Master's thesis
Regional studies
Development Geography

THE LOCAL PERCEPTION ON CHANGES IN WATER AVAILABILITY AND ACCESSIBILITY IN THE TAITA HILLS, KENYA

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Tiivistelmä – Referat – Abstract

Denna forskning bidrar till vattenrelaterad forskning genom att poängtera den sociala aspekten i vattenfrågor. Genom etnografiska metoder studerar man lokalbefolkningens uppfattning om minskade vattenresurser. Det är av intresse att undersöka hur lokalbefolkningen förklarar miljöförändringarna. En målsättning för studien är också att testa hur lokal kunskap kunde stöda beslutsfattandet genom en deltagande variant av geoinformatik (PGIS). Denna avhandling jämför två avrinningsområden: Wundanyi som är ett fuktigare område i höglandet och Mwatate som är ett torrare område lägre ner.

Det krävs tvärvetenskaplig forskning för att studera vattenförhållandena, särskilt vilka faktorer som begränsar tillgången. Vatten kan mätas såväl kvantitativt som socialt genom att uppskatta tillgången till vatten. Vattentillgången styrs på basen sociala relationer inom befolkningen. Utvecklingsländer, såsom Kenya, är beroende av regnförsörjt jordbruk och därför har missväxt omfattande följder för ekonomin. Att diversifiera försörjningen i området är nödvändigt för att minska på fattigdomen och skydda vattenresurserna. Vattenbristen begränsar möjligheten att kombinera vatten med andra tillgångar, vilket i sin tur minskar på inkomsterna i hushållen. Den primära lagen som styr vattensektorn i Kenya är Water Act 2002. Integrerad förvaltning av vattenresurserna (IWRM) har varit grunden för denna lag. Lagen har blivit kritiserad för att ignorera den juridiska pluralismen, som existerar särskilt på landsbygden. De fattiga på landsbygden har ingen möjlighet att påverka de statliga institutionerna som fattar beslut om vattenresurserna. PGIS föreslås vara ett redskap för att inkludera lokalbefolkningen i processen.

Etnografi och ett deltagande samhälle utgör kärnan för forskingsmetodologin. Fältarbetet utfördes i Taita Hills i januari-mars 2013. Deltagande metoder som användes i undersökningen var, halvstrukturerade intervjuer, fokusgrupper, deltagande kartläggning, tidslinjer, transekter och GPS punkter. I huvudsak intervjuades jordbrukare och två workshops ordnades i vardera avrinningsområde. Analysen baserar sig på innehållsanalys, SPSS, historisk översikt, analys över hur familjerna försörjer sig, samt PGIS. Data jämfördes enligt kön och var man är bosatt.

Lokalbefolkningen i Wundanyi och Mwatate anser att vattennivån minskar på grund av skogsavverkning, speciellt när det gäller ursprungsskogen. Vändpunkten för miljöförändringarna var då markuppdelningen nådde de olika delarna av Taita i samband med att landet blev självständigt. Tidigare bodde jordbrukarna i byar som var omringade av tät skog. Efter markuppdelningen fick invånarna nya tomter och var tvungna att hugga ner skogen för att få rum för jordbruket. Befolkningstillväxten och religiösa grunder är dessutom vanliga förklaringar till miljöförändringarna. Vattentillgången är ojämlikt fördelad så att personer med politiska kontakter kan påverka beslutsfattarna för sin egen vinning. När det gäller markägandet, begränsar ojämställdheten mellan könen vattentillgången för kvinnor. Vattentillgången varierar lokalt i det bergiga landskapet. Den försämrade vattentillgången bland kvinnor tvingar befolkningen att hitta nya alternativa inkomstkällor, eftersom det regnförsörjda jordbruket inte längre är lönsamt. Fiskdammar blir allt populärare vid sidan om jordbruket. Många förlitar sig på tillfälligt arbete och på ekonomiskt stöd från sina arbetande barn. PGIS ger möjlighet för teknokrater och lokalbefolkningen att förstå varandra via de digitaliserade kartskisserna och då kan man utarbeta mer detaljerade handlingsplaner för vattenförvaltningen.

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Belinda Kivivuori

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Abbreviations

CBO	Community Based Organisation
DANIDA	Ministry of Foreign Affairs of Denmark
GIS	Geographical Information System
GPS	Global Positioning System
MDG	Millennium Development Goals
NGO	Non-governmental Organisation
NRM	Natural resource management
IWRM	Integrated Water Resource Management
IWRAM	Integrated Water Resource Allocation and Management
KNBS	Kenya National Bureau of Statistics
PGIS	Participatory GIS
PLA	Participatory Learning and Action
PRA	Participatory Rapid Appraisal
SLA	Sustainable Livelihood Approach
WPI	Water Poverty Index
WRMA	Water Resource Management Authority
WRUA	Water Resource Users' Association

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1 Introduction

This Master of Science thesis is an ethnographic study of the local perception of the reasons behind a reduction in the water resources in the Taita Hills, Kenya. More specifically the study area comprises two catchments: Wundanyi and Mwatate, named after the biggest rural centres. The ethnographically collected data is combined with geoinformatics through PGIS (participatory geoinformatics). The introduction presents the main aims and motives, the *Integrated land-cover-climate-ecosystem process study for water management in East African highlands* (Taitawater) project, gives a background to the focus chosen, and the research questions.

1.1 Aims and motives of the study

The thesis is part of the interdisciplinary project called *Integrated land-cover-climate-ecosystem process study for water management in East African highlands*, shortly Taitawater. The subproject team consists of a doctoral student, Johanna Hohenthal, and three master students, including myself. The work is supervised by Dr. Paola Minoia and the whole project coordinated by Prof. Petri Pellikka. The project is funded by the Academy of Finland. The two other master students focus on the institutional level of the water and land management, and the ecosystem services in the Taita Hills, whereas I focus on the perspective of the local inhabitant. Methodologically the study is participatory. This qualitative research aims to achieve an integrated approach by testing participatory methods in water resource management and involving different stakeholders to the workshops organised in each catchment that was chosen for this study. The findings from the other researchers in the Taitawater-project will be reflected against this study to achieve a broader approach. The project is a way of promoting development in the Taita Hills, which is a rural area characterised by a mix of agriculture and rainforest. The area is interesting because it is one of the biodiversity hotspots in the world with unique flora and fauna. The mountains partly covered by rainforest act as a source for fresh water that provide water also to the surrounding savannah in the lowlands. The area has experienced major changes in land-cover and now both the locals and the researchers have woken up to their effect on the water resources. The water issues are studied through forest sciences, physics, biosciences, geosciences and geography. There are researchers studying the water resources through remote sensing, rainfall in different locations, likens, biomass, cloud formation etc. There is a need for social sciences in which people are the key interest. Therefore, the

main motive for this participatory research is to give a voice to the water users that are highly affected by the actions taken in their community and in the government.

This kind of community based-research will hopefully promote the ultimate aim of bringing the decision-making power to the communities and empowering the community-members. There is a need for identifying the knowledge that is hidden in the local communities in order to work on detailed action plans that are suitable for the Taita Hills-area. The indigenous water rights have not been studied very much (Koppen, Giordano & Butterworth 2008), which justifies the need for also investigating the legal parallelism in the rural communities, that is to say that besides the government laws also customary laws exist and are followed still. Customary laws are common knowledge that is passed orally through generations. Village elders are representatives of these traditional laws and customs. Governmental laws are the ones that are officially enacted by ministries or the parliament. In Kenya the governmental laws that concern water are mainly presented in the Water Act 2002, which is the main law that regulates the water sector in Kenya.

However, this thesis focuses on the perception of the local water user, on changes in water availability and accessibility. The legal parallelism is only touched upon here, since it would require another type of methodology to be investigated.

The focus of this research is in investigating how the people in the Taita Hills experience the current water resource management and how they explain the environmental changes that are linked with the water issues. It is analysed how the local knowledge can be combined with scientific knowledge and institutional policies, that is to say how water management at the catchment level should be designed in order for it to be inclusive. This study contributes to research in constructing better models for water management at all institutional levels by bringing an insight into the existing grass-root level knowledge of the water resources. Participatory mapping and PGIS are tested for inclusive water management purposes.

1.2 Background

The problems related to water in the Taita Hills are power relations, gendered land ownership that affect the access the water resources, water management issues, forest destruction, and the locals' need to prioritise immediate revenue over catchment conservation that would pay off in the long run. The focus of this research lies in the

social aspect of the water problems. The information on the amount of water measured from river flow and water levels needs to be completed with information of how the water resources are managed by the humans and what determines the access to water. The Water Act 2002 clearly states that the primary aim is to ensure water availability at a reasonable distance to all households. However, only roughly two thirds of the population in urban areas have access to potable water, while the corresponding figure for the population in rural areas is less than half. The poorest and the most marginalised Kenyans are, according to Mumma (2005), least likely to benefit from the formal legal framework in the Water Act 2002. According to the local population, not only the lack of water is the problem, but also the quality of it. Locals say the quality is bad because of increased use of fertilisers and pesticides in the fields, which presumably causes health problems among the local population. They indicated that most of the households do not have tapped water and interruptions in the water supply in the pipe network occur frequently.

The furrows built by the locals follow the rule *"those who benefit from the water in the canal are responsible for maintaining it"* (Fleuret 1985, pp 110). According to Fleuret, men used to mainly be responsible for organising and doing the work, but in our fieldwork it was noticed that women seem to be doing most of the work today. According to from what we have seen on the field, the rule about the gendered nature of water management still seems to apply.

Problems in land ownership limit the access to water and affect the land use. According to Fleuret (1985), the *Taita* people follow the patrilineal heritage which has an impact on who has the right to land and the water resources within them. The water is seen as a common good, meaning that every inhabitant has the right to access and use the water, which makes a piped water system difficult to implement. In order for the pipes to be maintained and the water quality monitored, the money has to be collected from somewhere. However, local people are against it because water is seen as coming naturally and it is their right to use it freely. Paying for water in the Taita context would be the same as charging a berry picker in Finland (referring to the everyman's right in the Nordic countries).

To investigate the local knowledge of the water resources in the Taita Hills ethnographic research is needed to make way for inclusive water management. The first

research question is hereby: How are the changes in water availability and accessibility perceived by the local water users and how do these changes affect their lives?

Locals told us that several dams were built during the colonial times but when land became scarcer the dams were destroyed in order to gain agricultural lands. The dams were also seen as signs of colonialist governance, thus something the *Taitas* did not want to keep. In addition to this, it is reported that many children have drowned in these dams. Also during the field work period for this research a boy drowned in the Mwatate dam and another in a shallow well. The local children rarely learn to swim, which is very common in Africa in general. Traditionally, it has been dangerous to go into the water since the lakes are filled with bacteria and diseases or dangerous animals, like crocodiles. The sea is dangerous because of strong currents and sharks. Himberg (2011) states that also superstition is linked to this matter. Although Christianity has reduced witchcraft and in a way modernised the traditional beliefs, rainmaking for instance is still practiced and certain tree species are recognised as rain bringing objects. Some believe that rain is brought by supernatural forces and there are sacred places that are used for rituals and which cannot be used as agricultural land (Himberg 2011). These sacred places however, become fewer year after year. On the field people explained the environmental changes in many different ways. Some believe that it is God's will and some clearly think that the cutting of trees reduce the water resources. This brings us to the next research question: How are the causes of environmental change explained by the locals? This question supports the first question as the water availability and accessibility is affected by the environmental changes.

Conservation of the water resources is essential in the Taita Hills where new exotic, water consuming tree species have made the indigenous forests smaller. Deforestation has become the main problem in the Taita Hills. It can be seen from satellite and aerial photographs that the indigenous forest has reduced drastically in the recent years. Reforestation plans have already been made to increase the indigenous forest area (Pellikka et al. 2009). Conservation is difficult to promote in rural poor areas that lack capacity to put energy into conservation instead of providing for the families and have food every day. To promote a long-term investment in sustainable livelihoods is rather difficult and desperate poor need to prioritise in short-term investments that give immediate revenue. The third research question is: How is the current water availability

and accessibility affecting the livelihoods? To answer this question a livelihood analysis is conducted on data gathered from interviews.

The empowerment of the locals in order for them to gain access to water is considered as the key problem. PGIS (participatory geoinformatics) could be a tool for including all stakeholders in the decision-making. Hence, the final research question is: How could local knowledge through PGIS support decision-making?

2 Theoretical framework

The theoretical framework presents the theories related to the research problems from a global and a regional perspective. The local context is tied to the theories presented in this chapter later on in the results and the discussion part.

4.1 Water poverty in developing countries

The provision of water and safe sanitation in the rural areas are lagging behind the cities. Water can be considered scarce in local contexts where for example cities are constructed in arid areas. Development of water resources and infrastructure will always be an integral part of the economic development. It provides transport links, hydroelectricity for industry, and irrigation for agricultural intensification and drinking water for the population (Agnew, Woodhouse 2011).

Climate change is one of the reasons to increased water poverty. Predictions on how precipitation will change are very uncertain. For instance, fresh water supplies are threatened by the sea-level rises. More extreme precipitation patterns will lead to more droughts and more floods (Agnew, Woodhouse 2011), which many locals in the Taita Hills claim. According to Agnew and Woodhouse, the African countries are most likely to suffer the most from water stress and scarcity. Developing countries, such as Kenya, are highly dependent on rain-fed agriculture and therefore the impacts on the yields and the economy are vast. Shorter growing seasons are results of irregular rains and seasons.

Water stress and scarcity are measured with the Falkenmark index that indicates how much water is available annually per person (Brown, Matlock 2011). This includes not only domestic water, but also water used for agriculture, industry, production etc. The water resources are considered scarce if there is less than 1000m^3 of water per inhabitant per year. If the equivalent figure is between 1000m^3 and 1700m^3, the country is considered to be water stressed. This is the easiest indicator to calculate and provides

state governments and large organisations with an overview of the water resources at a national level.

A water poverty index (WPI) can be calculated by combining social and physical sciences (Sullivan 2002) or in other words, economic poverty with water accessibility. The index involves information on water availability, access to safe water, water quality, clean sanitation and time used for collecting water for domestic use. Sullivan suggests that also the water needs of the environment should be integrated into the economic accounting systems in order to achieve sustainability. WPI is an integrated tool for investigating the water resources of a community. In contrast to other indices for measuring water availability, WPI can be calculated on a micro-scale and it involves also the social aspect of the issue. The macro-level hydrological data can also be combined with water stress information at a household level through GIS (Sullivan 2002).

There are several indicators to measure the water resources both quantitatively and qualitatively. These indicators help to understand the circumstances of the water resources but some of them provide only raw data that needs to be combined with qualitative research. They are especially good in an environment that is going through changes in land cover and that might suffer from decreasing water levels. The indicators help in viewing the changes from multiple perspectives, which is helpful for decision-makers.

Komnenic et al. (2009) discuss the usability of indices in developing countries and particularly criticises the use of WPI. According to their article, a country can have a low WPI, thus be water poor and still have a safe water access of over 90% (Komnenic, Ahlers & Zaag 2009). They argue that combining many types of information in one index actually results in information loss rather than a multidimensional view on the issue. The water-related issues and their drivers are complex and require a separate observation of all indices. Komnenic et al. recommend that water poverty should not be considered the same as low water accessibility due to poverty in a society. Apart from economic or social conditions, the lack of access to safe water can also be due to mismanagement of the water resources or physical unavailability (Komnenic, Ahlers & Zaag 2009), which was also observed in the highlands of the Taita Hills.

Socio-economic groups are often unevenly benefited by irrigation and actually Hussain and Hanjra (2004) claim that the division of land resources determines the distribution of benefits from irrigation as well. Corruption is a general problem which increases the inequality in water accessibility.

There are many successful examples of how productivity has significantly risen after introduction of irrigated agriculture (Hussain, Hanjra 2004). However, economic growth and poverty reduction does not always walk hand in hand (Narasaiah 2007). Large dams have been built in several countries to provide energy and to increase the irrigation, which has clearly boosted the national economy. However, dams have a limited life span of around 30 years. This is why supply-side approach has lately shifted to demand-side management instead, where the water demand is controlled instead of increasing the supply. Sustainable development is closely linked with the demand-side water management as it concentrates on responsible usage of the water resources. The balance between economic growth and sustainable development has for long been and will be a discourse that humanity argues about. Many researchers underline the linkage between poverty alleviation and access to water (Sullivan 2002, Cook 2007, Toure et al. 2012). Often, poor people stay poor even though the national economy is on the rise. India is a good example of this. Rural poor depend heavily on land and water resources for their livelihoods (Hussain, Hanjra 2004). Irrigated agriculture allows farmers to implement new farming technologies and intensify cultivation that considerably increases productivity. According to Hussain and Hanjra, new employment opportunities, income increase and new livelihoods can lead to an improved quality of life in the rural community. Considering these benefits, it is understandable that decision-makers and locals of the rural communities are willing to invest in irrigation. However, it would be advisable to also look into the drawbacks and what can go wrong. Hussain and Hanjra point out that irrigation in higher altitudes, such as in upper parts of the Taita Hills, can reduce the water availability in lower areas.

