum pine), *Croton*, *Hagenia*, *Macaranga* and *Hagenia* (AWF 2015). These trees provide communities with construction materials, fuel and timber for sale. Some parts of the Imatong forests are turned into plantation forests, specifically designed for timber. Although this might increase productional timber value of the forest, it is often at the expense of most other ecosystem services, especially when not properly regulated.

The presence of medicinal herbs is also important. Medicinal herbs have proved an effective measure against multiple diseases, outbreaks of which occur regularly in the region. Access to modern medicine is also limited in the catchment, stressing the importance of these local medicinal herbs.

The Imatong Forests present a number of regulatory services as well. Forests are known to increase infiltration capacity in soils. Taking into account the coincidence of these forests with the areas of highest rainfall, the role these forests play with regulating floods and droughts becomes apparent. By increasing infiltration capacity, the Imatong Forests increases the amount of precipitation infiltrating into the soil during the rainy season and thus limits the amount of direct runoff. Floods are hereby directly mitigated. Additionally, the increase in infiltrated precipitation provides an increase in the baseflow to the lower catchment, which mitigates the droughts during the dry season.

The forest also acts as a (micro)climate regulator. Forests affect what is called the surface albedo or reflectivity of the surface, and hence absorb more heat than bare soil. At the same time, trees use solar energy for evapotranspiration cooling down the local climate. Combined with shadow from the vegetation, the moist and cool conditions provide propitious conditions for the growth of several layers of vegetation, including crops for food and fodder.

Other regulatory service is the limiting of soil erosion and purification of air and water. Tree roots fortify the soil, making them stronger and very resistant to erosion, while also being able to filter out pollutants. The tree canopy meanwhile can purify the air through photosynthesis.

The Imatong Forests present a biological hotspot. Many endemic and endangered species occur. This can be regarded as a cultural service. Combining this biological significance with ecotourism could provide benefits to the local people as well. Considering the current ongoing conflicts however, this service can only be regarded in the long-term.

On the other hand, communities indicate that forests play a significant role in terms of security during the conflict. When violence breaks out again families hide in the dense forest until the situation has calmed down again.

Drylands

Drylands, including dry savannas and dry shrublands, are part of the so-called East Sudanian Savanna, which runs from Cameroon all the way to South Sudan, Ethiopia and Uganda, and comprise the majority of Kinaite Catchment. These drylands are hot and wooded and composed mainly of shrubs, trees and tall elephant grass, and provide similar ecosystem services as the Imatong Forests, albeit generally to a lesser degree.

Wild fruits, vegetables and medicinal plants can be found in such ecosystems as well, mostly in the more vegetated parts. Beekeeping is common in the area. Livestock and goats are herded often also herded in the shrublands. These animals make most out of the resources available in these areas and form an important source of milk and meat, which have a high nutritional value. Hunting for wild life and harvesting white ants provide another source of high-protein food to rural communities. The useful trees in the drylands, such as shea, baobab, locus-bean, tamarind, coconut, balanite and various species of acacia trees (World Wild Life 2017), are well-protected by communities in order to harvest fruits, leaves, bark, flowers and seeds for food and medicinal purposes. Other trees and grasses, such as *Terminalia*, (also) provide timber, fuel wood, and poles for construction of tukuls, fencing of kraals and construction of drying racks.

Shrubs and grasses in drylands are quintessential for mitigating soil erosion since vegetation reduces the impact of rainfall on the soil surface, the detachment of soil particles, and runoff rates. Also, wind erosion is prevented.

Savanna vegetation plays a significant role in recycling nutrients, in maintaining soil processes, the hydrological balance and controlling salinity in the soil for having at least two stores of vegetation and transporting water from the deeper layers to the soil. Shrubs reduce incoming radiation and contribute to the development of a layer of litter, which increases soil water content and in turn augments water availability for other species. Roots and soil life associated with the vegetation ensure a good soil structure increasing the infiltration capacity.

Dryland ecosystems, with their variety plant and animal species, also play an important role in pollination, seed dispersal and pest and disease control, which are important for plant development, and hence for securing access to fodder and food.

The shadow of savanna trees is widely used for local gatherings, community meetings, and cultural-religious events. At each homestead, a tree for shade is reserved for social interactions. As for the Imatong Forests tourism is currently not possible because of political instability and civil unrest, but could form an important source of income in future – large patches of relatively intact habitat remain and there are still reasonable numbers of larger mammal species despite the pressure of hunting. The lands belong to a regional center of endemism as they support more than one thousand endemic species of plants.

Wetlands

Wetlands and their surroundings provide a broad range of highly valuable ecosystem services, which play an important role towards water security, food security and disaster risk reduction.

First and foremost, wetlands provide water for domestic use (drinking, cooking and washing) and for watering livestock. Since Kinaite Catchment is a drought-prone area the presence of surface and shallow groundwater in and close to wetland area is of major importance for communities. Shallow groundwater, moreover, is a relatively safe source of water for domestic use. Since it is stored in the subsurface it is less vulnerable for pollution.

Communities indicate that the wetlands of Kinaite Catchment are rich in fish, crocodile, reptile and small mammals, of which the meat is rich in proteins and hence plays an important role in food security. Hides are treated to produce clothes, shoes, bedding and mats. Wetlands are also recognized for the widespread availability of edible plants and medicinal herbs. The latter are mentioned multiple times as successful way to counter sickness. The areas also provide grass and wood for fuel, reeds for thatching homesteads and clay for construction. The surrounding grasslands are preferred areas for grazing livestock, mainly cattle but also goats and sheep, as pasture is generally available far into the dry season.

Grasslands and riverine vegetation slow down and filter runoff water promoting infiltration and sedimentation in the floodplains and on the river banks. These processes promote the natural recharge of shallow groundwater systems and the buildup of fertile soils. Naturally in-stream vegetation slows down the flow reducing flood-risks downstream. The presence of water and dense vegetation regulates microclimatic conditions, favoring the development of a diverse and extensive animal life. The fertile soils of the wetlands are also used for the cultivation of for example amaranth, mrenda and sorghum.

Wetlands also provide cultural services. Many of the wetlands and river beds are filled with clay, which communities use for decoration purposes. Surface water bodies, such as rivers and ponds,

are used for swimming. The wetlands of Kinaite Catchment also for an Important Bird Area (IBA), where songbirds route from Europe to East Africa rest (AWF 2014 and 2015).

Arable lands

Arable lands are typical anthropogenic ecosystems. Originally these lands belonged to the Imatong Forests, the drylands or the wetlands ecosystems groups, but have been opened up for cultivation of crops.

The main crops grown on the arable lands are sorghum and maize, both staple foods in South-Sudan, combined with vegetables. Sesame, groundnuts, millet and/or cassava are much grown as well, and some use of beans, bananas and mangoes is reported. These crops do form the main source of food in Kinaite Catchment. Since all other vegetation was cut down or burned, these lands do however provide little other provisioning services.

During the cropping season surface runoff is slowed down and water infiltrates fostering soil water content. Some farmers use windbreaks and (live) fencing. These serve as shelter belts, improve microclimatic conditions and contribute to the attenuation of dust storms.

No cultural ecosystem services were identified that were associated with these arable lands.

Urban areas

Built-up areas form another anthropogenic ecosystem. Provisional and regulatory ecosystem services are usually widely reduced or non-existent in urban areas. The land is cleared of natural resources, such as wood or edible plants, in order to provide space for houses and infrastructure. The changed landcover also diminishes the regulatory ecosystem services of these areas. Reduced vegetation cover, for example, leads to reduced mitigation of micro-climatic warming and a reduced ability to improve air quality. Due to compaction of topsoil, infiltration in urban areas is low and runoff of (polluted) water high.

Built-up areas provide the setting for many human activities that are essential for a well-functioning society. Most cultural and socio-economic activities are associated with built-up areas. Built-up areas provide a multitude of livelihoods. Markets give the rural population the possibility of generating income and provide the population that does not practice subsistence agriculture with food. Social exchange is an important non-economic service that can be associated with markets and other gathering places in urban areas. Cities and towns are often places for cultural or religious events. Local branches of the government are often located in urban (sub-) centers so that these areas also have an important function for the democratic order of a country. All these services, of course, are created by the human population and are largely detached from the actual ecosystem of the urban area.

4 Environmental Hazard Risk Assessment

4.1 Historical disaster identification

The highest impact disasters in Kinaite Catchment are the past and ongoing conflicts. Between 2002 and 2005 before the independence of South Sudan at the hands of the Lords Resistance Army (LRA), and again from 2013 when the South Sudanese Civil War erupted, many people lost their lives or their homes. Much of the remaining population sees migration as the only solution, either to the city (mostly Torit) or to neighbouring countries (Uganda, Kenya & Ethiopia).

Besides the conflicts, natural disasters occur as well. Recurrent floods were reported throughout the catchment, with especially heavy floods in 2000, 2013, 2014 and 2016. The floods resulted in the loss of crops, livestock and property, leading to widespread hunger. Deaths have also been reported. In reaction, the local people repeatedly relocated to higher and safer grounds, but floods seem to remain a problem. In 2016, landslides associated with floods were reported in the Lokojeli area.

Droughts, linked to the late start of the rainy season or dry spells, occurred regularly as well with poor harvests as a result. This in turn has led to long periods of hunger (i.e. chronic food insecurity) and to mass migration. Major droughts were reported for 2005, 2011, 2013, 2014, 2016 and 2017. Communities try to cope with droughts by switching to fishing, collecting wild fruits and vegetables and hunting.

Disease outbreaks, of cholera, malaria, measles, typhoid and etisu skin disease, have all been recurrent and have also led to loss of life and increase in hunger. Use of traditional herbs and salt water has been used to counter these diseases, but health organizations have also increased their presence in the area providing the local population with medicine and treatment. Sickness in livestock (like the Newcastle disease) occurs regularly as well, contributing to hunger.

Besides these major disasters, also wild fires threaten lives and property as a regular. Wild fires are mostly a result of uncontrolled burning practices.

A full list of historical disasters reported by local communities in this project is attached in Annex 3.

4.2 Current threats

Lately, many villages are seeing returnees, people that left during the fighting's are coming back. Birth rates are high since the last active conflicts. These two factors contribute to a rapidly increasing population and pressure on the land. Moreover, tenure regulation and land use planning is still poor in the area, which has led to a range of problems.

For one, more and more land is being cultivated, including wetland areas and erosion sensitive areas such as stream banks and slopes. Slash and burn is common practice in these agricultural lands. The increase in agricultural activity combined with poor practice is actively contributing to erosion, wildfires and deforestation. Poor practices are not only occurring in crop cultivation, but

also in livestock holdings and fisheries. Overgrazing and overfishing are locally causing problems, which aggravate conflicts over land. Besides this, mostly due to the increased levels of erosion, problems with water quality have also been reported and sedimentation in rivers is exacerbated.