In areas where catchments provide water over state borders, it is crucial to agree on cross-boundary coordination in order to avoid failure in water management. There are several issues that can occur that reduces the agricultural productivity and eventually the livelihoods due to loss of fish, flash floods, and reduced water levels (Hussain, Hanjra 2004). In the long run, Hussain and Hanjra claim that this might result in conversion of fertile land into wasteland, economic loss, and contaminated groundwater

that is used for irrigation and creates serious health issues. There are also several environmental concerns around the large irrigation systems. The negative impacts of large dams are well known (for instance, there are numerous papers written on the critique against the world's biggest dam project in China: the Three Gorges Dam), but in addition to this there is a concern that there is not enough money to manage the irrigation systems to build proper drainage systems in the fields and that the water used for irrigation becomes saline and reduces soil fertility (Hussain, Hanjra 2004).

4.2 Livelihoods and the environment

The assets, activities, and the access to these determine the living gained by the individual or the household. All these together form a livelihood (Ellis 2000). The assets comprise human, social, physical, financial and natural capital. Sometimes also cultural capital is a part of the analysis. In this study the human capital comprises age, education, health, farming experience, ecological awareness and household size. Social capital refers to the safety networks in the community, group membership, marital status and the number of children. Conflicts or sudden death in family decreases the social capital of an individual. Physical capital is the infrastructure built for water and waste water. Financial capital is money that exists to buy water or the time used to fetch it. It also comprises the expenditure patterns of a household, such as income sources, what money is spent on. The natural capital refers to water, trees and land. Livestock and the type of crops that can be grown in the area are also part of the natural capital.

The access to these assets is essential in the livelihood analysis that needs to be conducted in order to understand how access to water is determined in the communities. Access can be either restricted or enabled by social norms and rules within the community. Drought, floods, diseases, pests and bad conflicts are examples of shocks that challenge livelihood sustainability, since shocks immediately destroy assets (Ellis 2000). In addition, Ellis speaks about livelihood diversification, that is *"the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living"* (Ellis 2000, pp. 15).

Livelihood diversification is closely linked with poverty reduction and conserving of the environment (Ellis 2000), which would protect the water resources. This link will be further explained in the next chapter. The rural poor look for alternative activities to farming, which would reduce their vulnerability to shocks such as drought and floods

when water becomes less available. However, non-farm income is highly dependent on human capital that is education and good health. Soil erosion and unpredictable rains and seasons have become a problem for the farmers in Sub-Saharan Africa and Ellis claims that the poor are particularly interested to diversify their incomes. However, poverty in the assets needed prevent them from securing diversification options (Ellis 2000).

Fisher and Treg (2007) address in their article the issue of the interconnectivity between poverty alleviation and biodiversity conservation. Biodiversity conservation protects the water resources in the Taita Hills where the upper parts are covered by rainforest. According to them, most of the biodiversity hotspots in the world are located in developing countries where poverty is a constraint to conserve them. One of these hotspots is located in the Taita Hills, Kenya where the majority of people depend on farming. People know that cutting trees is harmful for the environment and the water resources, but since the land demarcation people have no other choice than converting forest into agricultural land in order to provide for their families. Ellis (2000), points out that the farmers in developing countries contemplate for example whether it is worth the effort to build terraces to prevent soil erosion and gain the expected future income from it, or continue as before and gain the current opportunity cost of labour time. He also claims that no farmer cultivates in ways that would cause yields to decline. In many cases, there is simply no capacity to divert labour from current income activities into conservation activities (Ellis 2000).

Water is connected to all forms of livelihood capitals, as in certain cases it must be paid for with revenue gained from other economic activities, like agriculture, or in time spent collecting the water (Clarke 1998). In combination with other assets water can produce certain types of income. According to Clarke (1998), water scarcity is limiting the capacity to combine water with other assets, thus reducing the income of the household. He also claims that the monetisation of water, that has increased the provision of water resources in Kenya after its independence, has paradoxically reduced the food security of the pastoralists because they cannot move freely anymore and use water from any borehole like before.

In general, what is experienced in the rural communities is that the locals rarely consider future income streams. The current income mostly outweighs the possible

future income that could be gained from long-term investments in sustainable farming. According to Ellis (2000), insecurity and uncertainty are the main reasons for locals to live one day at the time and not contemplate the future.

Ellis suggests that increased alternatives on non-farm income sources could reduce the unsustainable use of natural resources. Currently, the water resources are depleted in order for the locals to survive. The shortage of labour is usually a hindrance for labour-intensive conservation practices for settled farmers.

4.3 Understanding the linkage between poverty alleviation and water accessibility

The concept of *ecosystem services* can be used in understanding the linkage between poverty reduction and catchment conservation (Wittmer, Berghöfer & Sukhdev 2012) that in this case affects the water accessibility. Wittmer et al. suggest that the main environmental and natural resource assets to maintain a livelihood can be identified through this concept, in other words, to understand the parts of nature that humans depend on for their survival.

The ecosystems provide humankind with certain benefits that are called ecosystem services. These are defined in the Millennium Ecosystem Assessment (2005). Ecosystem services consist of all the benefits that humans gain from ecosystems. They can be divided into four different categories: provisioning, regulating, supporting and cultural services (Millennium ecosystem assessment 2005). They all are important for life as water can be linked to all categories. The ecosystem services are connected to human well-being and are even considered to reduce poverty. They provide basic material for good life, security, health and good social relations if the natural resources are cherished. Changes in land use and cover and climate change are the main drivers of change on the ecosystem services. Of course, also the use of pesticides and fertilisers increases the impact on ecosystem services.

The supporting services involve nutrient cycling, soil formation and primary production. Also the cultural services provide spiritual and for example aesthetic value. In the Taita Hills spirituality is clearly affecting the water resources since some forests are sacred (*fighis)* and the rivers that originate from these *fighis* are clean. Wetlands and forests are seen as the most important ecosystems in the Taita Hills as they are perceived to protect the fresh waters.

One of the most precious services that the ecosystems provide is drinking water. Water is related to all categories that the ecosystem services are divided into: provisioning, supporting, regulating and cultural services. The ecosystem services are stated to reduce poverty and since water also goes hand in hand with wealth (Sullivan 2002, Cook 2007, Agnew, Woodhouse 2011, Toure et al. 2012), one understands the complexity of the issue of declining fresh water levels. In nature, everything is linked to each other which is actually best explained through the ecosystem services. The agricultural and forest production are particularly important ecosystem services. Forest cuts are globally the most urgent problem in tropical areas where the forest is essential to maintain the fresh water resources.

The link between deforestation and reduced water resources has been questioned for a while already since it is difficult to obtain scientific evidence of this link (Gallart, Llorens 2003). Climate change also contributes to the changes in water flow and precipitation. Omoro (2012) clearly states that deforestation endangers the provision of the ecosystem services. He found in his research that there are certain indigenous tree species that could be planted to restore the ecosystem services that have been lost in the Taita Hills. He also studied the perception of the locals and according to him, locals think that planting of exotic trees are the reason for reduced ecosystem services like medicinal plants and declined water levels (Omoro 2012).

4.4 Water management at the catchment level

Integrated water resource management (IWRM) is an implementation tool for managing and developing the water resources by using an integrated approach, ensuring protection of ecosystems for future generations. It aims to involve different kinds of stakeholders and use the knowledge of various disciplines. This is done through participatory methods in the management planning and aims to balance social and economic needs in the community.

The IWRM has been present for decades and has been reviewed and criticised in several publications already. Biswas (2008) states that many of the concepts used within the water management issue are too vague to promote development. He claims that there should be a clear destination towards which we are heading with all our development plans that are created for different countries and communities. If only sustainability is stated as an aim, it is not clear what is meant to be achieved in the end. Integrated water

resource management (IWRM) is a similar concept that is easy to understand and therefore also popular and globalised, but lacks a clear definition. It can also be interpreted in different ways depending on one's own disciplinary background. For example, economists and social scientists do not seem to agree on the definition for economic and social welfare. IWRM is also criticised for being a 'one-model-fits-all', which is not an accepted model in development studies. Biswas lists different cultures that have to be taken into account before building up a plan for how water resources should be managed. Political systems are different in all countries and corruption might stand in the way for an integrated water resource management. He mentions that the concept has been present for almost 50 years without creating a well-integrated water policy, which indicates that it needs a more specific definition to be used in practice.

Allan (2003) suggests that IWRM should be renamed IWRAM, integrated water resource allocation and management, "*to capture the unavoidable conflictual nature of water allocation and management in water scarce regions"* (Allan 2003). He speaks for an innovative use of the IWRM, which is also the aim of this project when testing the suitability of PGIS in a catchment level water management.

Integrated water resource management (IWRM) is internationally regarded as the most efficient mechanism (Rahaman 2009). However, there are a number of challenges linked to its implementation. Rahaman (2009) argues that implementation competence is the critical part of a successful natural resource management. Finding the link between the theoretical concept and the practical implementation seems to be the main challenge. There is a need for practical guides based on experiences, since IWRM has been present already for decades.

IWRM promotes cooperation between stakeholders to learn about each other's needs. This is the reason for this thesis and was achieved by organising workshops for the locals and involving them in the research on how water availability and accessibility can be improved. This decreases the risk of conflicts concerning how the water resources should be managed. As Rahaman suggest in his case study from Brahmaputra river basin (2009), the principles of IWRM should be addressed properly in the national water policy.

Managing the water resources is closely linked with land use and therefore the changes in land cover must be considered in IWRM. Scanlon et al. (2007) underline, that the

changes in groundwater cannot immediately be detected simultaneously with the change in land cover. The impacts on the water resources are much slower, thus the timing of full-scale impacts of a land use change must be carefully considered when setting up remediation programs (Scanlon et al. 2007).

Catchment monitoring should, according to Kongo et al. (2010) be conducted through participatory methods. Catchment monitoring is a crucial part of a mutual understanding of hydrological processes and for the creation of a sense of ownership of the resources in the community. Traditionally, catchments have been monitored in uninhabited areas, thus excluding humans even though they are actually a vital part of the catchment. Many researchers have experienced both vandalism and thefts of the instruments used to measure the waters, but by involving various stakeholders in the research locals feel the importance of the study and when they are helping out in the process, the risk for vandalism reduces (Kongo et al. 2010).

Gallart et al. (2003) suggest that the consumption of all water by all kinds of land use should be considered for a successfully integrated catchment management. This includes rain-fed agriculture, irrigation schemes, industry, etc. Management on the catchment scale brings many benefits when the knowledge of the people who live in the catchment can be utilised in designing the water management.

Many integrated catchment management strategies have failed worldwide in both industrialised and the developing world, due to lacking delivery mechanisms and policies that would enable the local institutions and communities to participate (Batchelor 1999). The delivery mechanisms require funds and funds can mostly be found among the donors in Sub-Saharan Africa. Attitudes from the institutions towards genuine community involvement act as a constraint. Batchelor further indicates that the professionals lack training in interpersonal skills, which makes it difficult to bring the local community members and different stakeholders around the same table.

Many articles that examine the reasons behind failed catchment water management mention poor administration, lack of training for the officials, coordination problems and mismanagement (Bourblanc, Blanchon 2013). In South Africa the substantial inequality through apartheid seems to be the key constraint for successful water management. Bourblanc and Blanchon highlight the prominent role that the attitudes among the population and government officials have on the actual implementation of

the Water Acts. Negative attitudes towards involving local water users into the design process often impede an integrated type of water management. Past legacies, such as apartheid in South Africa, have left traces in the current culture and those are rather difficult to change.

The Water Act 2002 in Kenya is influenced by the integrated water resource management (IWRM) and local knowledge undervalued. Therefore, the Water Act is not very inclusive in its design. It has partly been done in the Water Act 2002, but not in the local governments. Legal pluralism is a reality in the rural areas of Kenya and should be the basis for the water law (Mumma 2005). According to Mumma, the attempt to decentralise the functions in Kenya has failed in the sense that the ultimate decision-making still remains centralised. The rural poor only have limited access to state based institutions that decide about the water resources. In Kenya, corruption at local government level is also hindering the proper implementation of the Water Act 2002 (Mumma 2005). This is one of the reasons why the most marginalised people without access to water, are least likely to benefit from the legal framework that the Water Act 2002 provides, as Mumma (2005) states.

The Water Act 2002 is becoming dated and it has not even reached a nation-wide implementation after more than ten years. If IWRM was to be implemented properly at the local level in the rural areas of Kenya, many studies indicate that it would require participation of every relevant stakeholder and hereby a genuine community involvement (Minoia, Guglielmi 2008), which is the primary reason for this research. Most of the rural communities in Kenya are engaged in agriculture, which is also the case in the whole Sub-Saharan Africa where the majority of people are either pastoralists or farmers according to Kongo et al. (2010). Therefore, it is important to create a sustainable action plan for how the agricultural sector could be developed without depleting the water resources. Scanlon et al. (2007) suggests that the productivity of the rain-fed agriculture should be increased and wetlands restored and created, which provably protects the freshwaters against nitrate contamination.

In the Water Act 2002 it is stated that all water resources are controlled by the Ministry of Water. The Ministry has the duty to promote sustainable use of the water resources throughout Kenya and organise research concerning this topic when needed. The authority has the power to charge for water use and in practice it sells the water rights to

a small section of the community that consist of property owners who are able to acquire water permits (Mumma 2005). This does not in any way guarantee a sustainable use of the water resources because the privatisation of the water is leaving large community groups outside the system. The Water Act 2002 does not recognise the legally pluralistic environment that the rural poor live in. This is in turn reflected in the registration of the community water systems. Usually in rural areas, most of the water projects are of a self-help type, which are relatively easy and cheap to register. The problem is however that the registration is done under an informal system operated by the Ministry in charge of community development. Therefore, the official Law of Kenya does not provide for the self-help water systems. In other words, the self-help groups completely lack legal personality and corporate identity, which means that it is impossible for the group to own land under the official land laws. Despite of these unofficial registration procedures, Mumma claims that the community projects operated by self-help groups work in a satisfactory manner. Legal personality and corporate identity do not seem to have much relevance in the rural communities which proves the existence of the traditional community laws that in some cases seem to be of a bigger importance to the community members.

Rockström et al. (2010) suggest a paradigm shift in IWRM, from water management in irrigated agriculture towards water management in rain-fed agriculture. They call for more investments into rain-fed agriculture that in the future will provide a larger part of the world's food production. IWRM focuses on developing new irrigation techniques with blue water and involves planning, allocation and management of those. However, agricultural production as an ecosystem service depends on green water (Rockström et al. 2010). Green water is not visible in rivers or lakes such as blue water, but is absorbed in the soil to the crop roots and is then transpired directly to the plant. According to Rockström et al., yield failures occur due to extreme variability of the rainfall, not due to the amount of it. Dry spells are a normal variation in a semi-arid climate and occur every year after rainy season. Therefore, dry spell mitigation is a common way of minimising the risk of crop failure during dry spell. Conversely, during meteorological drought (when precipitation is below average) more advanced mechanisms are needed. Farm-level water management involves management of the water resources to bridge over dry spell, instead of only focusing on how to maximise the rainfall infiltration (Rockström et al. 2010). To conclude, Rockström et al. suggest

that the rain-fed agriculture is upgraded in the developing countries during the next 50 years after a period of 50 years of developing the irrigated agriculture.

3 Local setting of the Taita Hills

3.1 Physical geography

The Taita Hills (Fig. 2) is a mountain massif located in the south-eastern part of Kenya (3°25'S, 38°20'E) and the northernmost part of the Eastern Arc mountains. The altitude varies from 700 m to 2208 m above sea level and it has been covered by cloud forest and rain forest for millions of years (Rogo, Oguge 2000). The highest peak is Vuria, 2208m.a.s.l. followed by Iyale, 2104m.a.s.l. There are numerous endemic plant- and animal species which make the Taita Hills one of the hotspots of biodiversity in Africa. The mountains are surrounded by dry savannah. The mountains and the forest act as natural "water towers" and are a source for rivers that provide water for the local people. The clearance of forests, especially on steep slopes has resulted in soil erosion. Also, the disappearance of vegetation cover causes soil erosion (Fig. 1) on the plains. In the dryer lowlands overgrazing and firewood collection has caused problems as the rivers transport silt that is cumulated in river channels and ponds (Pellikka 2011).

Figure 1 Gullies are created as a result of soil erosion, which is a common problem in the lowlands. The picture is taken from Teita Sisal Estate, Mwatate. (Kivivuori 2013)

The study area consists of two catchments (Fig. 3): Wundanyi and Mwatate catchments, which are named after the biggest rural centres in those. The area can also be divided topographically into the lowlands and the highlands, since there is a significant difference in climate, vegetation and soil between the two. In figure 3 the digital elevation model is based on data from Chiesa Geonetwork.