Illegal logging and brick making are causing deforestation destroying and fragmenting wildlife habitats, while wildlife is already severely threatened by an increase in poaching. Interviewees specifically mentioned is a huge decrease in the elephant population.

The link between management practices, threats and disasters is, however, not clear to most people. As a result, little is being done to counter the problems, while risks are increasing in light of the current threats, especially in combination with climate change. Changes in weather patterns have already been reported. A study by the Ministry of Environment (2016) of Southern Sudan found a decrease of 15-20% in summer rainfall across parts of South Sudan and a temperature increase of more than 0.4 ºC per decade over the past thirty years. Additionally, they report on observed trends and anecdotal evidence indicating that

1) duration and timing of rain has become more erratic;
2) rainy season is delayed and shorter; and
3) the desert is expanding southwards.
4) The frequency of floods and droughts has increased over the last eight decades.

These observations are in line with stakeholder interviews. A study by Future Water (2011) states that, at the moment, Kinaite water resources cover the current demand, but 'analysis for future use indicates that the combined impact of climate change, population growth and irrigation development, without measures, will lead to substantial water shortages'. A study by INR (2014) states that the projected climate change suggests that flooding may aggravate, crops are at risk, and riverine areas are threatened by increasing sediment loads, bank erosion and collapse.

To conclude, Kinaite Catchment has historically dealt with a range of problems, but little is being done to mitigate the risks. In fact, with current practices and climate change, risks are getting larger. If no changes are made in land management or interventions, the population will remain unprepared for future disasters.

4.3 Hazard risk assessment

Based on the historical disaster identification and current trends, a number of hazards and threats can be identified. A hazard is defined as a potential problem that, when it actually happens and harms humans becomes a disaster. These are mostly natural, but also includes conflicts. Hazards identified in the catchment are:

- Hunger
- Civil war/conflicts
- Floods
- Droughts
- Wildfires
- Landslides
- Human diseases
- Crop and livestock diseases
- Conflicts over land

Threats are potential problems, mostly caused by humans, which by itself are not problematic but contribute to the likelihood or severity of potential hazards. Threats identified in the catchment are:

- Population increase
- Shift cultivation

- Stream bank cultivation
- Slope cultivation
- Deforestation
- Soil erosion
- Overgrazing
- Overfishing
- Illegal logging
- Brick making
- Wildlife habitat destruction and fragmentation
- Poaching
- Climate change

Many of these threats and hazards are intimately linked and some are more likely or have a higher impact than others. A full explanation of the threats is given in Annex 4. In order to determine which threats and hazards are prioritized for solutions, identification of the key threats and hazards is important. The identification of key hazards and threats was done through scoring exercises with local communities.

Identification

For this paragraph, five villages throughout the Kinaite Catchment have made an assessment: Katire, Bur, Imilai, Lafon (Agulumere) and Lokila (lomorwo). The communities have identified the hazards and threats in their area, as elaborated in this paragraph.

The most stressed and recurring hazards as reported in the assessments are hunger and conflicts. Hunger can be caused by a multitude of threats, but are often caused by mechanisms of crop failure like droughts, floods, wildfires, landslides and crop disease. Conflicts and human disease can contribute, as access to the fields and harvest are denied or labor to work the crops becomes missing. Livestock diseases can also contribute to hunger. Finally, land conflicts were identified as a serious hazard of which the impacts are generally limited, but the occurrence widespread.

The most important current threat is population growth: it directly increases the number of people at risk and exacerbates the impact of all other threats. The main result of population growth looking at catchment management is an increase in agricultural lands and deforestation (see Figure 11).

The major problem with agriculture in the catchment is that it is guided by poor agricultural practices. Because of this, frequency of wildfires increases, soil erosion is increasing and land is degrading. This goes double for both slope and river bank cultivation, which are extremely erosion sensitive areas and are therefore separately mentioned. Moreover, river bank cultivation causes decreased water quality as well.

Not only crop cultivation is increasing, but also livestock holding and fisheries. The implications of too much of these factors is clear; the fish stock deteriorates and the grazing lands deteriorate.

Meanwhile, deforestation is a direct effect of increase in cultivated area, but is considered a threat on its own. Major downsides are intrinsically linked with the ecosystem services of forest: deforestation means a decrease in forest products and less mitigation of floods and droughts.

Figure 11. Google earth images of the land just south of Torit town, Upper image of the year 2005 and lower image of 2016. Expansion of agricultural land and urban area is clearly visible.

Separate threats mentioned by the villages include brick making and poaching. Brick making is another direct cause of deforestation, and due to the high population increase has become a major activity. Poaching is mentioned as a major problem in de downstream of the catchment. Not only is poaching a problem because of the reduction it causes on wildlife populations, it is often combined with burning practices, contributing to wildfires and land degradation as explained earlier.

Ranking

Subsequently, in the communities of Katire, Bur, Imilai, Lafon and Lokila, the identified hazards and threats were ranked based on impact and probability. This way, the key threats and hazards can be identified. During the ranking exercise, participants rank the hazards and threats with a number 1 – 4 for the scope, severity and irreversibility using criteria. The summary of the criteria is presented in the table below, the full description of the criteria is presented in Annex 7.

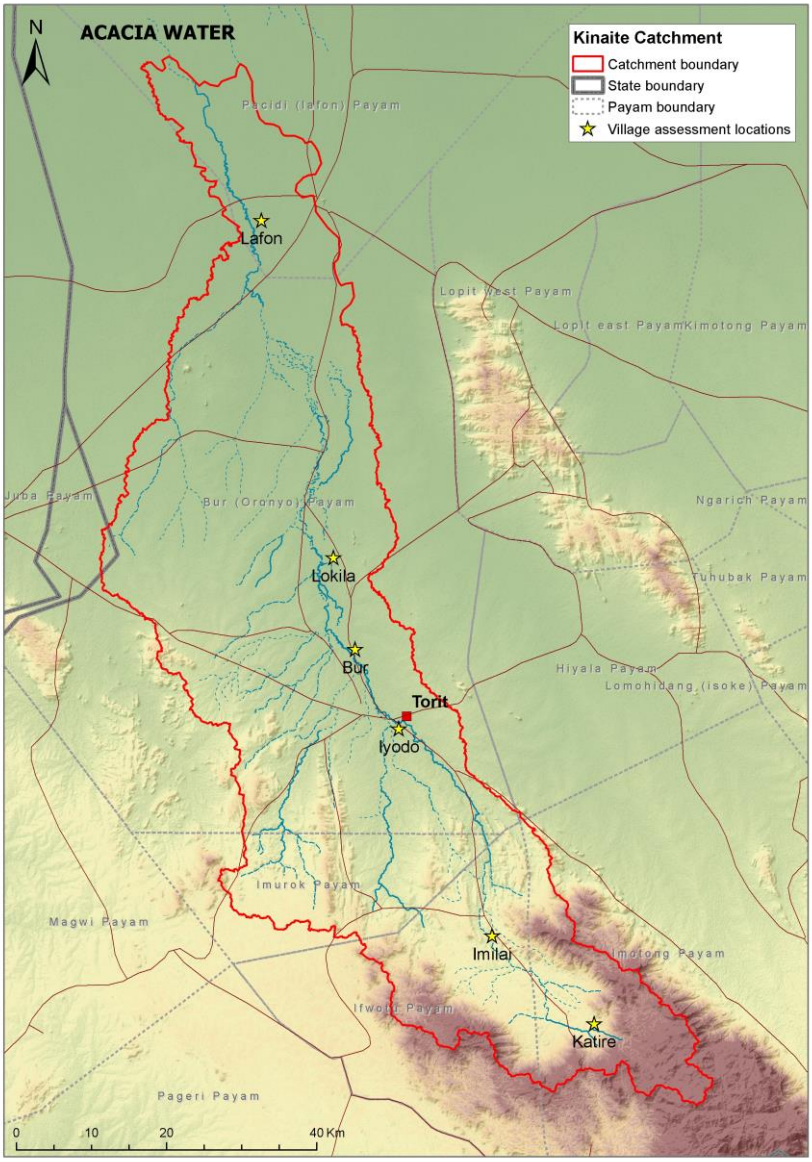

Figure 12. Stars on the map indicate the locations of the village assessments included in this study.

In decision-making, low-consequence / low-probability risks are typically perceived as acceptable and therefore only require monitoring. In contrast, high-consequence / high-probability risks are perceived as unacceptable and a strategy is required to manage the risk. Combining the scoring exercises, the key hazard and threats can be identified for Kinaite catchment.

Table 1 Summary description for the scoring exercise

Threat level	Very high	High	Medium	Low
Ranking	4	3	2	1
Probability	Almost certain	Likely	Unlikely	Rare
Scope	Very widespread or pervasive	Widespread	Localized	Restricted
Severity	Destroyed	Seriously degraded	Moderately degraded	Very minimal impact
Irreversibility	Effects irreversible	Reversible but very costly	Effects reversible with commitment	Effects easily reversible

The scope is the proportion of the ecosystem or community that can reasonably be expected to be affected by the threat within ten years, given the continuation of current circumstances and trends. Severity is the level of damage to the target from the threat that can reasonably be expected given the continuation of current circumstances and trends. Irreversibility is the degree to which the effects of a threat can be reversed and the target affected by the threat restored.

The full rankings per village are presented in Annex 5. The overall values per threat and hazard are presented below in Table 2 and Table 3.

Table 2 Threat ranking per village. Catchment ranking is calculated through the sum per village, while local ranking is calculated through an average

nr	Threat	Katire	Bur	Imilai	Lafon	Lokila	**Local ranking**	**Catchment ranking**
1	*Deforestation*	12	9	6	6	9	8	42
2	*Stream bank cultivation*	7	7	5	7	5	6	31
3	*Soil erosion*	7	6	3	3	2	4	21
4	*Shift cultivation*	6	3		6	3	5	18
5	*Sedimentation in rivers*	2	8		4		4	16
6	*Overgrazing*				8	4	6	12
7	*Poaching*				11		11	11
8	*Overfishing*		7				7	7
9	*Brick making*	3					3	6
10	*Population increase*	5					5	5
11	*Water pollution*			5			5	5
12	*Bush Burning*			4			4	4

Deforestation is the main threat throughout the Kinaite catchment with the highest threat scores in the upper Kinaite catchment. Stream bank cultivation, soil erosion and shifting cultivation pose significant widespread threats as well. Poaching is highest in the local ranking, only considered a major threat in the village of Lafon. Overgrazing and overfishing score high in the local ranking as well, only considered a major threat in Lafon and Bur area respectively. Results of this threat ranking align with earlier results from AWF in 2015, who concluded deforestation and increasing cultivation as the most urgent threats.

Additionally, it should be mentioned that slope cultivation is considered a major threat in the catchment as well, but it is lacking in this assessment as it occurs mainly locally, and not near any of these specific villages. Considering the height of importance of the other types of cultivation, this type would likely have a high score as well.

Table 3 Hazard ranking per village. Catchment ranking is calculated through the sum per village, while local ranking is calculated through an average

nr	**Hazard**	Katire	Bur	Imilai	Lafon	Lokila	**Average**	**Sum**
1	*Conflicts (LRA/civil war)*	15		10	15	10	13	50
2	*Drought*	10	10	8	8	8	9	44
3	*Floods*	7	7		5	1	5	20
4	*Crop pests and diseases*		7	9			8	16
5	*Human diseases*		3		5	3	4	11

6	*Wild fires*	*4*		3			4	7
7	*Livestock diseases*			3	4		4	7
8	*Land conflicts*		5				5	5
9	*Skin disease*	*2*		1			2	3
10	*Landslides*	*1*					1	1

The highest ranked hazard is the ongoing conflict. However, droughts are esteemed a very important hazard as well, almost scoring as high as conflicts. Third highest ranked are floods, although crop pests and diseases are a large hazard locally.

Risks and hazards identified in Torit Town

Torit town was not included in a community ranking exercise but some general risks and hazards were identified in Torit Town. Flooding of the river is considered a natural hazard. It is closely linked to river siltation and sedimentation, which is identified as an individual threat. Pollution in the form of liquid and solid waste dumping, but also air and water pollution are identified as threats. Activities such as car washing in the river contribute to this pollution. Further risks in Torit town could arise from for example an increase in use of Torit airport, or the Juba-Uganda road.

Population growth, singled out as an important threat, has led to an increased anthropogenic impact on the environment, visible for example in the comparison of satellite images (Figure 11). The images show the extent of deforestation and increase in agricultural lands over the past ten years close to Torit Town. Deforestation is identified as an individual threat in Torit Town itself. Due to the rapid expansion of the built-up areas and population increase, the pressure on the available natural resources and ecosystem services is increasing. For example; more energy is needed by the increasing town population for cooking so an additional increase in deforestation could be expected. Drought is an important hazard in the entire catchment and likewise in Torit Town. It increases the risk of famines, which are perceived as an important threat as well. Population increase in Torit town could make the community more vulnerable to famines. Finally, diseases pose a considerable hazard to the population of Torit Town.

Figure 13 Poor waste disposal in Torit town.

4.4 Hotspots map with key threats

In addition to the key hazard and threat identification and the understanding of the threats in the Kinaite Catchment, a spatial map is developed showing the locations of hotspots and extent of each key threat (Figure 14). The village assessments, google imagery and field visit provided information about the locations of the key threats.

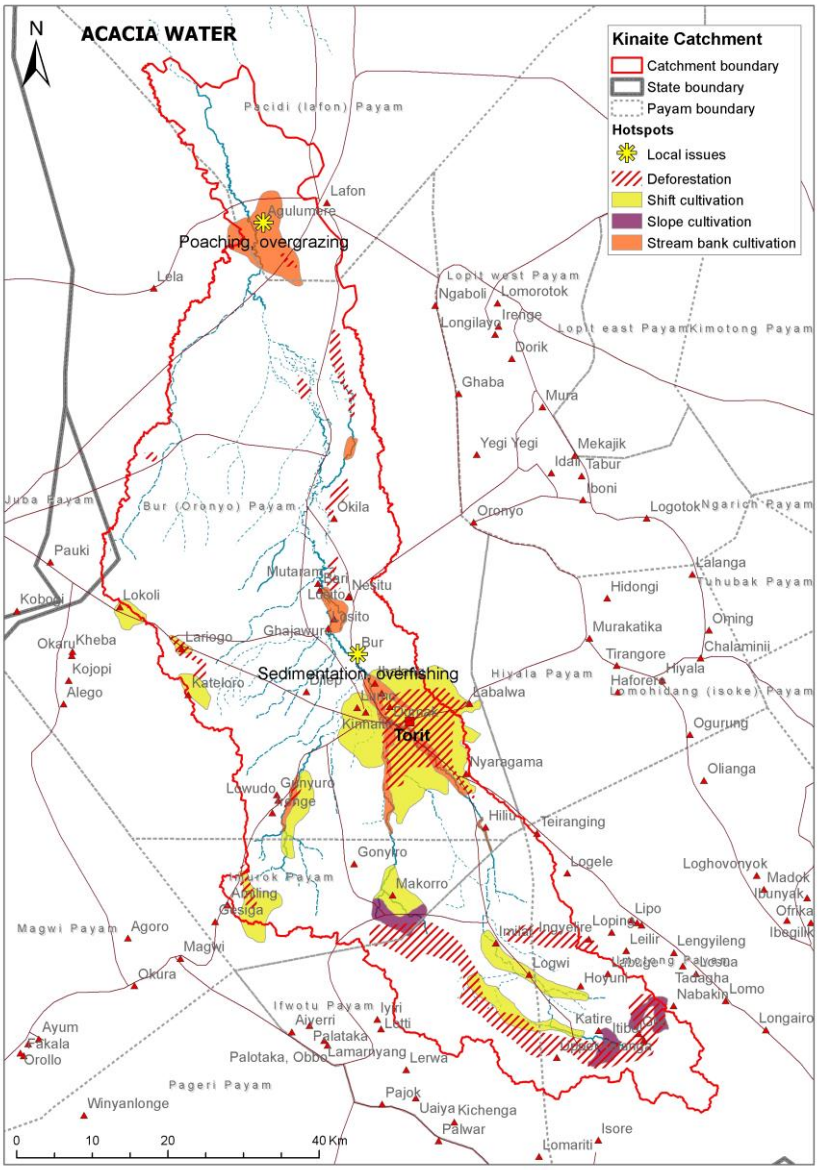

Figure 14: Hotspots of key threats in Kinaite catchment

Deforestation is an issue throughout the catchment. Deforestation on slopes and erosion sensitive areas like the riparian zone poses a high risk to soil stability. Stream bank cultivation is a problem in the mid and lower Kinaite Catchment with a clear hotspot around the town of Agulumere (Lafon). Shifting cultivation is mainly seen around the urban centre of Torit and several communities. Based on google earth imagery it is determined that these areas are rapidly expanding each year. Slope cultivation is an issue around the community of Makorro and several spots east of Katire. Severe local issues in Agulumere (Lafon) are poaching and overgrazing while sedimentation and overfishing are issues in Bur.

Possible flooding in Torit Town is a threat with a high impact. This threat in Torit Town is exacerbated by ongoing sedimentation of the river. As the population density in Torit Town is high, famine, hunger, and pollution of the environment are additional threats in the urban area.

5 Solution identification

Many of the identified main hazards and disasters are either linked to the conflict situation or the unsustainable use of natural resources. Deforestation, shift and river bank cultivation and soil erosion are related to the expansion of agricultural lands, poor agricultural practices and the cutting of trees. These practices undermine, amongst others, the capacity of the ecosystems to provide ecosystem service. Hence hydrological and microclimate cycles are disrupted resulting in more frequent and intense droughts and floods.

Although challenging there are several interventions that can mitigate or at least attenuate the impact of these hazards and disasters. There is an intrinsic need to protect and (re)build the overall resilience of the system, so that it can provide the maximum of ecosystem services. The need to implement the measures presented below is all the more urgent in light of the projected climate change.

5.1 Good agricultural practices

Good agricultural practices reduce soil erosion, increase soil moisture content and fertility. This way, productivity is increased and resilience of the system is build. Resilient agricultural lands contribute to food security in times of drought and disaster risk reduction. An increase in yield of the current agricultural lands would hopefully diminish the future expansion of these lands. Therefore, a larger surface area would be left for the natural ecosystems.

Soil and water conservation measures are of key importance in the entire Kinaite Catchment. Soil water conservation in the upper catchment reduces high runoff rates downstream and increases baseflow. In the mid and lower Kinaite Catchment it is important to create more resilience against drought. There are several possible interventions. Basic soil and water conservation practices include mulching, vegetation strips and soil bunds. On sloping agricultural fields, vegetation strips should follow the contour lines. It would be good if some of the vegetation strips include fruit or nut trees. These would provide direct benefits to the communities or farmers, and therefore more likely not cut down or burned. Plantation of wind breaks with vegetation also reduces wind erosion.

Adjusting the cropping patters also creates more resilience. By making use of crop rotation, adoption of drought-resistant crops and crop diversification, more stable and productive agricultural fields can be created. Also agroforestry with for example fruit and nut trees is highly recommended for the entire Kinaite Catchment. Besides providing an additional source of food, the trees provide shadow, transport water to the upper soil layers and positively influence the microclimatic conditions. Combinations with for example. shea, baobab or locus-bean can easily be combined with crops such as millet, sorghum and maize.

For irrigation practices in the mid and lower Kinaite Catchment flood adapted agriculture is recommended. With this type of irrigation practices crops are produced outside of the flooding period or flood resistant crops are grown. Diversion ditches, soil bunds and spate irrigation should be applied as low budget flood control interventions. Interviewees indicated that spate irrigation could be applied in the areas downstream of Torit.

Rainwater harvesting at field level (e.g. zai pits, demi lunes, trenches) can be applied to increase soil water content. Also, opportunities to collect water in dams, ponds and tanks for small-scale irrigation purposes create in increase in water security.

5.2 Ecosystem-based use of natural resources

Ecosystem restoration provides a major opportunity to build resilience. Ecosystem restoration interventions improve water availability, crop production and the condition of pastures on the short term, and ensure the maintenance and recovery of ecosystem services in the long term. The carrying capacity of different ecosystem should be respected and taken into account when management of natural resources is planned. An optimal used ecosystem increased the coping capacity of the ecosystems and the people. A frequent mentioned coping mechanism for drought is reliance on wild fruit and vegetables. These are important ecosystem services for resilience.

Traditional management practices could be recovered in the Kinaite Catchment. This could include sustainable exploration of forest products and maintenance of the different layers of vegetation. This way, the productivity of trees, shrubs and grasses/herb layers are maintained. Charcoaling for instance would not need to be a problem, as long as it is 1) combined with sufficient tree planting, and 2) tree cutting or charcoaling is not applied in erosion sensitive areas. Rangeland management practices like controlled grazing or rotational grazing take the carrying capacity of the rangelands into account.

Hunting of larger mammals should be regulated to maintain the wildlife populations of different species. Same applied for wood logging and land clearing. Regulation is needed to prevent uncontrolled expansion of agricultural land and illegal logging. Wetlands should be protected by delineation, establishment of rules and regulations for use. Location for watering of livestock should be assigned and access ramps should be constructed to avoid destruction of riverine vegetation. This prevents intensification of soil erosion on the flood plains and river banks.

5.3 Strengthening of the value chain

An increased income is welcome throughout the Kinaite Catchment. Strengthening of the value chain is possible in combination with good management practices. The desk study revealed that in the 1980's more than 70 ha of small-scale coffee production was present in the Kinaite Catchment (Krijnen et al., 2012). A recovery of the coffee production in the upper parts of the catchment would provide an increase in income. Knowledge of the elders should be transferred to the youth in the catchment.