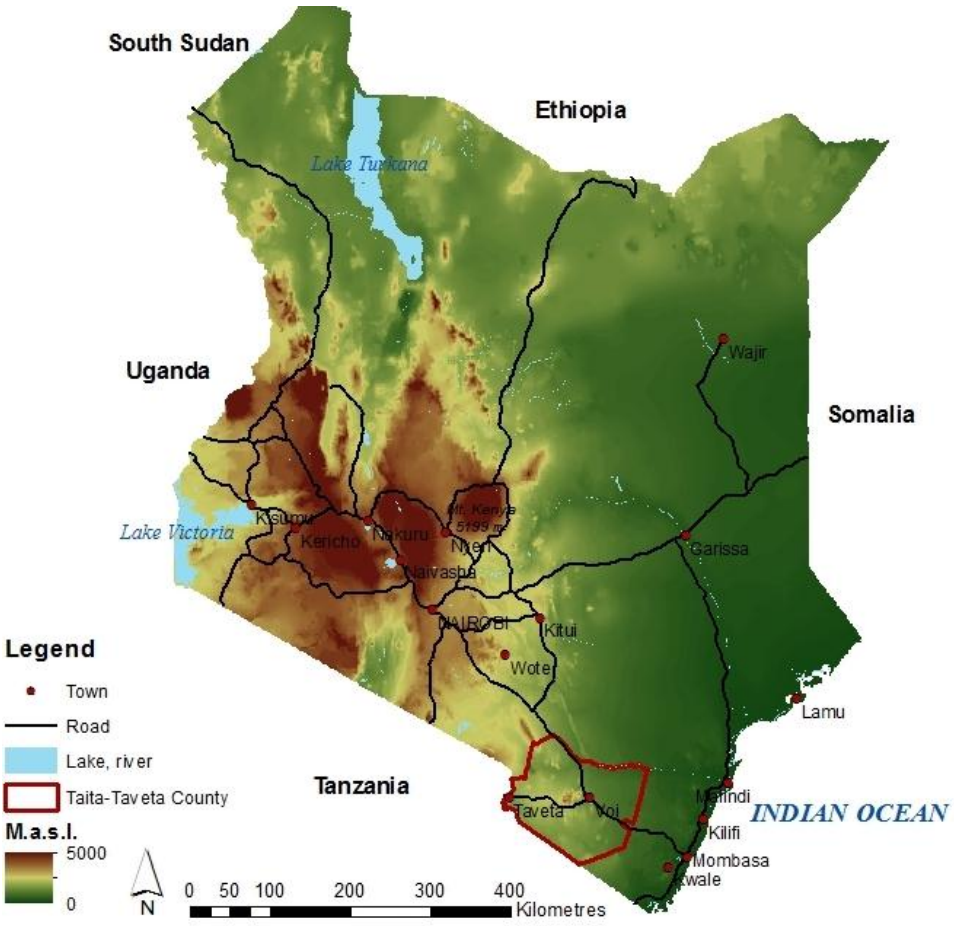

Figure 2 The Taita Hills is located in the Taita-Taveta County in South-Eastern part of Kenya (data based on WRI 2013).

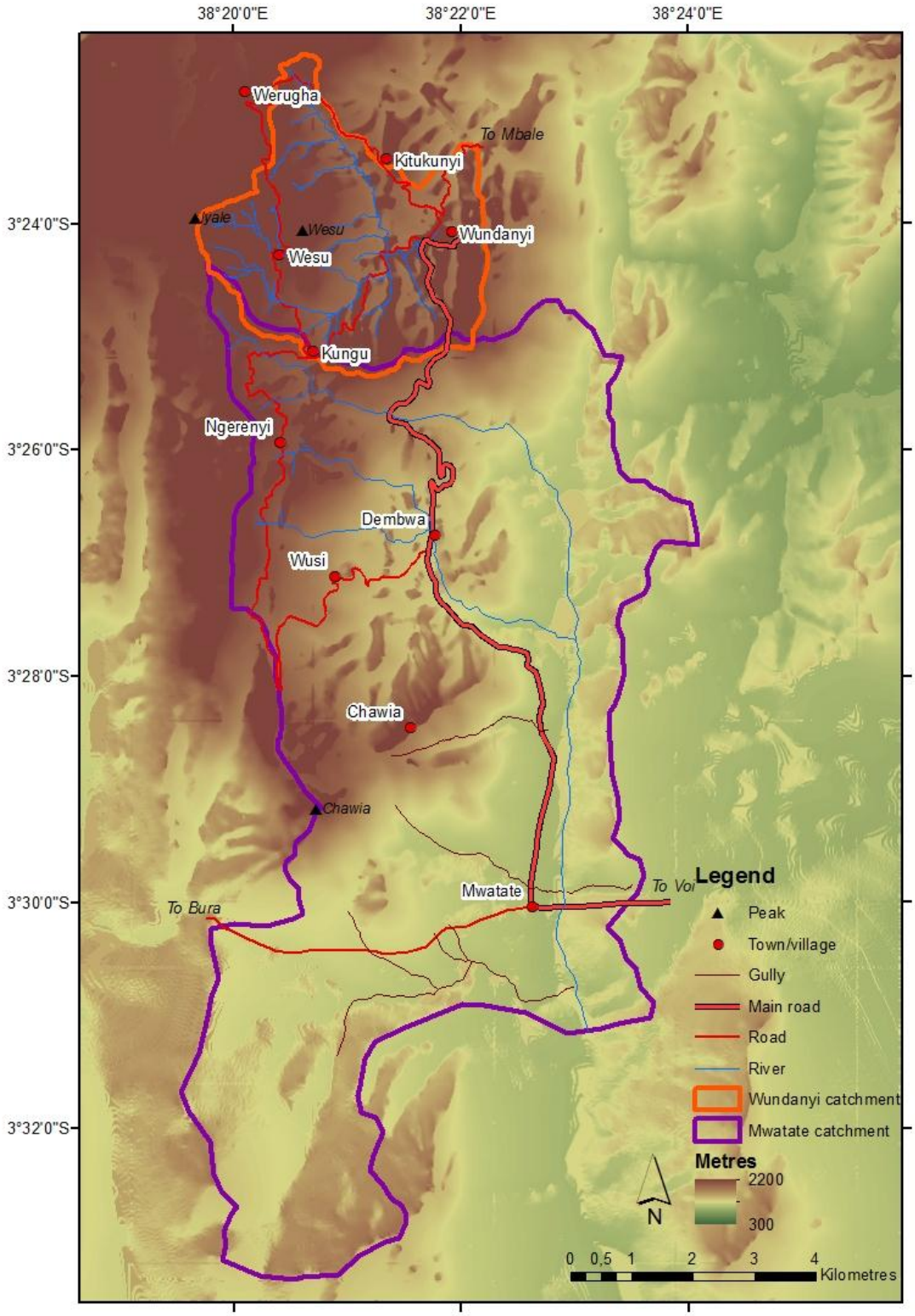

Figure 3 Hillshaded map of the study area.

The climate in Taita Hills varies from arid to tropical savannah and monsoon climate. The area is located slightly south of the Equator, in the inter-tropical-convergence zone which means that there are two rainy seasons per year. The so called long rains take place between March and July, and the short rains between October and December. The rainfall is considerably higher in the upper parts, particularly on the southern and eastern slopes, because the trade winds are not blowing from the same direction all year round. In April during the long rains, the south-eastern trade winds are blowing from the Indian Ocean causing heavy orographic rains, especially in the highlands. During the short rains the north-eastern trade winds are not blowing through the dry horn of Africa, therefore not causing as heavy rains (Pellikka 2004). According to the locals, the rains have become more irregular in the recent years. In Mwatate they say that it rains extremely heavily for two or three days, causing floods, and after that it is dry for months.

Wundanyi catchment in the highlands has an average annual precipitation of 1500mm and an average temperature of 17°C. The lowlands have an annual precipitation of around 500mm on average, but there the variability of precipitation from year to year is high (Pellikka et al. 2005). The lowlands often suffer from drought. The average temperature in the lowlands is 25°C. (Pellikka 2004)

The agricultural fields are becoming a dominating type of land use and mostly the fields are of the intensive small-scale type and rain-fed. Some of the forests that are left in the Taita Hills are the so called *fighis* or sacred forests that have an important value for the locals. These forests have remained almost untouched while the surrounding forests have been destroyed. The introduction of exotic tree species pine, eucalyptus and cypress has disturbed the life of the endemic species in the area.

The indigenous forest in the Taita Hills consists of tree species that have been present naturally without human involvement. The specific indigenous tree species that are believed to attract rains, protect from soil erosion and even control the water quality are Mngima – *Prunus Africana*, Mkuyu – *Ficus sycomorus*, Mora - *Nuxia congesta*, Msuruwachi – *Albizia gummifera*, *Erythrina abyssinica*, *Nuxia congesta*, *Ficus lutea*, *Myrica salicifolia Nuxia congesta*, *Ocotea usambarensis*, *Rapanea sp.*, *Maesopsis eminii*, *Osyris lanceolata* etc. (Himberg 2011). In the national report on Kenya by Food

and Agricultural Organisation of the United Nations (FAO) the indigenous forest is defined as follows:

> *'A group of trees whose crowns are largely contiguous and include the ecosystem that makes it up and a tree canopy cover of over 10 % and the canopy is essentially of indigenous tree species growing under natural conditions and excludes planted indigenous plantation forests*.' (FRA 2010a: 7).

Exotic forest contains trees brought from elsewhere and that do not grow naturally in the area. The most common exotic tree species in the Taita Hills are cypress (*Cupressus lusitanica*), eucalyptus (*Eucalyptus saligna*) and pine (*Pinus patula*). Mixed forests are those that contain both indigenous and exotic tree species.

3.2 Socio-economic features

The Taita-Taveta County (prior to 2007 Taita-Taveta district) is one of the 47 counties created after the elections in March 2013. The headquarters of the County is in Wundanyi, the biggest rural centre in the upper part of the Taita Hills with a population slightly under 5000. There are two main rural centres in the Taita-Taveta County: Wundanyi, Mwatate and a town called Voi. Voi is located by the main road between Mombasa and Nairobi. Mwatate, with a population of around the same as in Wundanyi, is located in the lowlands next to Teita Sisal Estate. The population has grown considerably in the whole county. In 1962 it was just above 90 000, but in 2009 it is estimated that the population has grown up to 280 000 (KNBS 2010). However, it cannot be underlined enough that the figures presented in this chapter are not absolute. It is very difficult to get accurate data from the study area, which is often the problem in developing countries particularly in rural areas. There is simply no reliable data available and the figures presented here are based on estimations from different sources. The data collected for the Taitawater project is guiding the numbers.

The main livelihood in the Taita Hills comes from agriculture. Around 80% of the population in Taita-Taveta County gets its main income from farming (Najjar, Spaling & Sinclair 2012) and this has been the case for generations. Many locals were explaining that most of the coffee production has stopped and the production of cash crops has lost its popularity after the end of the 90s when the prices for coffee dropped. Most of the farming is self-sustaining small-scale and rain-fed. One of the biggest sisal plantations in the world is located in Mwatate in the lower part of the Taita Hills.

According to Clarke (2010), the population increase has together with intensive farming resulted in a serious scarcity in land and water availability in the highlands. New land is cleared for agriculture in the lowlands so that people from the hills can have a place for cultivation.

As most of the population rely on agriculture, they are highly affected by changes in climate and weather. The unpredictable seasons and declining water availability have made it more difficult for the farmers to produce enough crops which keeps the income level low. People are looking for casual work outside their homes or try to search for income in other fields, like timber or small scale business. (Zschauer 2012)

Health-wise, a clear majority in the Mwatate and Wundanyi catchments seek medical help for respiratory diseases. In the year 2012, 16 926 cases of these were reported in Mwatate, and 23 313 cases in Wundanyi (Kenya Health information system 2013). It was seen on the field that *Taitas* often have a fire inside their houses but no chimney to let the smoke out. Among the locals, smoke is not considered poisonous and so they heat up the house with a fire inside. Traditional cooking is also done on fire. Malaria is another common disease during the rainy season.

In the health statistics it can be seen that Wundanyi in the upper zone of the Taita Hills is more developed. People in Wundanyi suffer from diseases, such as hypertension, diabetes, and rheumatism that are common diseases in welfare countries. These diseases are completely lacking from the statistics of Mwatate. Regarding water-borne diseases, diarrhoea is the most common, but also dysentery and typhoid occur.

Today, almost all children in the study area commence primary school (KNBS 2007). Of the respondents in Wundanyi catchment 13 finished primary school, 2 started but did not finish. 21 graduated from secondary, 2 did not complete. 3 went to vocational school to study engineering, teaching or sewing. Only one had studied at a university in Nairobi and had a Bachelor's degree. He was planning to continue to a Master's degree. All the nurses had gone to college and one retired agricultural officer had gone to a Catholic college. The older respondents replied that they went to intermediate school which was part of the old schooling system. Graduating from intermediate school corresponds the first years in secondary school today. In Mwatate, the educational level is slightly lower, but the data from there is not comparable with the data from Wundanyi, since a bigger part of the respondents in Mwatate worked in a hotel or

hospital. The literacy rate among males in Taita-Taveta is 92.9% which is higher than average in Kenya (84.8% among men), but for females the rate is lower than the national average: 67.7% in Taita-Taveta compared to a national average of 73.6% (KNBS 2007).

People in the lowlands are poorer than in the highlands. Water becomes scarcer and people are depending on food aid in the lower parts of the Mwatate catchment. A woman in Mwatate location told us that people from even lower areas come to Mwatate to beg, even though the situation is extremely bad in her location as well. There is simply no water left for people in the lowlands and they are blaming the people in the highlands for using all the water and destroying the catchment.

According to KNBS data from the year 2005-2006, only 53.2% of the population in Taita-Taveta have access to safe water, which is slightly below the national average (54.7%). Together with the whole central Africa, Kenya suffers from economic water scarcity (WWAP 2012), meaning that communities lack the necessary infrastructure to take water from rivers and aquifers. In the Taita Hills water collection is also time and energy consuming.

Irrigated agriculture is desired for among the locals. The definition for irrigation is the appropriate quantities of water applied to crops under controlled circumstances and often in a timely manner (Adams 1989). The crops are irrigated manually using horse pipes, cans or buckets. Currently, it is not allowed to irrigate with piped water and both among the people and the local governments it is discussed how to build irrigation systems for the farmers in order to boost the economy and reduce poverty.

4 Research compilation

In this chapter, the research methods and the analysis of the data are thoroughly explained. The data was collected in the Taita Hills from two catchments, Wundanyi and Mwatate within a period of two months together with the team-members of the Taitawater sub-project who work with the social aspect of the water related matters. Also, the analysis was conducted in co-operation with PhD student Johanna Hohenthal, who will include the results in this thesis in her doctoral dissertation.

4.1 Ethnography and community participation

According to Fetterman (2010), ethnography is about giving a voice to the local people that are affected by certain phenomena. It is a way of telling their stories and opinions in a local context in a scientific way (Fetterman 2010). The written reports could then act as a link between technocrats, often being the decision-makers and the local communities. Fetterman further explains that ethnography is not only a method but also a product, a written text. Typically ethnography involves direct citations and detailed descriptions. The ethnographer is interested in peoples' everyday lives and how for instance decreased water levels affect their livelihoods. This is done through observation and interviews. Fetterman (2010) explains that the ethnographer tries to catch the insider's view of the social and cultural scene.

Ethnography is closely connected to culture as an insider's view requires a cultural understanding. Weisner (1996) clarifies that ethnography puts the cultural place in the centre of the study which allow community development as the descriptions of the everyday lives can reach higher levels in the power hierarchy. The detailed descriptions make ethnography scientifically important as it can brings information on the contemporary world (Fassin 2013). Fassin also says that it questions the obvious but reveals the unknown.

Cornwall & Jewkes (1995) claim, that when local knowledge and perspective is the core of the research, participatory methods are required. Participatory methods include research *with* the locals to avoid exploiting information from the community and therefore a difference in where power lies can be noted when comparing with other methods (Cornwall, Jewkes 1995). The participants are present in the whole process and are finally given a chance to be informed of the results of the whole project through reports and seminars.

Participatory learning and action (PLA) was chosen as a guiding framework for the methods to gather data (Table 1). The idea behind PLA is to use participatory and visual tools for getting communities involved in consultation (Thomas 2004). According to Thomas, PLA is suitable for rural communities in the developing world and has in many cases proved effective in promoting active community participation in decision-making. PLA challenges the idea of top-down effect and 'one size fits all' science (Pimbert 2004) by involving non-experts that are affected by the studied phenomenon. By

involving the locals in the project the community and the environment have been indicated to benefit more from the on-going community development project. The essential part is to share knowledge through discussion, workshops, reports etc. The information is given back to the local community and not exploited. The participatory methods used in this thesis include formal and informal interviews, workshops, participatory mapping, focus groups, timeline drawing, and transect walks. Participatory mapping is a relatively new method but it has already been successfully used for mapping natural resources in a cultural landscape. Also, the data can be used for decision making, risk management, planning and problem solving (Aditya 2010, Fagerholm, N. Käyhkö 2009, Gaillard, Pangilinan 2010)

This research contributes to the project and other water related research by addressing the social aspect of the water related issues. It is an integral part of the integrated approach of the whole project and the main channel to let the locals explain their side of the story.

4.2 Political and ethical dimensions

There is a set of issues that must be taken into account when doing field work in a rural community in a developing country. First of all the timing of the fieldwork affected the results, since it was the time right before the big elections where the president, the government as well as local administrators were elected. The campaigns were running hot and people sometimes linked our interviews and workshops with these campaigns. The campaigners offered money and food for the voters and so the participants in our workshops might have linked our activities with politics. The institutional officers and big stakeholders were either reluctant to be interviewed in these political times, or then they told what the voters wanted to hear, which might not have been the truth or the actual plans.

Kongo et al. (2010) remind that researching in a rural area gives a big responsibility to the researchers when the local community lack the capacity to counter check the findings. IWRM is a relatively new concept in the Taita Hills, which means that a great deal of efforts needed to be put into the educative part of the project. The concept needs to be explained and promoted as a suitable tool for the water management in this particular rural area.

Power relations have an impact on the research and should be well measured in order to obtain truthful results and acknowledge how these power relations might have affected the responses. The most obvious difference between the respondent and the interviewer was the wealth. Parallels are drawn between skin colour, country/continent of origin and wealth. Also, the fact that the interviewers in this research team were women might have made it easier for the women to take part in the activities.

The development of the technology in geoinformatics has been rapid in the recent years, but not as rapid as the changes in participatory methods. This brings new issues to consider when using PLA methods and PGIS. The PLA methods are include the local population which leads to questions about empowerment and ownership (Chambers 2006). The most popular method, participatory mapping which was also used in this study, brought up a number of issues that were taken into account. The key issues that Chambers (2006) mentions are taking people's time, raising expectations, distribution of information, researchers working with the same people repeatedly, and causing tension or violence in the community.

The participants of the research were often interested to hear how they will benefit from participating in a workshop or being interviewed. It is not fair to give them too high expectations of the results and how much power the researcher has. It was explained many times what the research team is doing with the results and to whom they are distributed. We could not have emphasized more that we are not donors and that we did not have contact with the decision-makers and thus power to change the circumstances in the communities. Our task is to inform the decision-makers and hope for them to use the information in their future work for the communities. If the respondents are left with disappointment they are less likely to participate in another research project again.

In the beginning of the workshops certain rules were set together with all participants to assure good ethics for equal participation. The rules concerned intimidation, promotion of common interest and not individual, equality, avoidance of conflicts, constructive discussions, and good cooperation.

Both workshops lasted around seven hours, which is a considerable sacrifice from the locals' side. Therefore, lunch and snacks were offered and the travelling costs reimbursed.

Reports are written from both workshops and in addition to those, by the end of the project a bigger report of the whole Taitawater-project will be written. Ultimately, these reports will be distributed to participants, both private persons and institutions and a session organised where the locals can be informed of the results and understand the big picture. A few times we met people who said that they had taken part in interviews before and wanted to know how that research had evolved. It is of course difficult to give an answer since that might have been a completely other research team that we knew nothing about. Researchers go to the same villages if they are easily accessible to save time and the risk is that the respondents have given so many interviews that they tell what they think we want to hear. Participatory mapping might not work in a situation like this if the person has done it before and has seen what the researchers are looking for. Chambers (2006) state that locals sometimes complain about the fact that researchers do not visit the most remote villages.

Anonymity was assured by not publishing the name of the respondent, unless they wanted to give their name. The coordinates of the houses will not be published. They were only collected to locate where the water they use is coming from.

To conclude, it is essential that none of the research methods cause tension or violence in the community. According to Chambers, this can happen especially when women are involved. In the Taita Hills women are quite strong and do not have to be afraid of expressing themselves to a visitor. Some husbands had a difficult time in letting his wife respond to the questions without intervening in the discussion. We have a reason to believe that none of the women at least were put in danger because of our interviews. In the workshops the participants were women and men and they worked together, although the men had the leading role in the group activities.

4.3 Methods to gather data

The thesis integrates quantitative and qualitative methods in an integrated approach that is required in studying the development of the water resources and their management (Agnew, Woodhouse 2011, Koppen, Giordano & Butterworth 2008). Already in 1984, Whyte was discussing the importance of integrating methods in the research, and this has still not become reality in most cases. In addition to triangulation of the data, the integrating methods allow us to obtain a deeper understanding in the issue (Whyte, Whyte 1984).

Table 1 Methods and tools used in the thesis.

Method/tool	Aim
Semi-structured interviews	Understanding the context of the locals' everyday lives in terms of society, economics and politics.
Workshops/focus groups	Used to gather different stakeholders in a common discussion about the water issues.
Participatory mapping	Sketch mapping was conducted to localise water points, forests, cultivated areas, water infrastructure etc.
Time line	Timelines helped to get an insight into the local's perceptions about main drivers for change in water availability and management.
Transect walks	Validating the sketch maps with GPS-points and to obtain further information about the history and changes.
GPS-points	GPS-points and sketch maps are input to ArcGIS to produce maps.

Valuable information about the local's perception of why the water resources are declining, and a possible adaptation to the current situation, was gathered ethnographically from the interviews, transect walks, and from two workshops organised for members of various stakeholders related to water. The workshops contained group discussions, timeline drawing and participatory mapping. The aim was to create a discussion among the locals with possibly differing opinions on how the water resources should be managed. Two workshops, called Water and Livelihoods were organised in Wundanyi and Mwatate catchments. They resulted in maps from each group, audio and video recorded material from the presentations and discussions, and timelines.

Table 2 Participation in Water and livelihoods workshops groups.

Wundanyi	Participants*	Mwatate	Participants*
Kitukunyi/Wasinyi	7 (4 f/3 m)	Mwatate/Mwachabo	9 (5 m/4 f)
Wesu/Yale	10 (8 f/2 m)	Chawia/Wusi	4 (2 m/2 f)
Shate/Mbirwa	5 (3 f/2 m)	Kidaya/Ngerenyi	5 (0 f/5 m)
Mogho/Sungululu	4 (2 f/2 m)	Kishamba/Modambogho	5 (1 f/4 m)
Total	*26 (17 f/9 m)*	*Total*	*23 (8 f/15 m)*

*f=female, m=male

The data from the workshops included information about the location of water points, forests, swamps, gullies, water tanks, water pipes etc. (Fig. 4 and 5). In addition, issues were mapped by using yellow post-its that were placed on the areas, for instance where a spring has dried up or where forest has been cut. Each group presented their own maps for all participants, thus giving information not only to the research group but also to other people living in areas nearby. A mutual understanding of how the areas interact with each other was at least at some level achieved.

One of the main challenges in the whole research was our lack of knowledge of the languages spoken locally: Taita and Kiswahili. Our respondent also did not know English, apart from some cases, and therefore we needed to rely upon interpreters. The questions in the interviews were asked in English and if necessary, translated to the respondent. Usually, the background questions about the respondent could be asked in English, but most of the interviews were conducted in complete reliance on the interpreter. Possible misinterpretations must be taken into account.

4.3.1 Semi-structured interviews

In ethnographic research, interviewing is along with participant observation a primary method in understanding the context of the locals' everyday lives in terms of society, economics and politics (Crang, Cook 2007). Crang and Cook argue that interviewing cannot be treated as a separate method as such, because conversation is always involved in social research. All interviews were audio-recorded and transcribed right after the conversation.

The interviews with the water users in their households, hotels or hospitals were semi-structured (App. 1). According to the Kenya National Bureau of Statistics (KNBS 2007) a household is defined as a fenced or unfenced compound where a person or a group lives and share a common source of food and income. The persons are all answerable to the same household head that makes the everyday decisions in the household. His or her authority should be acknowledged by the other household members. In the report by NAFRI, NAFES, NUOL (2005) a household is defined by a group of people, usually based on kinship, who eat together and typically engage in joint economic activity.

The aim was to interview the local water users in Wundanyi and Mwatate catchments. The informants were selected from aerial photographs to cover the whole catchment.

Table 3 In total 82 interviews were conducted in the two catchments. Respondents were aged between 18 and around 75. Some of the older respondents were not sure about their age.

Age group	Wundanyi	Mwatate	
18-30	7	6	
31-40	11	8	
41-50	15	6	
51-60	6	5	
61-70	8	5	
71-80	3	2	**Total**
Total	50	32	**82**

Table 4 Gender division of the interviews.

Sex	Wundanyi	Mwatate
Female	25	20
Male	25	12
Total	**50**	**32**

Table 5 Stakeholders represented in the interviews. The institution is the Wundanyi prison located in the centre of the village. The prison is a major water user.

Group	Wundanyi	Mwatate
Farmers	36	21
Town dweller	4	5
Hotel	1	2
Entrepreneurs	6	2
Hospital	2	2
Institution	1	0
Total	**50**	**32**

Before beginning the interviews with the locals the research team made sure that it was appropriate to visit the households and include locals in our research. The village chiefs granted us permission for research in the area, if we made sure that our project reports will be available also for them. Our research team and our task were also announced on the local radio to inform the people. That announcement had apparently reached many, since many of the families said they had been expecting us when we arrived. We were always warmly welcomed and sometimes even offered something to drink and eat. People also recognised our research assistant who is local and explained in Taita our reasons to interview.

Most of the interviewees are farmers, because they represent the clear majority of the whole population in the study area. Town dwellers are those who are renting a room or an apartment in the rural centres to work there. Small entrepreneurs are shop keepers, carpenters and a few pump attendants working at a petrol station. The carpenters were asked mostly about the wood they use in their furniture, since they are not using any water for their work. The aim was to have an equal gender division among the informants (Table 4), but in Mwatate the men were harder to catch at home since they were mostly working outside the home, while in Wundanyi they also did farming next to their homes. The centre of Mwatate is much dryer, compared to Wundanyi and the fields are rarely next to the house.

Only two people refused to be interviewed, because one had a new-born baby that she had to take care of by herself and the other one had just returned from a funeral and moved to another household. Mostly, the interviewees were easy to find as nearly every person asked was willing to sit down and talk to us. There were of course some differences in how much they talked and expressed themselves. Only one interview was excluded from the data as the respondent practically did not answer any of the questions. One respondent suffered from a mental disorder and had a very good imagination. However, this interview could be included in the analysis as the person was accompanied by another family member who helped to censor the information together with some common sense from the researchers' side, before further analysis.

It was essential to have a local research assistant who translated the questions to Kiswahili or Taita. Sometimes the replies were long in Taita and we were not able to understand. The reply was then translated to only a few words, resulting in some minor losses of information. On the other hand, when the interviewees spoke their mother tongue they were able to express themselves better and spoke more freely. If they spoke English, no information was lost from what was said, but some things might have been unsaid because of speaking another language than the mother tongue.

Some of the questions were in a questionnaire style so that some statistics could be calculated. Other questions were open and gave room for discussion. The order of the questions sometimes varied, depending on the type of respondent (farmer, hotel manager, nurse etc.). Semi-structured interviews were useful for investigating perceptions on the decreasing water resources. According to Longhurst, the semi-

structured interviews significantly contribute to geographic research, *'especially now that discussions about meaning, identity, subjectivity, politics, knowledge, power and representation are high on many geographers' agendas'.* (Longhurst 2010, pp 113).

The interviews concerned water consumption and resources, natural hazards, waste water, possible health problems, cultural traditions that affect their behaviour, and opinions about the water management. These questions were planned in such a way that the answers would give information on how this knowledge can be used in developing sustainable management of water resources. All interviews were audio recorded so that details could be checked afterwards (Longhurst 2010). The interview session started off with informal chatting and asking permission for recording the interview. The first questions were about the respondent to create a background that the rest of the questions could be mirrored against. In many cases these question could be understood and answered to in English. After this, the conversation moved on to water use, water related hazards, water management and land use. The last questions were so called timeline questions about the witnessed changes in the area concerning the discussed themes. The most difficult question to answer seemed to be "Do you think you are richer or poorer than your parents/grand-parents?" and "How do you see your future?". These were the last two questions and often the interview ended by discussing the concept of wealth.

The interviews were supposed to be individual but what often happened was that other family members or neighbours suddenly joined the conversation. Crang and Cook (2007) are pointing out that this is almost bound to happen when interviews are conducted in peoples' homes where other persons easily can drop in and become curious of what is going on. Sometimes the interview felt more like a focus group discussion, which in fact gave more information of the issues.

The interviews were the primary method to gather information on how locals perceive the water availability and accessibility and how they think that affects their livelihoods. Through the interviews also the explanations to the environmental changes were examined.

4.3.2 Workshops and the focus groups

Two workshops were organised in the two catchments of study: Mwatate and Wundanyi. The workshops allowed the researchers to see group dynamics and to gather

information from people that might have not been available for the individual interviews.

The participants were divided into groups formed according to the home village and together they created a map of their home area, with emphasis on water points, rivers and forests. The collective conversations allowed further elaboration on the same themes as in the interviews (Denzin, Lincoln 2011). The participatory mapping and timeline drawing are further explained in the following chapter. Simultaneously with the activities there were lively discussions on the issues related to reducing water levels. The groups consisted of people from the same village but did not necessarily represent the same stakeholder. There were participants from forest groups, water projects, water resource users' associations (WRUA), and farmers' groups. The idea was to bring together these people in order to understand what is affecting the water resources in the catchments and how a solution for the problems could be found so that it is beneficial for everyone. Each group had a facilitator and an interpreter. A chairman and a secretary were elected in each group. Five groups were created in Wundanyi (Fig. 4):

1. Kishenyi dam/Sangenyi
2. Wesu/Iyale
3. Sungululu/Mogho
4. Kitukunyi/Wasinyi
5. Birwa/Shate

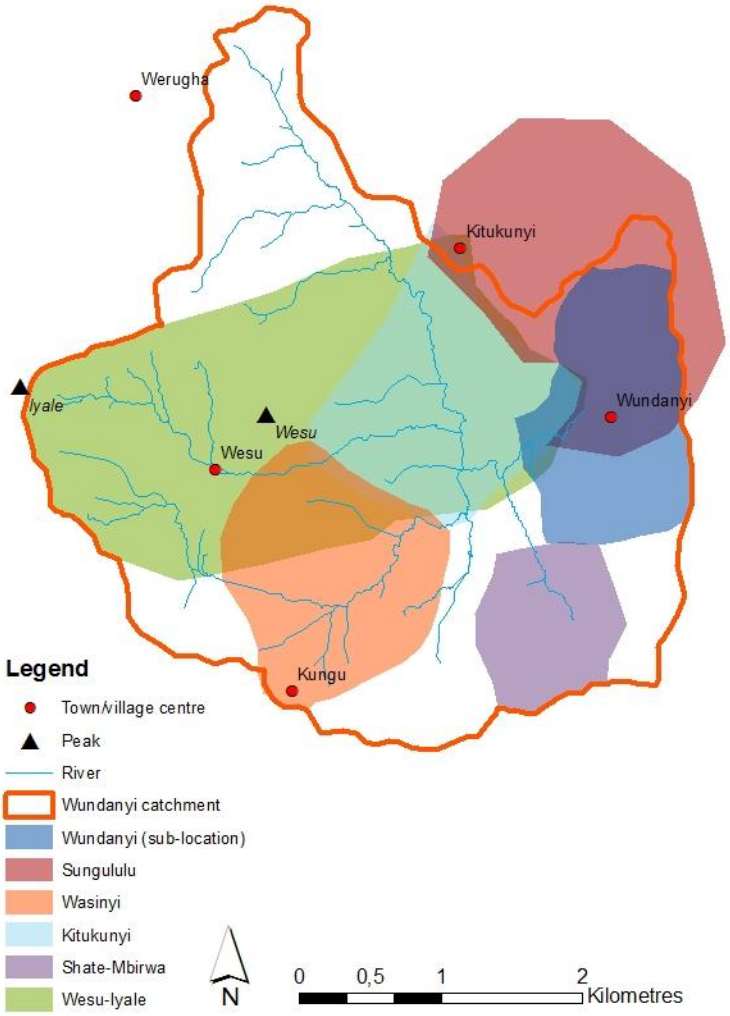

Figure 4 The sub-locations represented in the Water and Livelihoods workshop held in Wundanyi. In the results the livelihood assets follow the same division of regions.