There are also abandoned Arabic gum stands. Arabic gum production could be reintroduced with capacity building and improved market linkages Krijnen et al., 2012). Communities need to be trained for nursery techniques, planting, tending, tapping, collection, cleaning, grading, processing and marketing. There is much interest in Arabic gum as an export product both for the East and US markets. These markets are willing to buy it directly from local traders.

Resources marketing and value chain addition is also possible on a smaller scale, e.g. honey making. But improved access to credit and markets is necessary. Small-scale village savings and loans associations (VSLAs) could be established to achieve these goals (INR, 2014) . This makes it easier to make communities self-sustainable.

5.4 Institutional strengthening

Communities, local leaders and government officials all stress the need for institutional strengthening. There is limited to no access to extension services, rules and regulations in Kinaite

Catchment. Rules and regulations are not enforced, traditional management practices are being lost, and there is no structural support from governmental institutions and non-governmental organizations to facilitate the sustainable use of natural resources. In part this is due to the conflict situation, but changes must be made. The current situation with for example illegal logging, poaching and waste disposal near Torit town need enforced regulations.

The local government could do the following:

- Take lead in creating awareness to the community on the need to sustainably manage resources
- Take lead in guiding and mobilising community by-laws
- form special interest groups to own and conserve the natural resources
- Give more power to and empower communities, provide training and build capacity
- Enforce existing rules and regulations. This can also be done through communities/community leaders.

The directorate of Environment communicated several plans for Kinaite Catchment to wetlands International:

- Plan to initiate awareness on the importance of wetlands along Kinaite Catchment
- Conduct sensitisation workshops and meetings on possible options of wetland protection to communities along the catchment
- Facilitate environmental regulations (EIA/EA) and monitoring.
- In depth analysis on vegetation cover and status of erosion and run off
- Conduct training to improve organisational capacity for staff in the directorate and county level to manage wetlands
- Enforce environmental protection bill/policy at State Level
- Organise communities according to special interest groups (by-laws to govern them)
- Create strong relationship with Wetlands International by having a contact person to coordinate

To protect the wetlands of Kinaite Catchment, the above-mentioned plans should be applied also to the other ecosystems in the middle and upper catchment in order to reduce sediment transport and polluted water towards the wetlands downstream.

6 Conclusions

In South Sudan, the Protracted Crisis Horn of Africa (PCHA) Project aims to improve community is stability and resilience through strategic interventions for food security, water security and disaster risk reduction (DRR). The project focuses on Kinaite Catchment, which is situated in the Eastern Equatoria State close to the border with Uganda and covers almost 4000 km2. Over the past years, the catchment was ravaged by conflict, first at the hands of the Lord's Resistance Army (2002-2005) and later on by civil war (from 2013 onwards). At the same time, however, the area has to cope with droughts, famine and water shortages. In this assessment, ecosystems services were mapped, threats and hazards analysed, and possible solutions formulated towards identifying priority interventions to reduce disaster risk.

The catchment is characterized by and atypical geography with large altitude differences; the floodplains are at an altitude of 600 m asl, while the highest peak is at 3170 m asl. This results in a highly diverse biogeography and climate variability, which in turn is reflected in a rich biodiversity and a multitude of valuable ecosystems. To provide a good overview these ecosystems were categorized into four main groups according to their similarity and the linkages between the ecosystem services provided. The ecosystems are rich in provisioning, regulation and supporting, and cultural services.

- The Imatong Forests in the south, comprise of the montane forests, plantations and moist savanna at high altitude. These forests provide provisional services (e.g fruits, herbs, bush meat, timber and fuel wood) and regulatory services (e.g. microclimate regulation, soil erosion control, regulation of the hydrological cycle). Communities indicate that the forest also serves as an important refuge when violence breaks out.
- Drylands which are part of the East Sudanian Savanna and include dry savannas and dry shrublands. These lands are used as rangelands, while also providing similar provisioning and regulating services as the Imatong Mountains, albeit to a lesser degree. As a case in point there are shea, baobab, locus-bean, tamarind, coconut and balanite trees of which communities harvest fruits, leaves, bark, flowers and seeds for food and medicinal purposes. Each household also keeps one tree for social gatherings
- Wetlands, swamp forest, floodplains and grasslands dominate the areas where the rivers converge in the lower catchment. These ecosystems provide water for domestic use, fish for food, reed for thatching, and pasture for grazing, among many others. The wetlands do also play a fundamental role in flood mitigation through regulation of the hydrological cycle
- Lastly, a large portion of the landscape is covered with arable land, which is continuously increasing to meet increasing food demands. Especially around the main urban center of Torit a large area has area has been cleared for cultivation of crops.

Due to environmental degradation, these services are being lost at an alarming rate.

Threats, hazards and hotspots were identified to identify interventions and direct project and investments. Threats are activities or processes that have caused, are causing, or may cause the destruction, degradation, and/or impairment of ecosystems. Threats are dependent on temporal and spatial scales, and hence may have an impact at local scale and not at catchment scale, and vice versa. Hazards are situations that may lead to harm or cause adverse effects.

For the functioning of the system as a whole, and hence the support of all different ecosystems, the ranking of threats at catchment-level is most relevant. In that sense, deforestation, stream bank cultivation, soil erosion, shift cultivation and sedimentation are ranked highest in terms of threats. All these are strongly linked to the overexploitation of the natural resources system through the expansion of agriculture into erosion sensitive areas such as stream banks and slopes, poor agricultural practices, overgrazing, uncontrolled tree cutting and hunting, and overfishing. These human induced threats, in combination with the high variability in precipitation, are already resulting in an increase in frequency and impact of various hazards: droughts and floods, pests and diseases, and conflicts over land. The developed hotspot map clearly shows that the threats are particularly severe around Torit Town centre, on the slopes of the Imatong Mountains and along the river banks and floodplains of River Kinaite. The expected increase in population of Torit town provides additional problems with gully erosion and pollution with liquid and solid waste.

The next chapter provides recommendations and solutions.

7 Recommendations

The Civil War and its consequences are a given and cannot be addressed within the scope of this project, but interventions exist that can mitigate and limit the impact of hazards and disasters. To be successful, i.e. reduce disaster risk and increase water and food security, it is recommended to offer a package wherein interventions are combined:

- The upscaling of good agricultural practices, such as the application of soil and water conservation measures, development of agroforestry and establishment of field-scale water harvesting;
- The promotion of ecosystem-based use of natural resources, including for example regulation of hunting and tree cutting, reforestation and controlled grazing;
- The strengthening of value-chains (e.g. honey, coffee) through improved access to credit, knowledge and markets;
- The strengthening of institutions towards gaining a constructive foothold with the local population and building their capacity. The strengthening should revolve around building awareness, investing in environmental monitoring, enforcing of rules and regulations, establishingbye laws, and the empowering of communities, local governments and other institutions that could support implementation of interventions; and
- The development of management plans, with a special focus on high risk areas such as Torit town and protected areas such as the wetlands of Badingilo and Imatong Forest Reserve. An integrated catchment management plan (CMP) for the entire Kinaite Catchment is the ultimate goal.

There is an intrinsic need to protect and (re)build the overall resilience of the system, so that it can provide the maximum of ecosystem services. The need to implement the described measures is all the more urgent in light of the projected climate change. The CMP for Kinaite catchment should cover the following themes: Ecosystem protection and restoration, Water resources and Sanitation, Agriculture and economic development and Institutional strengthening.

It is important to create a synergy in all the ongoing planned activities of the local government, civil society, development organizations and the communities itself.

The following paragraphs provide recommendations in more detail for the support to institutional strengthening and the development of management plans.

7.1 Institutional strengthening

Capacity building at local government		
Goal	**Action**	**Outcome**
Create a knowledge base	Combine all reports and maps of this study and previous studies into, for example, an Atlas	Atlas with knowledge base
Engagement of local government in project	Supplement Atlas with an implementation manual, this includes suggested pilot activities	Implementation manual for pilot selection
Capacity building and creation of awareness	Organize a series of trainings - Understanding of key hazards and threats - Field visits - Support to civil society - Support to community elders - Support to good agricultural practices	Awareness raising and building of professional skills

Support to civil society		
Goal	**Action**	**Outcome**
Support to local NGOs and community based organizations	-Capacity building and strengthening of the enabling environment	Awareness at civil society and enhancement of professional skills
Support to constructive dialogues	Facilitation of stakeholder meetings, ease contact between civil society, local government and community leaders	Awareness and increased synergy between stakeholders
Support to civil society hydro-meteorological monitoring network	-Expand monitoring network with for example water quality or ground water level measurements. -Develop a freely accessible online dashboard with monitoring data	Improved availability of data and therefore improved data access for hydrological understanding. This would aid the planning of interventions to bridge dry spells.

Bottom up support community level towards DRR		
Goal	**Action**	**Outcome**
Good local agricultural practices	Establish farmer field schools (FFSs) for good agricultural practices, agroforestry, Arabic gum production, tree nurseries, coffee production	Demonstration pilots and trained local communities

Sustainable inclusive growth	Include youth in training programs and pilot studies.	Investment in future livelihoods and trained communities
Improved community resilience	Introduce alternative livelihoods program	Livelihood diversification
	Create VSLA's	Improved credit for pilots and improved financial management
	Promotion of reforestation and agroforestry	Reduced threats of for example soil erosion, increase of food resources in times of droughts.
	Introduce and promote alternative energy sources such energy saving stoves	Reduced pressure on natural resources
Increase water availability	-Introduction of rainwater harvesting techniques and improved water resources management. -Plan additional water resources infrastructure by using a water resources potential map.	Higher water availability and resilience in times of drought

7.2 Integrated Catchment Management Plans

A start towards an Integrated CMP for Kinaite Catchment could be made by creating management plans for certain sub-catchment or protected areas: wetlands and forest reserves. Both wetlands and forests play an important role in the hydrological functioning of the catchment and have a high value of ecosystem services. Good functioning forests and wetlands contribute greatly to the natural resilience. The wetlands in the Kinaite catchment play an important role in storing sediment and water and slowly releasing water after heavy rainfall. These wetlands and riparian areas are being cultivated and therefore reduced in hydrological functioning. As water is transported down a river, pollutants are absorbed and dispersed through a range of chemical and biological processes (AWF, 2014). Natural resilience is best secured through the protection of river banks, wetlands and forest reserves.

A management plan for wetlands and forests should include good agricultural practices and land management to reduce soil erosion. The soil is an important storage component for water in the Kinaite catchment. Potential for groundwater is low due to the presence of basement complex lack of large aquifers. In this regard, it is important to discourage agriculture on steep slopes, and cultivation of river banks which is likely to result in erosion. Water Resources Potential maps could be made to assist in the planning of new water infrastructure to capture precipitation and peak discharges. Water resources potential maps indicate locations where water can be used for recharge, retention and reuse (3R). The potential for different interventions depends on the characteristics of the landscape.

Paragraphs below describe the basis for management plans that together form the basis of an integrated CMP for the entire Kinaite catchment. Engaging the local population is crucial. The support of all stakeholders, local communities and local government is necessary for the solutions and CMP to succeed. Create awareness and give the local communities a say in the solutions and measures to take for instance by organizing communities by different special interest groups.

7.2.1 Management plans for protected areas

Develop wetlands management plans
Develop community based wetlands management plans. One management plan could set an example for surrounding catchment management plans.
The plan should include: -Raising awareness of the hydrological and ecological value of wetlands at the local communities -Set up a Wetland Management organization and engage local communities in management of wetlands. -Protection of wetlands by delineation of wetlands and riparian zones -Restore degraded wetland areas and river banks

Develop forest management plans
Develop community based forest management plans for a subcatchment/microcatchment to improve the natural resilience.
The plan should include: -Exclude agricultural activities and burning practices from protected forest areas. Explore possibilities for agroforestry together with local communities. -Set up an extended forest management organization and forest guard. Provide training about Monitoring vegetation, runoff, and control of poaching and burning practices. -Create awareness of the hydrological and ecological value of forests at the local communities and engage the local communities in the forest management. -Improve vegetation cover in degraded and erosion sensitive areas

7.2.2 Management plans for Torit Town

Develop waste disposal management plans
A waste disposal management plan should provide guidelines related to planning, collection, transportation, disposal, awareness and enforcement.
The plan should include: -Set up a monitoring system of waste disposal and water quality. -Set up a program to clean the current disposal areas in town -Set up a contact point to report toxic waste disposal -Upscale sanitation programs in Torit town. -Promote waste management at approved disposal sites -Create waste collection arrangements in town -Create awareness of the effects of uncontrolled waste disposal at the community

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Annexes

Annex 1 – Geological map
Annex 2 – Vulnerable species
Annex 3 – Historical disasters
Annex 4 – Explanation of threats
Annex 5 – Hazard threat ranking
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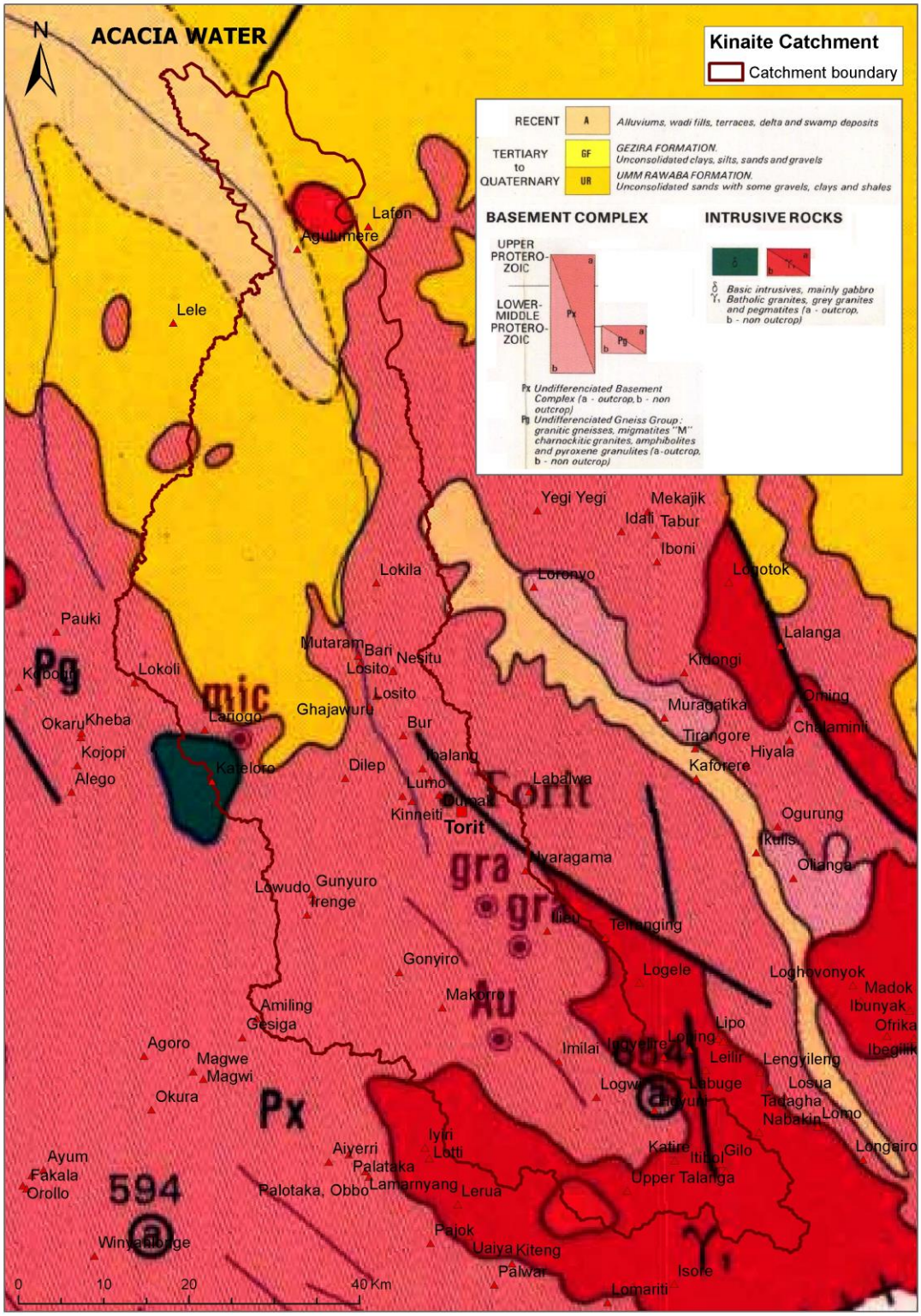
Annex 1 – Geological map



Annex 2 – Vulnerable species

The IUCN Redlist of Threatened Species (IUCN 2014) includes the following species of terrestrial mammals, birds, reptiles, and amphibians that have been modelled to be potentially present in the Kinaite catchment[3]

NT = Near Threatened, VU = Vulnerable, EN = Endangered, CR = Critically Endangered:

Acinonyx jubatus (mammal VU)
Acrocephalus griseldis (bird EN)
Aquila clanga (bird VU)
Balaeniceps rex (bird VU)
Balearica pavonina (bird VU)
Caracal aurata (mammal NT)
Ceratotherium simum (mammal NT)
Circus macrourus (bird NT)
Coracias garrulus (bird NT)
Eidolon helvum (mammal NT)
Falco naumanni (bird VU)
Ficedula semitorquata (bird NT)
Francolinus streptophorus (bird NT)
Gallinago media (bird NT)
Glareola nordmanni (bird NT)
Gyps africanus (bird NT)
Gyps rueppellii (bird NT)
Hyaena hyaena (mammal NT)
Limosa limosa (bird NT)
Loxodonta africana (mammal VU)
Lycaon pictus (mammal EN)
Neotis denhami (bird NT)
Oryx beisa (mammal NT)
Otomops martiensseni (mammal NT)
Panthera leo (mammal VU)
Panthera pardus (mammal NT)
Polemaetus bellicosus (bird NT)
Rynchops flavirostris (bird NT)
Terathopius ecaudatus (bird NT)
Torgos tracheliotos (bird VU)
Trigonocepts occipitalis (bird VU)

[3] LEFT assessment

Annex 3 – Historical disaster identificaiton

Disaster	What was the date?	What was the impact?	What was the coping method of locals?
Floods			
Flood	Recurrent	Displacement of populations/ Reduced crop production loss of top soil	Relocation to safer grounds
Flood	Sep-Oct 2016	Houses destroyed	Relocation of homes to safer grounds
Flood	2013 and 2014	Loss of crops and property	Relocation of homes to safer grounds
Flood	2013	Displacement of populations, loss of crops, life and property	Moved to higher areas
Heavy Rainfall and Floods	2000 Bur, Losito, Bari and Lomorwo	Destruction and loss of property Deep gulleys on roads	Migration from lower to upper areas; Sold livestock in Torit
Floods	2014 Lokwada and Lokoli area	Loss of life	Migrated to safer grounds
Flood	2016 Along Kinaite River	Crops and livestock were swept away	Moved to safer areas in Kuji and Libaa villages
Food/water shortage			
Drought	Recurrent	Poor harvest	Fishing, collection of wild fruits and hunting
Drought	2016	Poor harvest; Hunger; Mass migration of populations	Migration; Sale of livestock to buy food
Dry spell	2011 and 2014	Chronic food insecurity	Relied on acacia seeds, coconuts and mangoes
Drought	2013 All Villages	Hunger	Relied on wild fruits. Mangoes and Bananas planted along the rivers
Drought	2005 and 2013 (All villages)	Hunger; Migration to other areas	Relied on wild fruits (Ahamok) and vegetables (Lalup)
Drought	2016 - 2017 All Villages	Hunger	Relied on wild fruits and vegetables
Pests (birds)	2011-2017	Destruction of crops	Scarecrows
Livestock diseases	2013-2014	Loss of livestock Hunger	Moved livestock to uncontaminated villages
Crop Pests & Diseases	2011-2017	Damaged	Used scarecrows
Natural otherwise			
Wild fires	Annual (Jan - March) All villages	Loss of property Loss of fertile top soil	None
Wild fires	2016	Loss of property Loss of fertile top soil	Put away fires using bushes and soil

Landslides	2016 Lokojeli area	Soil erosion	Shifted to safer areas
Conflict			
Civil war	2005 and 2013 to date	Loss of life and property and displacement of populations/Lords Resistance Army in 2005 killed people and kidnapped children	Mass migration to neighbouring countries – Kenya, Uganda and Ethiopia
Civil war (LRA)	2002-2004	Loss of life Desturction of property	Migration to safer areas
Natural Resource (land conflicts	2010 (Lomorwo and Bari)	Delayed cultivation and thus hunger in the following year; Loss of property	Government intervention
Disease			
Cholera	Sep-Oct 2016	More than 20 people lost their lives	Red Cross and GoSS set up drinking water collection points and health units to handle patients in both mid and lower catchments
Cholera	Recurring	Loss of lives	GoSS opened up health points for check up
Human epidemic – Malaria	2000	About 30 people died	Medicine was provided by GoSS
Cholera	2014	Loss of life Loss of labour in farms	Medicine was provided by GoSS
Etise (Skin disease)	2015	Loss of labour in farms	Salt baths
Newcastle Disease	2017	Loss of livestock populations	Traditional herbs
Newcastle Disease	2014-2017	Loss of poultry	Quarantined sick chicken to stop the spread of the disease; Sold other chicken to Torit
Foot and Mouth Disease	2014	Loss of livestock populations	Moving livestock to other areas
Measles	2000	Loss of life - Children	Salt baths
Measles (Skin disease)	2003 Awira Village	Loss of labour in farms	Used herbs from mahogany and salt water to bathe
Cholera	2004	Loss of life	Boiled drinking water, and used herbs
Foot and Mouth Disease	2000	Loss of livestock	Migrated the livestock to other areas
Cholera	2007	Loss of life	Used traditional herbs (Ritho)
Human diseases (Typhoid, Malaria and Diarrhoea)	2015 (Lomorwo, Bari and Losito)	Loss of farm labour and productivity	Health Centre in Mutarram village
Etisu Kokorus (Skin disease)	2015-2016	Loss of productivity (people were nursing their wounds and could not go to farms)	Salt water baths Use of herbs (Akokou)