Four groups were created in Mwatate, but in the analysis they were combined into three groups (Fig. 5):

1. Mwatate/Mwachabo
2. Kidaya/Ngerenyi
3. Chawia/Wusi
4. Kishamba/Modambogho

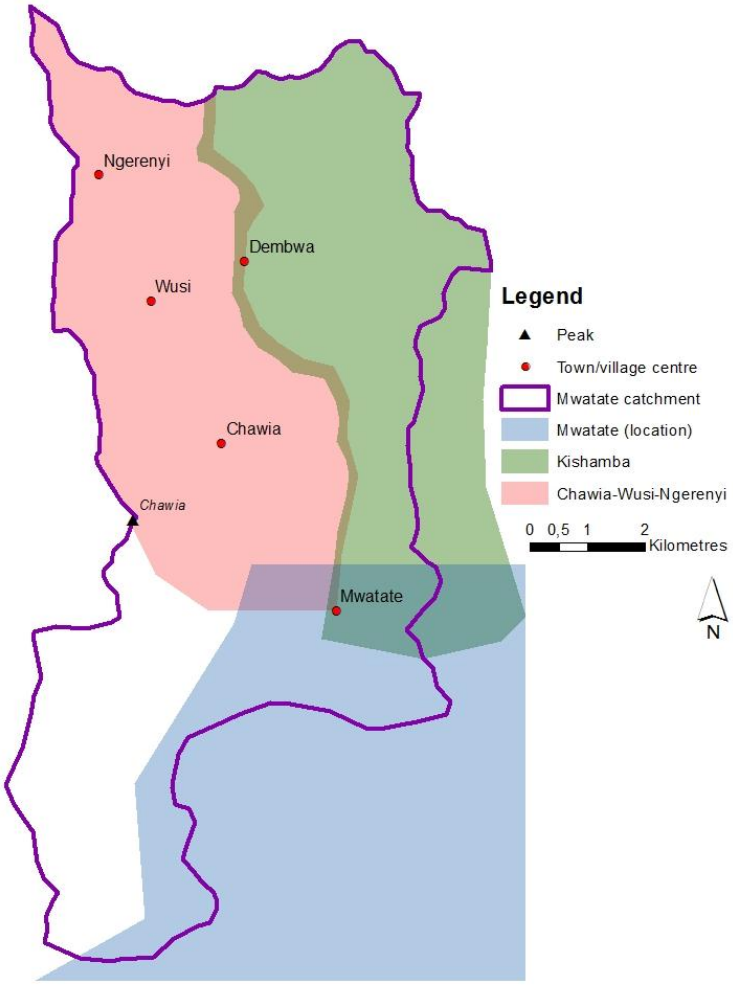

Figure 5 The locations represented in the Water and Livelihoods workshop held in Mwatate. Chawia, Wusi and Ngerenyi were combined in the analysis.

One person from each group presented the map and the timeline they had created together, for all participants in the workshop. Through these presentations participants were able to learn from each other and discuss. All presentations were audio and video recorded and if necessary, translated to the researchers who did not understand Taita or Kiswahili.

In the end of the workshop the activities were summarised in a final debate. Possible solutions for the water issues were lively discussed. It is beneficial for the community to share what one has learned from the activities and getting to know who lives in the next village and what their interests are. The workshop created a platform for the water users

to understand each other's needs and interests. The focus group discussions, the presentations, and the final debate provided deeper understanding in the locals' perception on why water resources are decreasing and why they explain the environmental changes in a certain way. Also, the focus groups helped to grasp the influence on their livelihoods.

Workshop reports were written to be distributed a first-hand information package of our findings to the local communities.

4.3.3 Participatory mapping

Participatory mapping, which is used in this research, is based on the concept of participatory learning and action (PLA). Participatory mapping not only identifies the places where these resources can be found, but also how they are used traditionally and how the use of them might have changed over the years. According to Fagerholm and Käyhkö (2009), social values are attached to landscape and these values can be studied geographically. Participatory mapping and PGIS enable us to study the cultural landscape and can for instance help to reduce natural hazards. Gaillard (2010) reveals that the method is fun for the participants and very useful especially among the youth. It makes abstract concepts like hazard, vulnerability and risk more concrete when these are marked with different colours on a map.

The reason why participatory methods were chosen is that they are crucial in research that requires integrated approaches (Lilja, Bellon 2008), such as understanding why water resources are less available to the locals now compared to the past. Potschin and Haines-Young emphasise the importance of interdisciplinary research in what they call sustainable science (Potschin, Haines-Young 2006). Interaction between researchers with a different background and methods is essential when studying the cultural landscape that involves social values, policies, politics, resources, and land use etc. One method of studying this is by using participatory mapping. In our study case the participants were mainly farmers, and the environmental and the socio-economic conditions vary widely among them, which justifies the need of participatory methods. Lilja and Bellon (2008) emphasise in their literature review about participatory research, that the participatory methods often are used after failure of nature resource management techniques to resource-poor farmers.

Participatory mapping does not require sophisticated tools or energy grid to run. As can be seen in figures 6−14, only a blank sheet of paper was used with markers in different colours to produce neighbourhood maps of areas that are seldom mapped in more formal way (Cadag, Gaillard 2012). This allows people with all kinds of skills and practical expertise to participate. Also, post-its were used to indicate the issues related to water resources and attach them on the sketch maps according to where these phenomena are taking place. Pokhrel (2011) argues that rural people often have more detailed mental maps compared to the urban people at least in Nepal where Pokhrel's case study took place. Drawing a map of the home area seems to work better in rural areas, because in general, people have lived their whole life in the same place.

The advantages with sketch mapping according to Cadag and Gaillard (2012) are that it is participatory, permanent and cheap. It is easy to set up and can contain large semiology. The participants can come up with their own legend for the map and are not restricted to follow somebody else's way of map drawing. The drawback with sketch mapping is that it is difficult to correct and adjust. Also, it is not scaled or geo-referenced. It is a challenge to convert this data into GIS-compatible data, but sketch mapping is the best alternative to gather civil society's inputs from non-technical participants.

The first activity in the workshop was participatory mapping. Each group had again a blank sheet of paper and markers in different colours. The secretary in each group drew the map according to what the other group members discussed. They began by drawing the roads, rivers, and main buildings. After that, indigenous and exotic forests, springs, dams, cultivated areas, fish ponds, water tanks and pipes were marked.

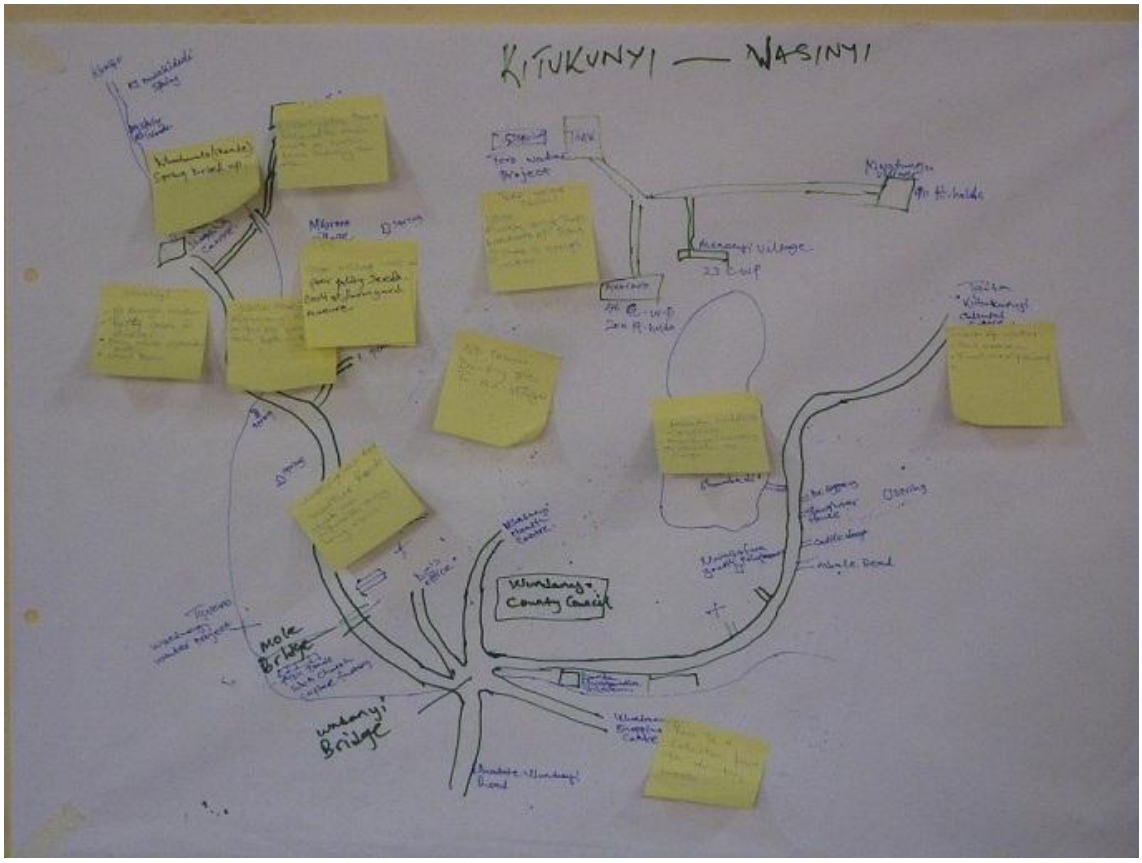

Figure 6 Sketch map by Kitukunyi – Wasinyi group in the Water and Livelihood workshop in Wundanyi.

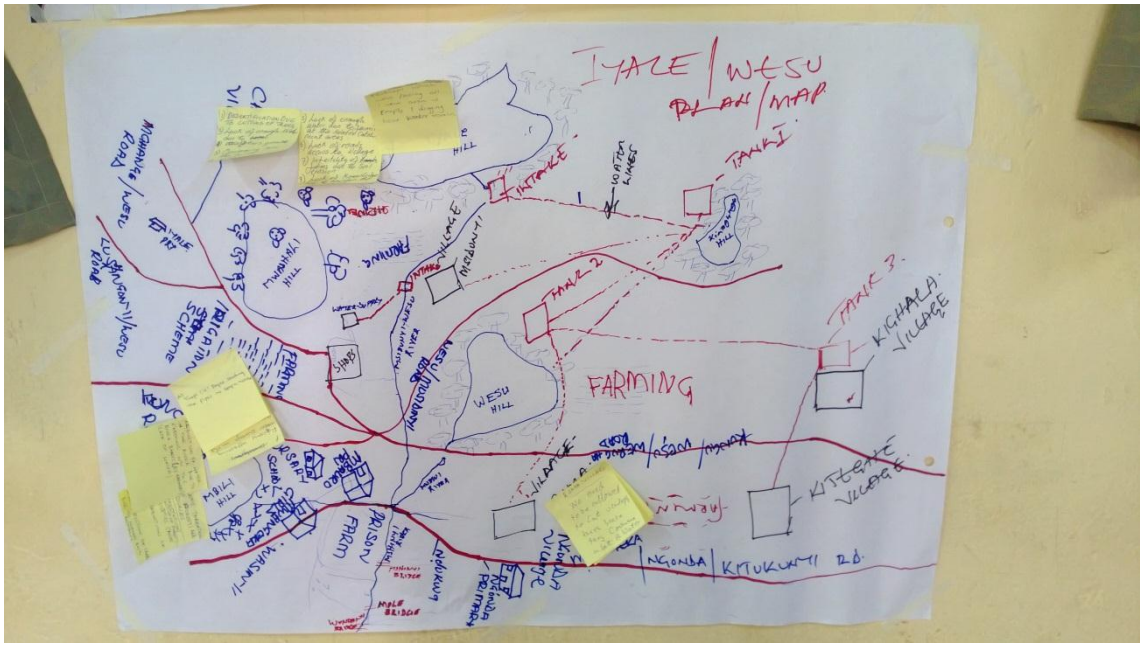

Figure 7 Sketch map by Iyale – Wesu group in the Water and Livelihood workshop in Wundanyi.

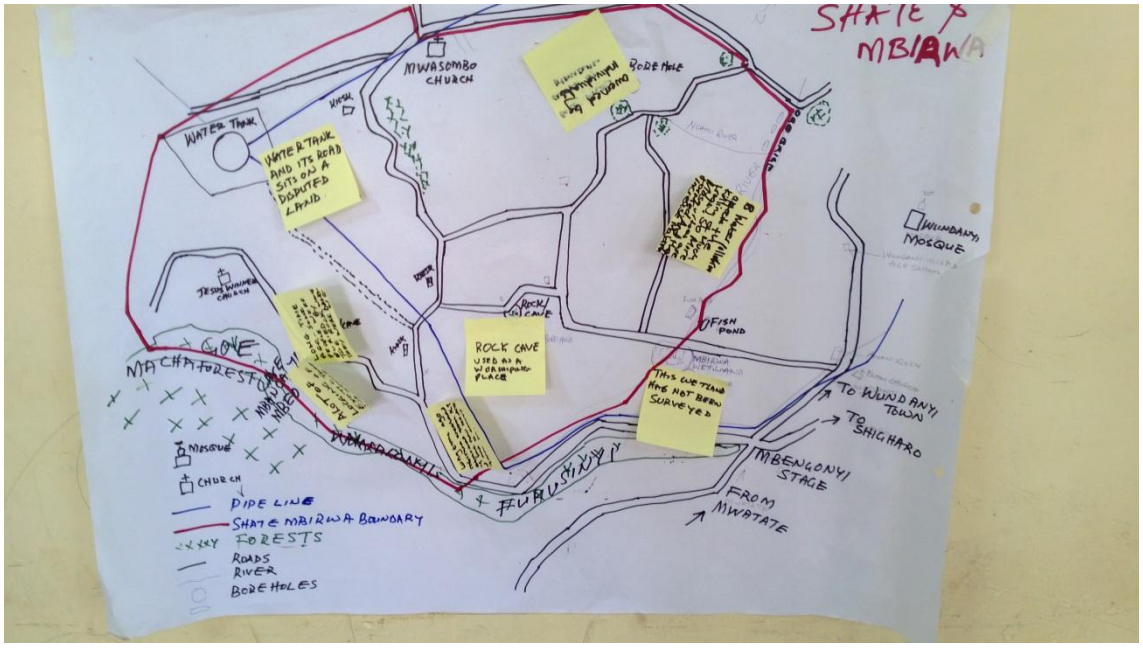

Figure 8 Sketch map y Shate – Mbirwa group in the Water and Livelihood workshop in Wundanyi.

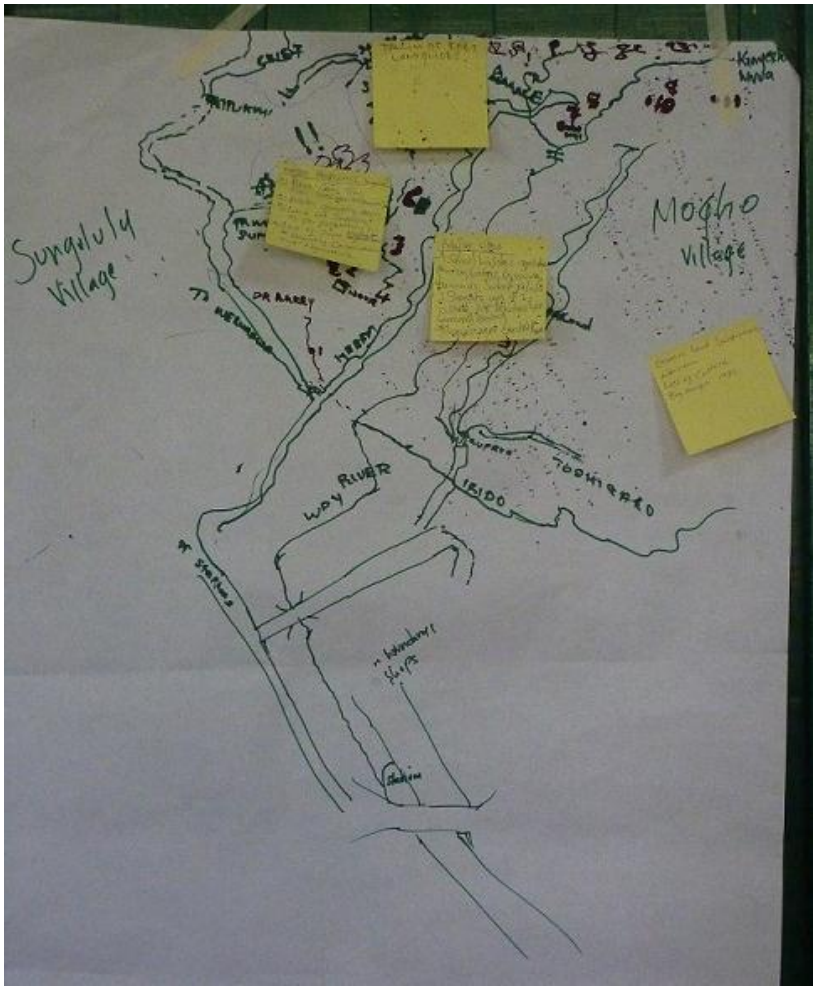

Figure 9 Sketch map by Sungululu – Mogho group in the Water and Livelihood workshop in Wundanyi.

Figure 10 Sketch map by Kishenyi dam – Sangenyi group in the Water and Livelihood workshop in Wundanyi.

Figure 11 Sketch map by Mwatate – Mwachabo group in in the Water and Livelihood workshop in Mwatate.

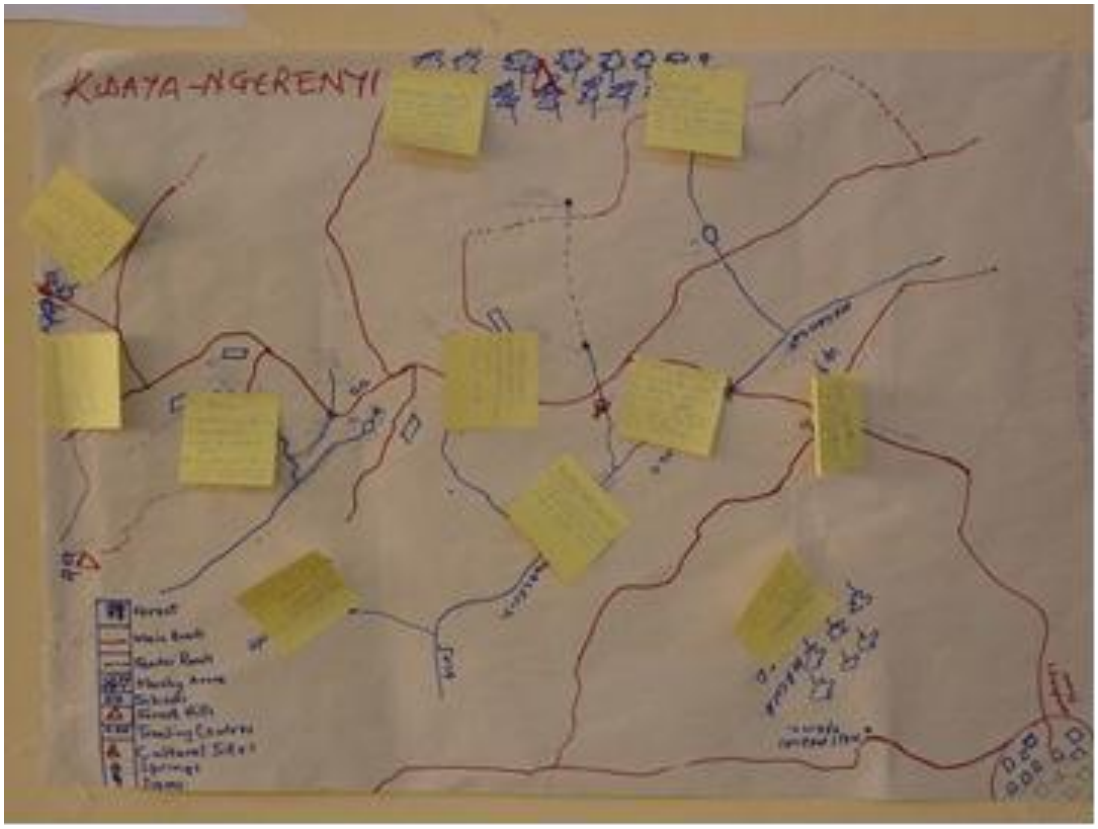

Figure 12 Sketch map by Kidaya – Ngerenyi group in the Water and Livelihood workshop in Mwatate.

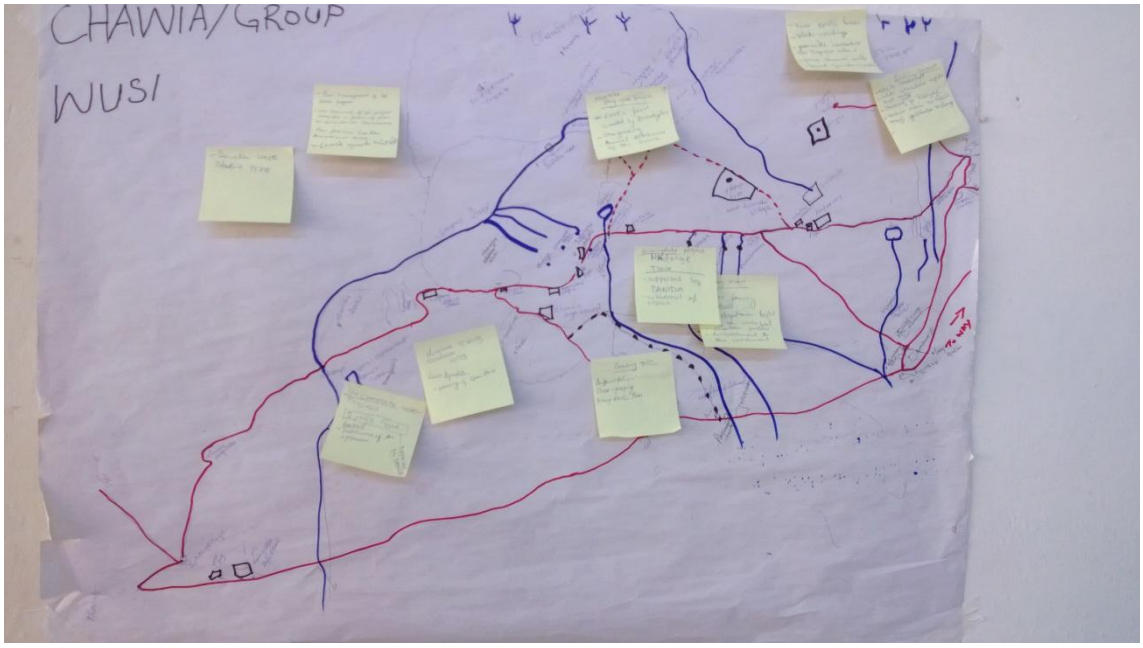

Figure 13 Sketch map by Chawia – Wusi group in the Water and Livelihood workshop in Mwatate.

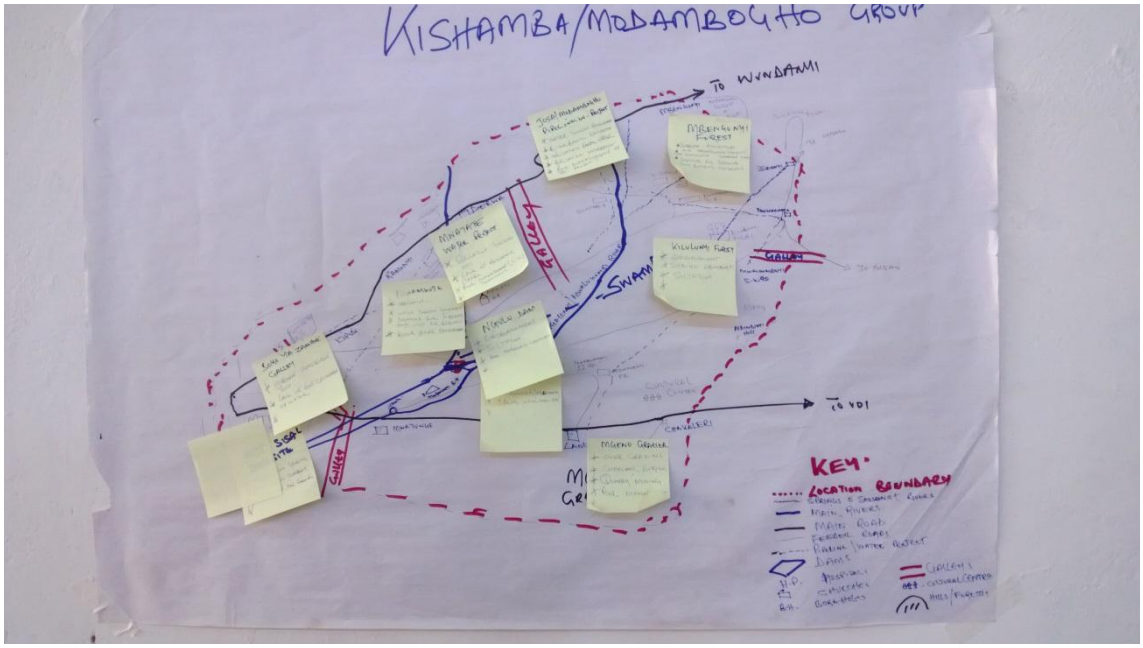

Figure 14 Sketch map by Kishamba – Modambogho group in the Water and Livelihood workshop in Mwatate.

In figure 15, the participatory mapping process in decision-making is visualised as a combination of the top-down and bottom-up processes. The communication between the government officials and the community members is crucial for successful natural management plans and their implementation. This is achieved when digitalising the

sketch maps with PGIS, which is further explained in the analysing methods, more specifically in chapter 4.3.5 (PGIS). The community data should be part of the official spatial plans (Aditya 2010).

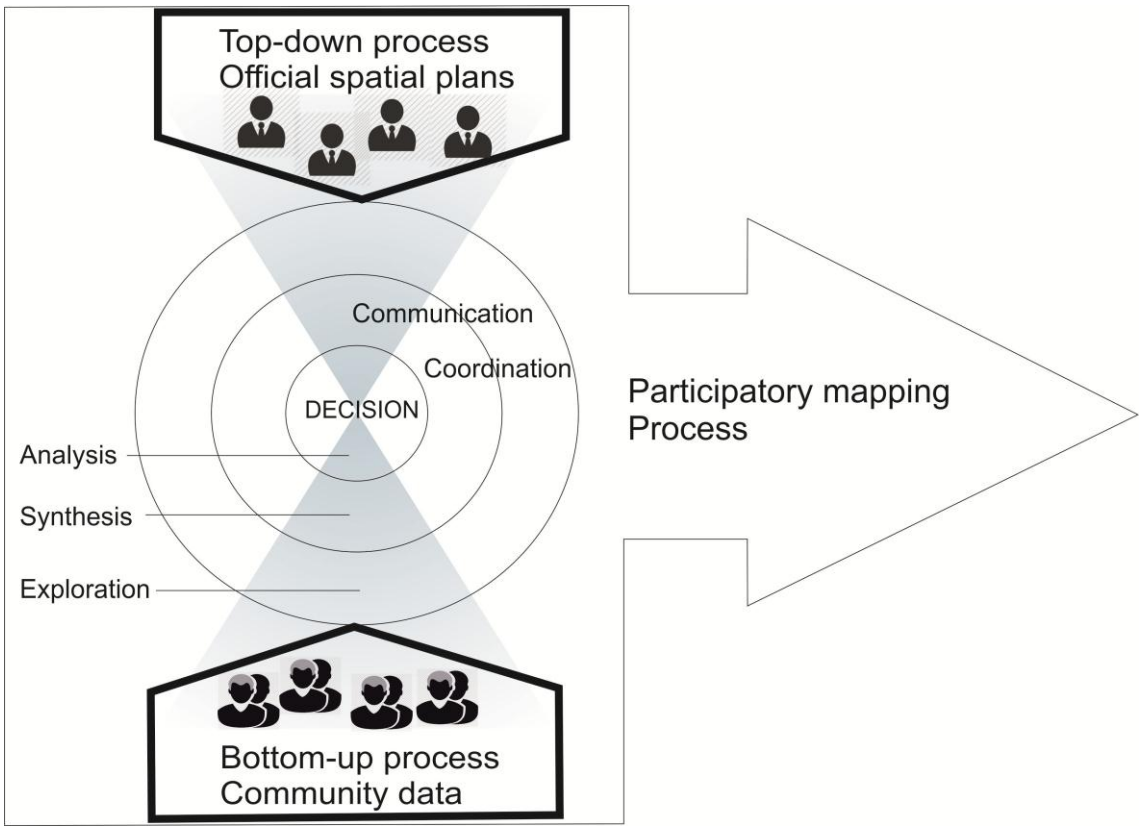

Figure 15 The process of participatory mapping in decision-making (Aditya 2010).

The participatory mapping contributed to the stories heard in the interviews and group discussions. The sketch maps are the data that can be analysed with PGIS and thus answer the last research question on how local knowledge can support decision-making through PGIS.

4.3.4 Timelines

Another activity in the workshop was to draw a timeline with the key events affecting the waters in the Taita Hills on a time span from 1900 up to present (Fig. 16). Also, positive and negative impacts of these events were indicated. The aim of this activity was to understand the perceptions of the occurred changes in land use and water resources. People remember things differently and this exercise is a way of creating the big picture of the events that generated certain issues.

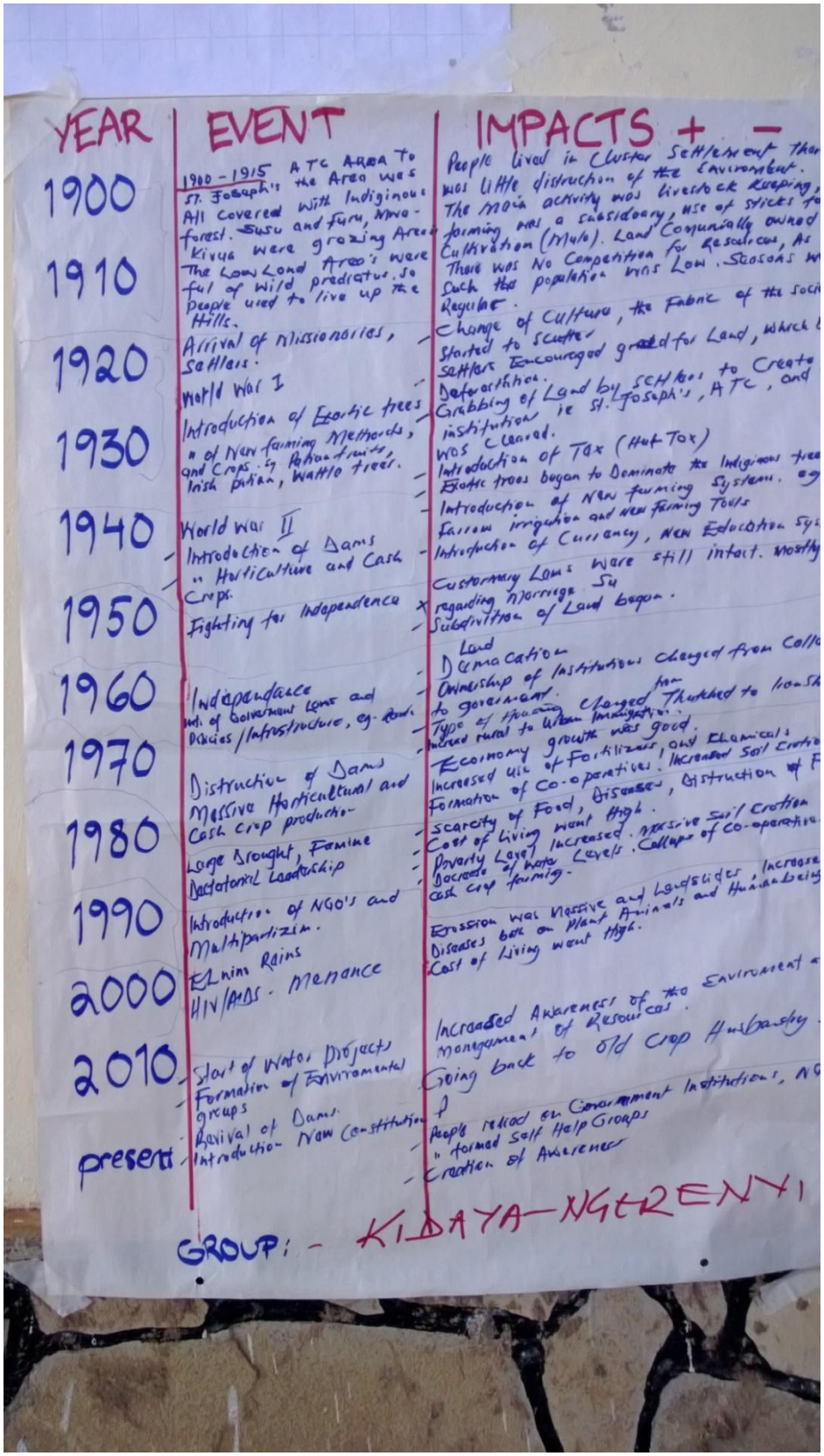

Figure 16 An example of a timeline made by the Kidaya-Ngerenyi group in the Mwatate workshop.

Timelines are helpful in constructing a chronological order of the events. This is further explained in the analysis of the historical review. It is also a way for the participants to cogitate which events have had the most impact on the water resources. It is difficult to remember in which order the events came and therefore it is preferable to discuss it with other people.

4.3.5 Transect walk

Transect walks involve walking through the study area with a local guide. Transect walks include observing, asking questions and listening (Thomas 2004). In this case the transect walks took us through the catchments, focusing on water points and other important points that had been marked during the participatory mapping sessions. Transect walks have been widely used in water and land use related research and projects (Cools, De Pauw & Deckers 2003, McCusker, Weiner 2003). Transect walks are part of the participatory methods in PLA and contribute to the information on the surroundings.