Annex 4 – Explanation of threats

nr	Threat	Short explanation	Effect
1	Stream bank cultivation	Cultivation near streams is common in the area, possibly due to fertile alluvial soils. This is resulting in an increase in sediment loads, bank erosion and collapse thereby reducing water flow mid-stream and causing sediment deposition downstream	Collapsed river banks during the rainy season led to loss of crops and property Sediment deposition downstream Erosion of riverbanks especially during the rainy season Loss of crops planted along the riverbanks
2.	Deforestation	Forests are mostly cleared for preparation of agricultural land. Wild fires and harvesting timber and other forest products for building and fencing is also one of the key causes of deforestation. Katire: The Teak plantation forest has been exploited for timber and construction materials. There are 2 saw mill and logging companies in the area: Techna and Lukiza respectively. Wild fires started during land preparation for cultivation has also had a negative impact on tree cover.	Increased soil erosion Increased river siltation Reduced availability and accessibility of wild game and other useful products such as medicinal herbs Loss of medicinal products and other biodiversity NB:Saw mills have offered employment to the Youth (former soldiers during the Civil war)
3.	Soil erosion	Soil erosion is evidenced by reduced top soil and deep gullies in several areas along the catchment, particularly from the sloping ranges to the settlement areas. Woodland areas show significant erosion.	Loss of soil fertility and productivity Increased sedimentation
5.	Sedimentation in rivers	Soil eroded off the land is washed into the rivers. During the rainy season, there is increased suspended loads and poor water quality (clarity)	Reduced water quality Increased sediment loads
6.	Brick making	Bricks are produced at a fast-growing rate in the catchment for both local and commercial use for the surrounding areas, particularly Torit town.	Loss of indigenous tree species Increased deforestation to fuel brick-making kilns
7.	Population increase	Migration of populations from conflict and hunger prone areas	Resource use conflicts

		has led to competition over resources such as fertile land.	Hunger due to uncultivated land under contention
8.	Shift cultivation	The demand for fertile and safe areas for cultivation in an area has led to clearing of vegetated areas for cultivation. This, coupled with slash and burn land management practices are one of the key drivers of land use change.	Burning of vegetation Reduced quality of the land Reduced resilience of the overall ecosystem against threats such as climate change and floods
9.	Overfishing	Due to increased population and poor crop production, communities are relying on fishing for nutrition and sale. This has led to reduced quantities of fish. Also, water levels in the Kinaite River have reduced considerably. This has had a negative impact on fish size and quantities.	Reduced fish quantities
10.	Bush burning	The practice of bush burning has been rampant in the recent past. Communities practice this activity for reasons such as clearing land in preparation for tilling before the rainy season, and to prevent pests and diseases.	Spread of wild fire which brought about loss of property and tree cover Degradation of top soil fertility and general land productivity over time
11.	Water pollution	Sedimentation as a result of soil carried away and deposited into rivers.	Increased suspended loads Reduced water quality
12.	Overgrazing	Overgrazing is one of the threats to the environment, where Intensive grazing thus causes the plant residual matter to decline and further contributes to numerous negative consequences to both the animals and the land.	Conflict over access to water and grazing lands Reduced soil productivity
13.	Poaching	Proximity to the Bandigilo National Park means the villages are close to the Wildlife Migrating Corridor. White-eared kob and Zebras are a delicacy in the lower catchment with sale of wild-game extending to Torit	Reduction of wildlife numbers Longer distances in search for wild game Bush-burning practice with negative impact is used during poaching

Annex 5 – Hazard threat ranking

During the community assessments in 5 different villages, the threats and hazards relevant to the communities were identified. The major risks of these threats and hazards were scored on their probability and impact (average of scope, severity and irreversibility) by a representative group of the community. Numbers between 1 and 4 could be assigned to a specific indicator of the threats or hazard.

The overall score provides a clear overview of major and minor risks per village. The overall score is ranging from 1 (minor risk) to 16 (major risk), calculated by multiplying the probability with the average of the impact components.

	Katire		Impact			Overall
nr	Threat	Probability	Scope	Severity	Irreversibility	
1	*Stream bank cultivation*	3	2	3	2	7
2	*Deforestation*	4	3	3	3	12
3	*Soil erosion*	3	2	2	3	7
4	*Sedimentation in rivers*	1	2	2	2	2
5	*Brick making*	2	1	2	1	3
6	*Population increase*	2	2	2	4	5
7	*Shift cultivation*	3	2	2	2	6
nr	Hazard	Probability	Scope	Severity	Irreversibility	
1	*Conflicts (LRA)*	4	4	4	3	15
2	*Measles (Skin disease)*	1	2	2	1	2
3	*Drought*	3	4	4	2	10
4	*Floods*	3	2	3	2	7
5	*Wild fires*	2	2	2	2	4
6	*Landslides*	1	1	2	1	1

	Bur Payam		Impact			Overall
nr	Threat	Probability	Scope	Severity	Irreversibility	
1	*Stream bank cultivation*	3	2	3	2	7
2	*Deforestation*	4	3	2	2	9
3	*Soil erosion*	3	2	2	2	6
4	*Sedimentation in rivers*	3	3	3	2	8
5	*Shift cultivation*	2	2	2	1	3

6	*Overfishing*	*3*	*3*	*2*	*2*	*7*
nr	**Hazard**	**Probability**	**Scope**	**Severity**	**Irreversibility**	
1	*Heavy Rainfall and Floods*	*3*	*2*	*3*	*2*	*7*
2	*Crop pests and diseases*	*3*	*3*	*3*	*1*	*7*
3	*Drought*	*3*	*4*	*4*	*2*	*10*
4	*Natural Resource (land conflicts*	*3*	*2*	*2*	*1*	*5*
5	*Human diseases (Typhoid, Malaria and Diarrhoea)*	*2*	*2*	*2*	*1*	*3*

	Imilai		**Impact**			**Overall**
nr	**Threat**	**Probability**	**Scope**	**Severity**	**Irreversibility**	
1	*Stream bank cultivation*	*3*	*2*	*2*	*1*	*5*
2	*Bush burning*	2	2	2	2	4
3	*Deforestation*	3	2	2	2	6
4	*Soil erosion*	*2*	*2*	*1*	*1*	*3*
5	*Water pollution*	*2*	*2*	*3*	*2*	*5*
	Hazard	**Probability**	**Scope**	**Severity**	**Irreversibility**	
1	*Lord Resistance Army (Civil War)*	*4*	*4*	*4*	*3*	*15*
2	*Wild fires*	*2*	*2*	*2*	*1*	*3*
3	*Livestock diseases (Foot & Mouth Disease)*	*2*	*1*	*2*	*2*	*3*
4	*Etisu Kokorus (Skin disease)*	*1*	*1*	*2*	*1*	*1*
5	*Crop Pests & Diseases*	*3*	*3*	*3*	*2 (seasonal)*	*9*
6	*Newcastle Disease*	*2*	*1*	*2*	*2*	*3*
7	*Drought*	3	3	3	2	8

			Impact			Overall
nr	Threat	Probability	Scope	Severity	Irreversibility	
1	*Stream bank cultivation*	3	2	3	2	7
2	*Overgrazing*	4	2	2	2	8
3	*Poaching*	4	3	2	3	11
4	*Deforestation*	3	2	2	2	6
5	*Soil erosion*	2	1	2	1	3
6	*Sedimentation in rivers*	2	2	2	2	4
7	*Shift cultivation*	3	2	2	2	6
nr	Hazard	Probability	Scope	Severity	Irreversibility	
1	*Lord Resistance Army (LRA)/ Civil war*	4	4	4	3	15
2	*Flood*	3	2	2	1	5
3	*Cholera*	2	3	3	2	5
4	*Drought*	3	3	3	2	8
5	*Livestock diseases*	2	2	2	2	4

	Lokila		Impact			Overall
nr	Threat	Probability	Scope	Severity	Irreversibility	
1	*Stream bank cultivation*	2	2	3	2	5
2	*Deforestation*	3	3	3	3	9
3	*Soil erosion*	2	1	1	1	2
4	*Overgrazing*	2	2	2	2	4
5	*Shift cultivation*	2	1	2	1	3
nr	Hazard	Probability	Scope	Severity	Irreversibility	
1	*Lord Resistance Army (LRA) war*	3	3	3	3	9
2	*Civil war*	4	4	4	3	15
3	*Malaria*	2	1	2	2	2