Transect walks were in this case a complementary method in order to validate the maps created by the locals in the participatory mapping sessions. We were able to get the coordinates of the places mentioned in the participatory mapping session by carrying a GPS-device on the tour. Also, additional data of the points was gained through short informal interviews with people we met on the way as well as through observation. There was always at least one local person with us who knew the area well, and who was able to contribute by telling his story of why and how the water resources have been declining during his lifetime.

Community maps made by the participants of the workshops mainly guided the research team through the transect walk. Additionally, knowledgeable locals explained the issues and changes along the transect walk. The data from the transect walks is a matrix where notes from specific points. The data is organised according to location, ecology, landscape, artefacts, use condition and problems.

Table 6 shows the notes taken from the two transect walks conducted in the Wundanyi catchment. Two other transect walks were also done in the Mwatate catchment, more specifically in Kishamba and in Chawia (Table 7). The table 7 from the third and fourth transect walks has the columns and rows in the opposite order compared to table 6. This had to be done to make the information GIS compatible, also for table 6.

The transect walks included points from bridges where the river and surroundings was visible, a coffee factory, water treatment plants, water installations, and fish ponds. The main problems were that rivers looked eutrophicated and that the maintenance of the installations is inadequate. Nutrients get washed into the river from farms, fish ponds, and the coffee factory. It remains unclear whether the coffee factory in Wundanyi has stopped using chemicals. The people at the coffee factory claimed that people want the coffee beans to be washed with river water because it tastes better. However, the river water is not clean according to the people that were interviewed higher up in the Wundanyi catchment. A local man told us that coffee farming stopped in 2000, but some small scale activities still going on (25 tons/ year). 6000 families used to rely on coffee farming, today only about 2000. Young people are no longer interested in coffee farming, and are now planting Miraa (khatt) for fast money. Politics have affected the price of coffee and there is corruption in the coffee board. The coffee farm gains 58 Ksh per kg. Many dams are to no use nowadays due to a low water level. Also, many water tanks that provide water to villages through gravity, are not working properly since the water pressure is not high enough. The water treatment plant in Wundanyi was built by the Ministry of Water. The Water Resource Management Authority (WRMA) is supposed to monitor the water quality. They have the discharge data but do not give it out. WRMA is supposed to manage the river banks, but the challenge is land ownership. The pumping from natural water sources should have a permit from WRMA. The asset holder for water infrastructure is with Tavevo, on behalf of the Government. The government was supposed to develop the infrastructure and then hand it to Tavevo.

In the Mwatate catchment the water in the collection points is muddy, especially during heavy rains. Sand harvesting destroys the river banks. Many water points are seasonal. During the dry season, not many of the rivers have water flowing in them. There are, however a few well protected water sources that are fenced and provide clean water.

Table 6 Transect Walk from Wundanyi to Wesu 4.2.2013 and 15.2.2013.

	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6	Point 7	Point 8	Point 9
Altitude (m)	1381	1383	1392	1417	1486	1540	1584	1606	1621
GPS	X: 429031 Y: 9623940	X: 428942 Y: 9623970	X: 428517 Y: 9623711	X: 428437 Y: 9624266	X: 427707 Y: 9623942	X: 427544 Y: 9623714	X: 427364 Y: 9623569	X: 427211 Y: 9623514	X: 427115 Y: 9623500
Location	Wundanyi Bridge	Coffee Factory	Wundanyi Pump house/bridge	Wundanyi Water Treatment Plant	Ng'onda Bridge	Diverted stream – along the road from Wundanyi to Wesu	Toro water project tap	Toro water project tank	Toro water project tapped source – near Wesu village
Ecology	River bank; Vetiva grass, Tetonia (used as manure and natural pesticide), banana/ plantain and trees cultivated on river banks	Field and bushes, few coffee plants. Next to the road.	Minor farming. Weeds near the river banks.	Grass, maize fields around, trees (exotic?)	Rock based river (stream) bed; trees around	Field on the right side of the road	Path, fields	Palm trees around, bush	Bush
Landscape	River in a valley	Valley	Crossing of three streams; steep slope on the southern side of river. Valley.	Slope	Slope	Slope	Slope	Level terrace on a slope	Level terrace on a slope
Artefacts	Bridge; Junction of roads to Mwatate, Wundanyi,	Coffee factory buildings; road	Bridge and diversion structure in river for getting water	Water treatment plant buildings and structures. Water	Bridge (reconstructed by CDF fund after destroyed by flood); road	Diversion structure	House near path	Water tank (made from cement) ; near path	Cement structure, and pipe connected to tank and other pipe

	Mbale, Government Hill and Wesu		to fishponds; road to Wesu; Pipe taking water to 3 tanks of 200 m^3. Pumphouse for sourcing water. Structure for silt capture. Steel hut for workers.	Laboratory. Tarmac road. Steel huts for workers.					from which water flows freely
Use	Rain-fed cultivation; Heavy traffic on roads	Field used for processing coffee beans (washing, treating, drying). Used to be a coffee farm.	River captivation as a water source for piped water. Pumps take water to treatment plant at 500 m distance (on northern side). Farmers who do horticulture pump water from the river.	Water treatment and purification. Pumping water to consumers.	Crossing the river	Irrigation channel	No water	Water reservoir	Water collection; Water source for tank
Condition/ Problems/ Plans	River banks full of weeds growing into river that block the flow of the river. Prison has released	After washing the coffee, the water is dumped to the shambas and to the river. Chemicals used to treat	This year water level is lower than usual. The machines in pump house are old. The pump house	Built by the Ministry of Water and Irrigation (MoWI). There is a sedimentation pool that is	Water level is low in the stream. Floods. Three years ago 1 – 3 drunken men were washed away by the	Diversion of water from the main stream reduces the water level, which possibly affects water users	No water	People burn down indigenous palm trees because they try to get rid off monkeys.	People don't pay for water flowing from the source because they conserve the area; but others pay for

	sewage into the river and still does sometimes. There have been a few cases of leakages from the petrol station.	coffee beans (zumithaion + fendrothion) are also washed to the river. They try to recycle the water and they have stopped using chemicals (?). They also use piped water to clean the beans.	was built in 1989 at this location because the 3 streams connect there. During rains the river floods, which stops the pressure of water for some time. There are issues with electricity cuts. There is siltation of the river which reduces the efficiency of the pump machines. The crabs dig the river banks.	exposed to direct sunlight. The water is filtered through different sizes of soil particles (sand). From there water goes to the final tank where it is chlorinated.. The laboratory monitors the pH and Cl- levels twice a day, but does not measure bacteria. The lab has good equipment but doesn't have qualified staff. Lab was established by DANIDA.	flooding river and so the bridge was destroyed. The CDF funded the new bridge.	downstream.			water served by the project. Water is clear.

Table 6 continues.

	Point 10	Point 11	Point 12	Point 13	Point 14	Point 15	Point 16	Point 17	Point 18
Altitude (m)	1666	1414	1415	1422	1422	1424	1650	1655	1659
GPS	X: 426385 Y: 9623627	x: 428719 y: 9623647	x: 428596 y: 9623730	x: 428383 y: 9623742	x: 428520 y: 9623881	x: 428438 y: 9623844	x: 426504 y: 9623794	x: 426876 y: 9623660	x: 426927 y: 9623653
Location	Wesu Water Treatment Plant	Wundanyi, field	Wundanyi fish ponds	Wundanyi M.O.H.A. fish ponds	Wundanyi fish ponds next to prison farm	Prison farm	Wesu, road over river	Wesu dam, Mwangage moda ("bush baby river")	Wesu, trench
Ecology	Grass, flowers, some trees	Cultivated with maize, cassava, sukuma wiki and sugar cane. Field surrounded by bamboos and grevilleas	Bamboo, indigenous trees, grass, few banana trees	Cultivated land with bananas and sugar cane. Surrounded by grass and grevillea	Surrounded by cultivated land with sukuma wiki, cabbage, tomato, banana, tetonia, passion fruit	Cultivated with bananas and sukuma wiki. Grevillea around	Cultivated river banks with bananas, grass and trumpet flowers, terraces	Indigenous trees like ficus, Prunus Africana and ginger	Indigenous trees like ficus, Prunus Africana and ginger
Landscape	Level terrace on a slope	river valley	river valley	river valley	river valley	river valley	slope	river valley	slope
Artefacts	Water treatment structures: circular tanks for sedimentation ; buildings	-	4 fish ponds owned by the Wundanyi fish pond group	2 fenced fish ponds owned by the Department of Probation Service, Aquaculture Project Wundanyi; road to Wesu	4 fish ponds, warehouse	Ditches crossing the farm, big and small road to Wesu	road, big pipe under the road where water flows	old dam structures, not working anymore	Dug trench, traditional way to irrigate with the hosepipe from the channel
Use	Water	farming	fish farming	fish farming	fish farming,	farming for the	farming,	cows take	irrigation

	treatment and pumping				farming, storage of fish food	prisoners	traffic	water, no homestead nearby, no human use	
Condition/Problems/Plans	Built in 1950's by the British. Was intended to supply the higher areas of the Taita Hills. Originally only sourced for Wundanyi. The treatment process is the same as in Wundanyi, although the structures are different. There is no laboratory, but still the residual chlorine is tested.	No terraces, possible erosion	Water looks dirty and green, uses river water, possible pollution, eutrophication	Water looks dirty and green, uses river water, possible pollution, eutrophication	Water is clear since the fish ponds were established recently, but probably fish pond pollution	Cultivation near the stream banks, flooding during heavy rains	Erosion, vegetation is blocking the water	Water level has declined so the dam does not work anymore. Nearby the soak pits of the Wesu hospital. These possibly leak into the river, because the base rock is close to the surface and infiltration is not possible.	Near hospital soak pit, plans to lay pipes and pump water to taps, declines water level downstream

Table 6 continues.

	Point 19	Point 20	Point 21	Point 22	Point 23
Altitude (m)	1520	1440	1610	1860	?
GPS	x: 428593 y: 9622482	x: 429017 y: 9622905	x: 426595 y: 9623032	x: 426360 y: 9624762	x: 426900 y: 9624159
Location	Shate/Mbirwa	Mbirwa wetland	Irrigation scheme in Wesu ex-dam	Kiangungu hill, tank 1	Wesu water tank (2)
Ecology	Cultivated with maize. Tetonia and some trees.	Cultivated with sugarcane, bananas, sorghum, maize, cassava. Some gravilleas, mango trees.	Cultivated with maize, cassava, sukuma wiki, sugar cane, french beans and vegetables.	On the side of the bare hill acasia, grevillea,pines and a few indigenous trees. The rock is covered likens.	Palmtrees, grevillea, pines, cypress, mixed forest.
Landscape	On a slope of the Mwasha forest highlands towards North	Valley, river starts from the wetland.	Wundanyi river. And an old dam. River valley. Field surrounded by terraces on the slopes.	Top of the Kiangungu hill.	On the Wesu hill
Artefacts	Ministry water tank, fenced, grave on the other side of the of it.	Well and pipe built by ABD/DASS in 2009. 2 fishponds nearby.	Road, bridge, pipes and a shack. Irrigation channels between shambas.	Tanks and water distributor with pipes.	Water tank and pipes. Water come from tank 1 by gravitation force and continues to villages further down. Project is funded by CDF.
Use	Water is distributed by gravity to lower areas.	Cultivation.	Private owners for farming.	Water distribution to villages around for free. Intake to the tank is from Iyale.	Water distribution

Condition/Problems /Plans	Conflicts regarding land ownership. Land was taken from the community but they are not served with the water.	The wetland is not surveilled and therefore it cannot be conserved. People claim land for farming.	Dam has dried u People fetch and divert water from the river for irrigation. The shambas do not look dry. Agro-chemicals from the shambas flow to te river.	Pipe was leaking and lots of water wasted. Poor maintenance. The tanks is managed by Iyale/Msidunyi water project. The drunken men of the project came to fix the leakage while we were coming down	No water in the tank due to leakage in the pipe next to tank 1. 3rd week without water. Group of drunken community members came to fix the problem. Free water but community pays for maintenance. Sometimes hard to collect these funds.

Table 7 Transect in the Mwatate catchment – Kishamba (23.2.2013) and Chawia (26.2.2013).

Point	Altitude	Coordinates	Area	Ecology / Landscape	Artefacts	Use	Condition/Problems and Plans
1. Mrumenyi Water Point		X: 429559 Y: 9622245	Mwacharo / Mbengonyi	On a slope, there are cliffs around. Some indigenous trees (”palm tree”). Fallow field,no terraces.The spring is coming from Mwachora forest.	Broken pipe from spring leading to concrete tank.	Water source	There was water, which was quite clear. People at the spring said water level had gone down. The spring used to be fenced by the water project, but the locals had taken it away. The pipe had been broken. The project was funded by CDF.
2. Mgalenyi River (WRUA secret. With us from until point 11.)		X: 430400 Y: 9620542	Kishamba – near Dawson Mwanyumba Health Center	Indigenous trees (Ficus) grows on the rocks. The river bed was rocky. The river comes from Kidaya/Ngerenyi (Josa river) and flows to the Ngulu dam/wetland. On the other side of bridge, there were bushes/weeds growing along river bank; grevillea and tetonia nearby. Level terrace.	Bridge and road. Health Center nearby.	Scooping sand. River cross point.	Water level was low. Water was clean. It is used for drinking. During March/April rains the river flows over the bridge. People cultivate upstream and to the river banks. The river flow was partly blocked on the other side by dead plants. The community doesn't clean it up because government is responsible for road maintenance.
3. Nbumbuni water point		X: 430523 Y: 9621086	Kishamba – Nbumbuni village	On a gentle slope. Water comes from Mwachora rock. Cultivation of cassava, maize, french beans, banana, papaya around the water point. Right next to the point there	Houses in nearby shambas. A flume for water (”kouru”) made from bamboo or banana trunk.	Water source for around 150 people and the school when the tap doesn't have water. Some people use it for irrigating french beans.	Water was flowing, but it was a bit salty, but clean. Some boil it, but nobody has got health problems. The water gets warm in the morning. The WRUA man said that

				was Ficus, further away Grevillea and Tetonia. There used to be a fishpond nearby.			if a cement structure is put, the source will dry up. Chemicals are used for french bean cultivation.
4. Kilulunyi Shrine		X: 431524 Y: 9619823	Ngulu Valley (Iparenyi Wetland)	The shrine is ¼ acres. There are indigenous, old, trees. Monkeys are inside. Around the shrine there are people's fields (maize etc.) Grevilleas and banana trees around.	Around the shrine there are ”monkey patrol” constructions (wooden seats/ huts)	Some still think it's sacred or forbidden place to go into. Others fetch firewood from there.	The fighi is very small. It used to be 4 acres. People have encroached the land around the fighi for cultivation, and claim it's theirs. The whole valley used to be forest and wetland, there used to be leopards. The WRUA planned to ask land surveyors to come so that they could reclaim the land and start rehabilitating the forest. The fighi used to be managed by community.
5. Mwalukumbi – river (from Dembwa) point		X: 431111 Y: 9619822	River valley – in Mwalukumbi area	A few ficus trees, coconut , mango and acacia trees. On a river bed ”valley”.	Bridge / concrete structure for road with drainage holes.	Water collection for domestic use, washing clothes, animals drinking. Some people use water for drinking, some only for washing and cooking and get drinking water from upstream.	Water level is low. Animals use same water, so water is partly muddy. The flow is reduced in the structure.
6. Ngulu dam (western side)		X: 431382 Y: 9618118	Ngulu valley, Ngulu dam	The dam is a natural dam (or wetland). The dam grows with reeds. People have cultivated inside the dam with arrow roots, sugarcane, maize, and bananas. There are big cut-	County Council poles to mark the dam area.	Cultivation.	Wet but drying up. People are clearing the reeds for agriculture. The land is under to county council as trust land. They have put poles, but no wires due to lack of funds. There is no

				down mango trees by the dam. The soil is marshy. No visible water. The dam floods during rains.			protection of wetland.
7. Mgalenyi (Josa) and Mwamukute (Dembwa) rivers join		X: 431557 Y: 9616806	Kipusi valley	Flat land. Two rivers join. River banks. Nearby cultivation of maize inside the wetland. A few mango trees around. There is water under the sand (base of river). The river is dry, used to be permanent flowing all the way to the sea. Now during rains the now Mwatate river flows to the sisal estate dam and Maungu.	Road on the eastern side.	Sand harvesting. Water source ? Trees have been cut near the road. Cultivation around the river banks.	No water flowing during dry season. Water is found in the river base under the sand. The sand harvesting destroys the river banks and depletes the water level.
8. Eastern side of Ngulu dam		X: 431 518 Y: 9617752	Ngulu valley, Kipusi valley	Reeds, cultivated land inside the dam. Arrow roots, sugarcane. Land is marshy and wet.	Poles by county council. Road nearby.	Cultivation, collection of reeds for animals.	The poles cost 1,2 million due to corruption. The cultivation had gone deep to the dam. The dam used to be 40 acres, now only 10 acres. It used to have lot of water, dividing it to both left and right side. The dam is trust land, but people own land right up to the poles. Some have encroached inside, claiming it ancestral land. The land was demarcated by the government. A chief started cultivation in 1988 in the wetland.
9. Water		X: 431094	Mwatate – by the	Dry, bushes and short trees.	Tarmarc road nearby.	Water source	The Sisters of Mercy have