4	*Drought*	*3*	*3*	*3*	*2*	*4*
5	*Flooding*	*1*	*1*	*2*	*1*	*3*

Annex 6 – Field Data Collection Forms

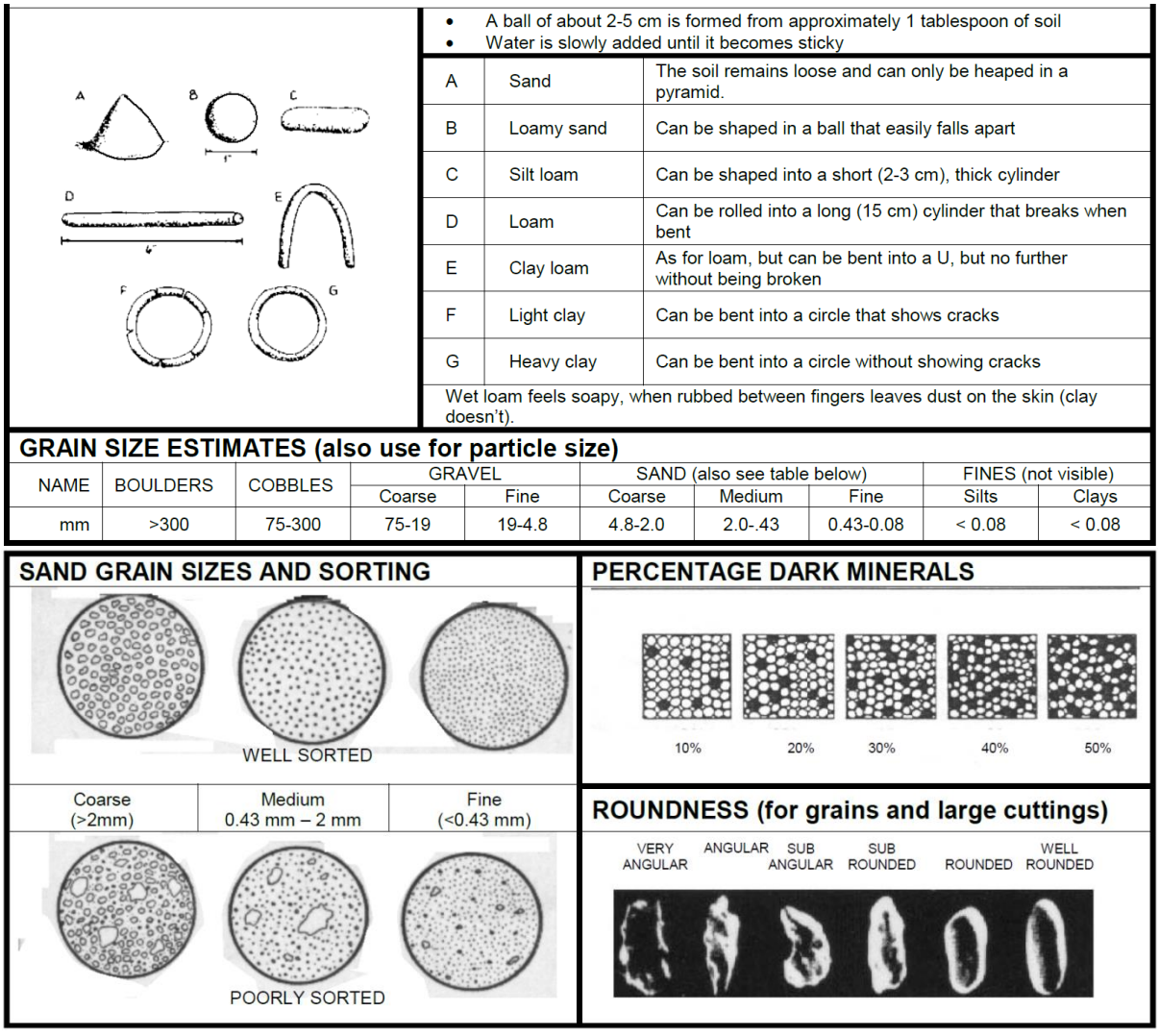
Site Description

Date:	Time:	Unique site no:	
Surveyor(s):			
Ecosystem main type:			No:
Ecosystem sub type:			No:
UTM zone: 36N	E:	N:	Alt.:
Location description:			
Location sketch:			
General remarks			

Pictures:		Description of picture		
N	E	Name	Remark	Picture number

Soil Description

Maps: Soil map
Visit the main map-units and make on-site observations, visit specific areas of interest. Cary out probing or dig a soil profile descriptions. Take a picture of the profile. Describe the soil texture of the main soil type. Estimate sand content of the soil if any (<10%, 10-30%, 30-50%, 50-70%). For sands estimate the grain size and sorting. Write down the color of the main soil type, take a picture of the soil and note coordinates.
Indicate improvements in written notes on the printed soil map.



- A ball of about 2-5 cm is formed from approximately 1 tablespoon of soil
- Water is slowly added until it becomes sticky

A	Sand	The soil remains loose and can only be heaped in a pyramid.
B	Loamy sand	Can be shaped in a ball that easily falls apart
C	Silt loam	Can be shaped into a short (2-3 cm), thick cylinder
D	Loam	Can be rolled into a long (15 cm) cylinder that breaks when bent
E	Clay loam	As for loam, but can be bent into a U, but no further without being broken
F	Light clay	Can be bent into a circle that shows cracks
G	Heavy clay	Can be bent into a circle without showing cracks

Wet loam feels soapy, when rubbed between fingers leaves dust on the skin (clay doesn't).

GRAIN SIZE ESTIMATES (also use for particle size)

NAME	BOULDERS	COBBLES	GRAVEL		SAND (also see table below)			FINES (not visible)	
			Coarse	Fine	Coarse	Medium	Fine	Silts	Clays
mm	>300	75-300	75-19	19-4.8	4.8-2.0	2.0-.43	0.43-0.08	< 0.08	< 0.08

Soil Assessment

Unique site no (from site description):		Soil profile no:	Date:
UTM zone: 36N	E:	N:	Time:
Picture number(s)		Total profile depth:	

Horizon/layer		Soil texture		Coarse fragments		Org matter		Roots		Diagram	
Hor/ layer	Depth	Main soil type/ texture	Sand content (%) and grain size (µ)	Ab.	Type	Ab.	Structure	Ab.	Size	Sketch	Color (put some wet soil below with your finger)
General remarks:											

Vegetation Assessment

Unique site no (from site description):			Vegetation plot no:		Date:
UTM zone: 36N	E:		N:		Time:
Picture number(s)			Total profile depth:		
% Cover by layer	Tree (A):	Shrub (B):	Herb (C):	Grass/moss (D):	Bare/other:

Trees				Shrubs			
Layer	Species	% Cover	Height	Layer	Species	% Cover	Height

Herb layer			Grass/moss layer		
Layer	Species	% Cover	Layer	Species	% Cover

Notes: (Sketch on next page)

Vegetation assessment continued

Unique site no (from site description):	Vegetation plot no:	Date:	Time:
Top view site sketch vegetation			
Cross section site sketch vegetation			

Wildlife and Plant Habitat Assessment

Interview with local communities and field observations for whole ecosystem (not only the plot). Focus on most common wildlife and specific species of interest for communities and the ecosystem, endangered species, and problematic and invasive species.

Wildlife				
Species	Preferred habitat feature(s)	Ab.	Resident or migratory	Comments

Plants			
Species	Preferred habitat feature(s)	Ab.	Comments (Usage, challenges etc.)

Maps: Land cover

Visit the main map-units and make on-site observations, visit specific areas of interest, GPS mapping, pictures. Indicate improvements in written notes on the printed land use map.

Coordinates		Description of land cover		
N	E	Main land cover	Remark	Picture number
General remarks				

Wetland/Flooding area

Maps: Land cover and flooding areas.

Visit to different flooding areas in the catchment area, especially the areas at the outflow of the catchment area. GPS mapping, pictures, interviews with local people to inquire: area flooded and floodlevels (cm above ground, max, average, low), how often, for how long, shallow groundwater availability (wells scoopholes present?). Indicate improvements in written notes on the printed land cover and flooding areas map.

Mapping of existing wells, ponds and areas with stagnant water

Coordinates		Type	Seasonality	EC (uS/cm)	Type of sediment	Picture number
N	E					
General remarks						

Mapping of flooding area characteristics

Name flooding area		General description of area				
Mapping of different parts within the flooding area						
Coordinates		Land use and land cover	Type of soil	Write down dates of flooding in floodplains over the last 5 years	Max water level and date	Picture number
N	E					
General remarks						

Flooding areas water needs

Visit to different flooding areas in the catchment area, especially the areas at the outflow of the catchment area. Interviews with local people to inquire: importance of the area (grazing, farming, harvesting of natural products such as grass cutting, reeds and wood), is flooding required? What is the optimal flooding situation (define years that were good, problematic wet/dry).

Mapping of flooding area water needs

Name flooding area								
General description of area								
Are there any activities depending on flooding (grazing, farming, natural products, water sources etc.)? If yes describe and draw on land use map								
Mapping of specific flood related activities/needs within the flooding area								
Coordinates		Type of activity/ water demand	Is flooding required?	What is the optimal flooding situation?	Indicate year/month that flooding was:			Picture number
N	E				Good	Too dry	Too wet	
General remarks								

Flooding problems

Visit areas where flooding has cause problems and interview people. Map problem areas, such as damage to property, land, infrastructure etc. Indicate problem areas and notes on land use and flooding area map.

Coordinates		Type of problem	Describe flooding situation	What has been the damage?	Which years has flooding been a problem?	Picture number
N	E					
General remarks						

Environmental issues

Mapping of environmental issues in the catchment such as land degradation, erosion, deforestation, invasive species. Visit to catchment areas for on-ground observations. Visit to the communities/villages and specific areas of interest and conduct interviews.

Coordinates		Name of area	Type of problem	Description of issue	Picture number
N	E				
General remarks					

Landscape view

If possible go to a high viewpoint within each different landscape in the catchment and take a landscape picture. Take coordinates and note the orientation in which the picture is taken.

Coordinates		Name of area, location of picture	Description of landscape	Orientation of picture (S/N, x°)	Picture number
N	E				
General remarks					

Annex 7 – Village assessment

The village assessment survey should be filled by interviewing a small group of inhabitants from the village. A diverse group is preferred: village elder or local council, women and men with different jobs or positions in the village such as farmers or herders. Please inform the group of the goal of the project and the goal of this interview: to gather information and opinions about the conditions of the ecosystems and threats and hazards in the surroundings of the village.

State	
Locality	
Village / community name	
Group composition	
Coordinates of village, UTM	

Basic data

Population	_____ households / _____ people
Number of livestock owned by the villagers (estimated)	_____ cattle _____ goats _____ sheep _____ donkeys
Total area	Total area of land belonging to the village: _____ square metre
Land for agriculture	Total cultivated area: _____square metre Cultivated area that gets water from the river: _____ square metre Cultivated area that depends on rain: _____ square metre Agriculture land that is not used: _____ square metre
Grazing area	Total grazing area: _____ square metre
Forest area	Total area under forest: _____ square metre
Wetlands	Total wetland area: _____ square metre
Is the number of households growing or shrinking? What trend do you see? (Birth rates, out-migration, immigration, other?	
Is this trend causing problems for particular households or for the community in general?	

History of the village

How old is the village?	
Are there any people who used to live in the village and who now moved to another place?	No / Yes, _____ households. Year in which they moved: _____ Reason why they moved:_____

Are there any people who recently settled in the village?	No / Yes, _____ households Year in which they settled: _____ Reason why they settled:_____
Can you summarise the history of the village?	

Changes in the environment

What has changed in the environment around the village in the past 50 years? When did this happen?	
How did these changes affect the community?	
How did the community adjust to these changes?	
What kind of wildlife do you see in the surroundings of the village?	
Do you gain any benefits of wildlife? Or disadvantages?	

Are there any endangered species known in the community? (for example trees or wildlife)	

Cultivation

Which crops are cultivated in this village? And when are they planted?	○ Sorghum, _____ square metre, ○ Maize, _____ square metre, ○ Groundnuts, _____ square metre, ○ _____, _____ square metre ○ _____, _____ square metre ○ _____, _____ square metre ○ _____, _____ square metre
What are the major challenges in crop cultivation for this community?	
Do any fields get irrigated in this village? If yes, which crops and which method is used for irrigation?	Yes / No
Is the cultivated area around this village increasing in surface area? If yes, please explain	Yes / No
Are there any bush burning activities going on? If yes, please explain	No/ Yes, _____ square metre,

Trees/shrubs

Which trees or shrubs that people can use are available near the village?	○ _____, a lot available / a little available ○ _____, a lot available / a little available ○ _____, a lot available / a little available ○ _____, a lot available / a little available ○ _____, a lot available / a little available
Are there any logging or charcoaling activities going on in this community? If yes, please explain	
Are there any tree planting activities going on in this community? If yes, please explain	
Are there any invasive species causing problems in the community? If yes, please explain	

Ecosystem services

Please list the different surrounding ecosystems/landcover types occurring in this community in the grey column.
Could you hereafter list the (direct) benefits of this ecosystem? And rank them from 1, most important, to +1 less important.

		Ecosystem Services						
		Provisional			**Regulation and maintenance**			**Cultural**
Ecosystems		Nutrition	Materials	Energy	Mediation of waste, toxics and other nuisances	Mediation of flows	Maintenance of physical, chemical, biological conditions.	Spiritual, symbolic, heritage, recreational
	examples	*Herbs,*	*wood*	*Charcoal*	*Water purification*	*Water storage in soil*	*Flood prevention*	*Ecotourism*
1 Forest	1.1 lowland forest	*1.* *2.*						
	1.2 Montane forest							
	1.3 Plantation forest							
2 Grassland	2.1 Dry Lowland Grassland							
	2.2 Seasonally Wet/Flooded Lowland Grassland							

3 Shrubland	3.1 Dry Shrub land							
4 Wetlands	4.1 Shrub dominated wetlands							
	4.2 Seasonal wetlands							
	4.3 Permanent wetlands							
5 Open water	5.1 River/streams							
	5.2 Ponds and lakes							
	5.3 Freshwater springs							
6 Rocky areas								

7. Agricultural land	7.1 Seasonally Flooded Agricultural Land							
	7.2 Rain fed agricultural land							
	7.3 Irrigated agricultural land							
Other								

Land management practices

What land management practices are applied by the villages in the surrounding ecosystems?	Please list management practices per ecosystem
Is any of the land management practices causing problems for the village or the environment? If yes, please explain.	
Are there any environmental permits needed for the land management practices?	
Are there any visible conservation methods in place to protect the ecosystem services?	
In your opinion, what role should the local community members play in the conservation of Natural resources in the area?	

Common sources

Are there any common or shared resources used by households in this village for their livelihoods? Examples: common fishing grounds, common grazing areas, forests etc	
How do you manage these common resources?	
How important are these for livelihoods or food security?	
Is access to these resources changing? Are these resources becoming less productive?	

Sources of water from the village (more than one answer possible)

Rainy season water sources	Dry season water sources
○ River ○ Lake/pond ○ Wetland ○ Open well ○ Water Yard or Mini Water Yard ○ Hand pump ○ Borehole	○ River ○ Lake/pond ○ Wetland ○ Open well ○ Water Yard or Mini Water Yard ○ Hand pump ○ Borehole

○ Other, _____ ○	○ Other, _____ ○
Are these sources used for Livestock and domestic use?	
Are there any issues with the management of water points? If so, please explain	
Are there any issues with the water availability of water points? If so, please explain	
Where do people get water when there is a water shortage?	

Hazards and Disasters
Have any disasters occurred in the past? If yes, please fill in the table per disaster.

Disaster	What was the date?	What was the impact?	What was the coping method of locals?

Which areas are most at risk from climate related (or other) events?	
Which groups of people are more vulnerable to particular hazards?	
What are the risks and vulnerabilities that threaten the families at any point of the year?	

Main needs in the village

What are the main needs in the village?

Other actors working in the village

Which NGOs, UN organisations, etc are working in the village at the moment?	
What activities are they doing?	
Which NGOs, UN organisations, etc worked in the village in the past five years?	
What activities did they do?	

Key informant interview

Introduce the project and the goal of this interview. Show the ecosystem map and explain the concept of ecosystem services.
Please note all relevant information.

key informant	Name: Profession: Organization: Connection of informant to Kinneti catchment:
Date interview	

Trends

What major trends do you see in Kinneti catchment?	
Are these trends causing problems? (in general, or for particular regions or communities?)	
How are the locals adjusting to these trends?	

Natural resources

How important are natural areas like Imatong forest reserve and Badalingo National park?	
In what way have the communities benefitted from the conservation areas?	
In your opinion, should the local communities be involved in the preservation of natural areas?	
In your opinion, what should the government and other conservation agencies/NGOs do to help the community participate in the conservation and Management of Natural Resources?	

Hazards and Disasters

Have any disasters occurred in the past? If yes, please fill in the table per disaster.

Disaster	What was the date?	What was the impact?	What was the coping method of locals?

Which areas are most at risk from climate related (or other) events?	
Which groups of people are more vulnerable to particular hazards?	
What are the risks and vulnerabilities that threaten the families at any point of the year?	

Land management practices

What are the issues with the most applied land management practices in Kinneti catchment?	
What are the major NRM related conflicts in the Kinneti catchment?	
What are the existing legal and traditional practices in place for managing natural resources, resolving NRM-based conflicts, managing land, water and forests?	

Ecosystem services

Please list the different surrounding ecosystems/landcover types occurring in this community in the grey column.
Could you hereafter list the (direct) benefits of this ecosystem? And rank them from 1, most important, to +1 less important.

		Ecosystem Services						
		Provisional			**Regulation and maintenance**			**Cultural**
Ecosystems		Nutrition	Materials	Energy	Mediation of waste, toxics and other nuisances	Mediation of flows	Maintenance of physical, chemical, biological conditions.	Spiritual, symbolic, heritage, recreational
	examples	*Herbs,*	*wood*	*Charcoal*	*Water purification*	*Water storage in soil*	*Flood prevention*	*Ecotourism*
1 Forest	1.1 lowland forest	*1.* *2.*						
	1.2 Montane forest							
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2 Grassland	2.1 Dry Lowland Grassland							
	2.2 Seasonally Wet/Flooded Lowland Grassland							
3 Shrubland	3.1 Dry Shrub land							

4 Wetlands	4.1 Shrub dominated wetlands							
	4.2 Seasonal wetlands							
	4.3 Permanent wetlands							
5 Open water	5.1 River/streams							
	5.2 Ponds and lakes							
	5.3 Freshwater springs							
6 Rocky areas								

7. Agricultural land	7.1 Seasonally Flooded Agricultural Land							
	7.2 Rain fed agricultural land							
	7.3 Irrigated agricultural land							
Other								

Annex 8 - Hazard threat ranking

This exercise consists of 2 scoring exercises. Based on this ranking exercise the key hazards and threats can be identified.
All hazards and threats that were identified in the previous exercise should be used in the ranking exercise. Per hazard or threat a scoring should be given by all the members of the consultation group individually. Based on the ranking in exercise 1A, the hazards and threats that are most likely to occur are identified. Based on exercise 1B, the hazard and threats that have the highest impact are identified. In decision-making, low-consequence / low-probability risks are typically perceived as acceptable and therefore only require monitoring. In contrast, high-consequence / high-probability risks are perceived as unacceptable and a strategy is required to manage the risk. Combining the scoring exercises, the key hazard and threats can be identified for Kinneti catchment.

Exercise 4A: Ranking based on likelihood of occurrence
The hazards and threats will be ranked on the likelihood of occurrence. A ranking will be done by stakeholders during the workshop using different likelihood categories such as rare, unlikely, possible, likely, almost certain.

Threat level	Very high	High	Medium	Low
Ranking	4	3	2	1
Likelihood	Almost certain	likely	unlikely	rare
	Based on historic occurrences, possible pathways, or changed circumstances (in management), this hazard or threat is almost certain. The probability of occurrence is very high.	Based on historic occurrences, possible pathways, or changed circumstances (in management), this hazard or threat is likely. The probability of occurrence is high.	Based on historic occurrences, possible pathways, or changed circumstances (in management), this hazard or threat is unlikely. The probability of occurrence is medium.	Based on historic occurrences, possible pathways, or changed circumstances (in management), this hazard or threat is rare. The probability of occurrence is low.

Exercise 4B: Ranking based on impact
The participants should score each hazard or threat with a number 1,2,3 or 4 for the scope, severity and irreversibility using the criteria below. Table 1 provides a short version of the criteria, hereafter more explanation is provided.

Table 4 Summary table of ranking

Threat level	Very high	High	Medium	Low
Ranking	4	3	2	1
Scope	Very widespread or pervasive	Widespread	Localized	Restricted
Severity	Destroyed	Seriously degraded	Moderately degraded	Very minimal impact
Irreversibility	Effects irreversible	Reversible but very costly	Effects reversible with commitment	Effects easily reversible

Scope - The proportion of the ecosystem or community that can reasonably be expected to be affected by the threat within ten years, given the continuation of current circumstances and trends. For

ecosystems, measured as the proportion of the target's occurrence. For species, measured as the proportion of the population. For communities, measured as the proportion of the total community population.
Severity – Within the scope, the level of damage to the target from the threat that can reasonably be expected given the continuation of current circumstances and trends. For ecosystems, typically measured as the degree of destruction or degradation of the target within the scope. For species, usually measured as the degree of reduction of the target population within the scope. For communities, measured as the degree of destruction for the community.
Irreversibility – the degree to which the effects of a threat can be reversed and the target affected by the threat restored. It is assessed for the impact of the threat on the community/ecosystem/species.

Table 2. elaborate explanation of criteria for ranking. In the table, only threat is stated, but all criteria are applied for threats and hazards.

Threat and hazard level	**Very high**	**High**	**Medium**	**Low**
Ranking	4	3	2	1
Scope,	Very widespread or pervasive, The threat is likely to affect 70-100% of the ecosystem or community	Widespread, The threat is likely to be widespread in its scope, affecting 30-70% of the ecosystem or community	Localized, The threat is likely to be restricted in its scope, affecting the ecosystem or community across some 10 – 30%.	Restricted, The threat is likely to be very narrow in its scope, affecting the ecosystem or community across a small proportion, 1-10%
Severity	Destroyed, The threat is likely to destroy or eliminate the ecosystem, or to affect 70-100% of the community population within the next 10 years	Seriously degraded, The threat is likely to seriously degrade/reduce the ecosystem, or to affect 30-70% of the community population within the next 10 years	Moderately degraded, the threat is likely to moderately degrade/reduce the ecosystem, or to affect 10-30% of the community population within the next 10 years	Very minimal impact, the threat is likely to only slightly degrade/reduce the ecosystem, or to affect 1-10% of the community population within the next 10 years
Irreversibility	Effects irreversible, The effects of the threat cannot be reversed, it is very unlikely that the ecosystem or community can be restored, and/or it would take more than 50 years to achieve this. (e.g. forest converted to a concrete market)	Reversible but very costly, The effects of the threat can technically be reversed and the ecosystem or community restored, but it is not practically affordable and/or it would take 20-50 years to achieve this (e.g. forest converted to agriculture)	Effects reversible with commitment, The effects of the threat can be reversed and the ecosystem or community restored with a reasonable commitment of resources and/or within 6–20 years (e.g., reforestation with seedlings)	Effects easily reversible, The effects of the threat are easily reversible and the ecosystem or community can be easily restored at a relatively low cost and/or within 0–5 years (e.g., growth of new vegetation cover after flood).

Table 5. Example table for ranking exercise

		Exercise 4A	**Exercise 4B**		
nr	**Threat or hazard**	**Likelihood**	**Scope**	**Severity**	**Irreversibility**
1					
2					

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