kiosk – Sister of Mercy		Y: 9614698	roadside		Water pipes, pump, and underground tank. Water kiosk.		a borehole in Kipusi valley from where the water is pumped to the catholic church. From there it is let down via gravitational pipes to the kiosk. The water is sold at 3 Ksh per 20 L. ”We don't sell, we give a service.” During dry season, they sell about 1500 – 2000 L per day. During rains, the kiosk is not active. The kiosk also supplies Mwakitutu school. People say the water is salty, don't want to buy it. But water has been tested, and is suitable for drinking. According to kiosk manager, the solution to water problems in Mwatate is to dig boreholes in Kipusi valley.
10. Ndoria Maji Safi water point		X: 431133 Y: 9615457	Kipusi (Mwatate) – along the road	Dry, bushes, short trees. Some big mango trees. Small slope.	Tarmarc road nearby. A yard for water collectors. Water pipes. Water tank (10 000 L) further up towards the house.	Water source. Individual business. Lots of customers.	The water comes from Kibarani area, serviced by county council via gravity. The man has connected directly to the main pipeline. He has tanks that store the water. Once they are empty, sells water from main line. The water is sold at 5 Ksh/ 20 L. He pays for water to county council as per the meter reading. Today he has consumed

							water of 10 000 L. Some who buy water are water vendors who sell for 40 Ksh/20 L.
11. Kengwa Water Point (Dembwa-Wusi Water Association) (21.2.13)		X: 421489 Y: 9618210	Wusi – Susu	Valley. The water was coming from a small indigenous forest patch. The forest patch was fenced. Below the water point there was a shamba, growing banana trees and vegetables.	A path. A pipe from which water was flowing. Inside the forest patch there was a small treatment system.	Water source.	Good condition. Water is clean. Source is well protected.
12. Mwaroko Shallow Well		X: 426858 Y: 9615911	Chawia forest	Mixed forest. Brackens (Saniainen). ”Trumpet flowers”. Trees a bit further around: Eukalyptus, Indigenous trees.	Fence around the well. The well was constructed from concrete. There was a pump but it wasn't working. A bucket was used to get the water.	Water source.	There was water. It was very clean. Pump was broken. The well was constructed by UNDP through Cross Boarder organization in 2001.
13. Mwaroko old water point		X: 426820 Y: 9615854	Chawia forest	Mixed forest. Brackens (Saniainen) and weeds around. Used to be a big natural dam, now has grown with weeds.	A path. Planks around the water point.	Water point for animals	Water point is unhygienic for human use. It is about 20 m from the shallow well. There used to be a lot of water. It started changing since 2000.
14. Dry channel		X: 426728 Y: 9615582	Chawia forest	Mixed forest. Lians. Small river channel. Large indigenous tree by the channel. Bushes.	A path.		Used to be permanent stream/river originating from Mwaroko.
15. Kwambandi water point		X: 426797 Y: 9615583	Chawia forest	Weeds and brackens around. Indigenous trees.	A path.		Now dry during dry season. Water during rains.
16. Old water point		X: 426873 Y: 9615607	Chawia forest	A bit water – but muddy. The same river from	A path.		Little water. During rains there is water.

				Mwaroko. One large bracken next to the water point. Some indigenous trees.			
17. Kwamlola water point		X: 426873 Y: 9615607 (Further from previous point)	Chawia forest	A stream channel that had been dug. The water was muddy. There were big and small brackens around. A bit open area, in the junction of paths. Indigenous trees.	Paths. Ariel – washing powder plastics.	Active water source for people who live around and animals. A place for washing clothes.	Some water, but it is muddy.
18. Iyomboni intake		X: 427188 Y: 9615010	Chawia forest	Indigenous forest. Monkeys around.	Dam (water intake with filtration) and pipelines constructed by Plan International and the community.	Serves water to upper and lower Chawia, directly to taps.	Currently there is too little water. The water was silted. The intake has become seasonal. There is a management committee that runs the project. They only charge small maintenance fees. People believe the water is safe to drink.
19. Mwambonyi water point (dam)		X: 427033 Y: 9615572	Edge of Chawia forest	On an open spot, a valley, next to the rain forest. There are shambas around the water point, cultivating sukumawiki, grass, bananas, grevilleas. Sheep grazing. There used to be a dam, but now it has been grown with reeds and now only a water point (spring).	Planks surrounding water point.	Water source. Irrigation ? Animals drink?	The valley is a communal field. The water looked quite muddy. A lot of cultivation around. People are encroaching to the forest, also because of monkeys. Government forest ends to the plot.
20. Active water point (near the		X: 427016 Y: 9615534	Close to the previous point, inside the forest.	Bushes. Indigenous trees. Large brackens. The spring joins with Mwaroko and	Sticks/small logs on water point	Used by animals and people for water.	There is little water and it is muddy. Animals also drink from there.

previous)				goes down to intake.			
21. Chawia environment committee tree nursery		X: 426821 Y: 9615981	Edge of the Chawia forest	Eucalyptus, grevillea. View to the valley.	House and tree nursery.	Tree nursery.	The group works with Dabico, TTWF and Nature Kenya. Dabico buys the tree seedlings for the community to plant them in their shambas. The CB-group has 18 members and they meet every Wed to water the plants.
22. Ngulu dam 2		X: 427386 Y: 9615757	Near Chawia market centre	Cultivation, surrounded by terraces. Maize, bananas, grass, sugarcane, grevilleas, and small eucalyptuses. Reeds in upper part of the dam. River valley.	Human made dam made of earth in the 1950s by the community.	Used for irrigation by the entire community for free.	There is always water in the dam. The source is in the forest but has been tampered with. The dam is silted. Mwadime: will dry up because they've planted eucalyptuses nearby.
23. Irumu tap		X: 428312 Y: 9614709	Ronge	Dry bush on a steep hill next to the road. View to the Bura Bluff, Mwatate dam and the sisal estate.	Tap.	Water point.	Tap is dry, but there is water during rainy season. The water comes through pipes from the Iyombonyi water source in the Chawia forest.
24. Ronge water tank		X: 428451 Y: 9614867	Ronge	Dry bush and some nut trees with a view down to the valley.	Water tank constructed by Danida in 2002. Football field.	Not in use.	There has never been water in the tank. The project was incomplete.
25. Ronge seasonal river		X: 428482 Y: 9614955	Ronge	Dry bush, cliff.	-	-	Water flows during rainy season from the Chawia forest.
26. Ronge water point		X: 428484 Y: 9614946	Ronge	Dry bush.	Pipe and concrete wall with water coming from Sangeni river, but it is seasonal.	Water point during rainy season.	No water in dry season. The river is seasonal since 2010, according to local children.

27. Mwasima nuru water project		X: 431450 Y: 9615657	Kipusi	Farmland, bush, some trees	Houses, fence	Borehole, privately owned	Community used to benefit from the borehole, but now the land is privately owned (Mr. Daudi). Conflict of land ownership. People pay 3 Ksh/20 l. Transportation of water to Mwatate cost 50 Ksh/ 20 l. and to Kamutonga 350 Ksh/20 l.
28. Dembwa River		X: 429274 Y: 9619058	Dembwa	The river is surrounded by indigenous trees, but on the other side of this green belt is agricultural land and on the other side is the tarmac road from Mwatate to Wundanyi.	Barbed wire crosses the river next to the concrete bridge. This marks the school compound and also protects the riverine forest.	People fetch water	
29. Green houses		x: 429138 y: 9619355	Dembwa	Open farmland	Amiran Farmers kit greenhouses. Long irrigation systems outside, but not working		Nothing grows inside the green houses. Outside some water melons and tomatoes grow. They pump water from the Dembwa river nearby.
30. Mambisi Dam + farmland		X:425873 Y: 9622076	Kidaya/Ngerenyi	Valley on highland. Natural wetland which had been scooped to make a dam (still empty). On the otherside indigenous trees (Miletia Oblata). Grass and hay growing in the dam. On the other side exotic trees. Further up the dam, there is wetland that is under cultivation. There are many trenches. The slopes on either side are also	A water pipe going through the dam supplying St. Mary's school. The pipe gets water from a stream originating from a spring (pipe only laying there in the water).	Not yet in use. The Mambisi water project is waiting for funding from the CDF to continue.	The secretary of Mambisi water project told us: The dam was scooped in 2011, on a bought land (now public) which used to be a private land. The dam area had been split in the middle during demarcation. The land owners were compensated. The forest near the dam is owned by the chairman of the project. In the proposal the

				cultivated and terraced. There are several springs in the wetland area.			neighbouring land owners should plant indigenous trees. The surveying of the area was done by a private consultant from Mombasa, which cost the project a lot. The consultant wanted to plan for drip irrigation and hydroelectric power. They want to also bottle water and sell it. The area used to be misty and full of indigenous trees and a lot of water this time. Temperatures started shooting up in 1984. Before in March there was enough rainfall. Now rains are shorter.
31. Mwakivua spring		X: 425665 Y: 9621731	Kidaya/Ngerenyi (Mwakivua)	Valley. Starting point of the dam (and wetland). Before the area was cultivated by bananas, now is cultivated by other crops and is eroded.	There are stones put around the spring.	People get drinking water from the spring.	Water looks muddy. Before there was a lot of water oozing from the ground, now water is more still.
32. Juke falls		X: 425814 Y: 9622028	Kidaya/Ngerenyi	"Water fall" originating from the Mwakivua wetland above. Small stream of water flows on rocks under the road.	Road and a valve going under the road.		
33. Spring Mwge Majegho		X: 426148 Y: 9621395	Kidaya/Ngerenyi	Spring originates from Mwakivua forest, bordering Fururu forest. Stream from the spring, going down is Ifusa stream.	By the road.		

34. Mwanginyi dam (manmade)		X: 426584 Y: 9621201	Kidaya/Ngerenyi	Reeds in the dam. The dam has grown with weeds. Water originates from Fururu forest. The water from the dam joins the Josa river.	By the road. There is a bridge. The road borders the dam. The dam structure was built by Vaby, a colonial who occupied the ATC.		
35. Ngulu river		X: 426657 Y: 9620322	Kidaya/Ngerenyi		By the road on the way to Ndiwenyi.		
36. Ndiwenyi forest wetland		X: 426892 Y: 9620189	Kidaya/Ngerenyi - Ndiwenyi	Wetland on the border of indigenous and exotic (eucalyptus) forest. The indigenous part is public is forest. The exotic trees are on a private land. There is cultivation (arrow roots) around.	Path going through wetland.	The indigenous forest used to be a shrine, but it is not used as shrine anymore. People don't find the myths relevant for their modern lifestyles.	
37. Ndiwenyi water point (Mwafunga)		X: 426878 Y: 9620075	Kidaya/Ngerenyi – Ndiwenyi – behind polytechnic	Syzygium Scholerophyllium (indigenous tree) forest. Down by the water.	Path leading down. Polytechnic further above.	The water point is still used by some for collecting drinking water. Animal tracks (?)	The chairman of the Polytechnic wants to build a dam out of the wetland, keeping the natural vegetation and the indigenous forest.
38. Spring behind polytechnic and school		X: 426828 Y: 9619969	Kidaya/Ngerenyi – Ndiwenyi – behind polytechnic	Brackens / Ferns around. The chairman said they dry up the place. Reeds. There used to be indigenous forest around, but now only little bit (see before) remains. Valley	The polytechnic staff accommodation is nearby on the hill. A secondary school is on the other hill.	The school takes water from the spring, because they don't have any other water. The spring water is very clean.	The indigenous forest was cleared in 1984 when the secondary school was built. The chairman of the polytechnic discourages the staff to cultivate down to the spring. However, there are some capsicum growing nearby and macadamia trees.
39. Ikungunyi		X: 426258 Y: 9619342	Kidaya/Ngerenyi – closer to Susu	The spring is on a slope. It originates from Susu forest.	The spring is built up by concrete. There are two	The water is used by the community around. The	The water project has problems with management

water project				The water flows down to Mwalolo/Josa river.	pipes in the construction. One is leaking, the other is just an open pipe (with a stick as a lock)	water is very clean.	and maintenance. There was a conflict between the Mwofugue school (by the polytechnic) and the community. The pipe going to school is now dry. The water was tapped from the wrong place, now the water level has gone down. There is also a small pipe tapped by an individual.
40. Mawombo spring		X: 426218 Y: 9619154	Kidaya/Ngerenyi – closer to Susu	The spring water flows down to Mwalolo/Josa river. Bushes around. On a slope.	There is a pipe going to one of the households. There are houses quite near.	The spring has been piped by individual households for domestic use and irrigation.	The land is private, and also the water (!!!) There is a public water point further up on the hill.
41. Ikungunyi water tank		X: 426384 Y: 9619307	Kidaya / Ngerenyi – closer to Susu	Near people's shambas. Some trees. Farming.	Water tank. Houses.	Not in use – tank is now empty.	The tank was supported by DANIDA. There were issues with the locals. They were not “properly sensitized” as Mwadime said. The leaders Elders, and chiefs should have taken care of the project.
42. Manganga river		X: 426397 Y: 961 (2?) 9363	Kidaya/Ngerenyi	The water is originating from Iyale, St. Mary's and Mwakivua. The river flows down to Josa. There were palm trees and some other indigenous trees. Also cypress trees. There is a small water fall as the water flows down.	Road passing the river. 2 Valves going below the road. Pipes for irrigation. An irrigation diversion (furrow) canal. Water pipe from Wesu (Ministry), which doesn't have water.	Pipes + canals used for irrigation. A water pipe for water, but has no water.	The Mambisi project wants to use the ministry pipe to supply water once the dam project is done.
43. Ngerenyi		X: 427052 Y: 9620540	Kidaya/Ngerenyi	Palm trees, grass, bush, indigenous and mixed trees	Dam, pump house (serving) to irrigation.	Fishing is done under institution. One needs to	

dam					Constructed by missionaries in the 1920's. They got land by giving blankets to people. This used to be one of the coldest areas in Taita. There was a big forest and scull caves. The missionaries cleared the land for farming and dairy/livestock	seek permission to fish from fisheries department. Water is coming from underground from Fururu springs. The locals are fighting for getting water for home use. Got funding from CDF?	

4.3.6 GPS-points

Collecting GPS-points with a GPS-receiver helps to obtain the accurate information of the positions in research. GPS technology has been combined with ethnographic research already, but mixing qualitative and quantitative methods requires an interdisciplinary research tem (Christensen et al. 2011). This combination has been much used when studying mobility of people. Here it was used in the transect walks but GPS-points were also collected from each household interview. GPS-coordinates were noted from every household to make sure it was inside the catchment and to afterwards see where the household gets its water. However, these coordinates cannot be published because the anonymity of the respondent is desired. The saved GPS-points allow participatory maps to be digitalised and provide an overview of the household interviews.

4.4 Analysis of the data

The data collected through interviews, workshops and transect walks were qualitatively analysed with the methods in table 8. Through all the analysing method a gender analysis was kept in mind, especially in the livelihood analysis.

Table 8 The methods used for analysing the data.

Method/tool	Aim
Content analysis	To categorise the textual material from transcribed interviews.
SPSS	To obtain statistics on the water users.
Historical review	To historically identify the major social and environmental changes, using timelines.
Livelihood analysis	To compare on a household level the different social classes in terms of access to water.
PGIS	To digitalise and visualise the locals perception on a map.

4.4.1 Content analysis

Content analysis is used in qualitative research for analysing textual data and to pick out the most relevant themes (Weber 1990). Saldaña (2012) explains that this method involves coding of the transcribed interviews by labelling sentences or sections in the text with a code. The codes eventually form categories that in turn form common

themes. The themes can then be elaborated into theories or assertions. In other words the texts are being categorised into theme "families" (Saldaña 2012).

In this research all the interviews were coded using this labelling method and by highlighting key words. After that, the found themes were organised in an Excel-sheet that helped us finding the most and least common replies in the interviews. For instance, the explanations for environmental changes in the area could easily be compared through this method. The content analysis was the primary method for analysing the interviews and to find the answer to the main research question about the locals' perception of the water availability and accessibility.

Differences between gender and informants from the two catchments, Wundanyi and Mwatate were compared and also the relationship between them studied.

4.4.2 SPSS

Statistics of some of the answers in the interviews were calculated using IBM SPSS Statistics software. Average household size, education level and access to water (how many have a tap in their household) are examples of what was calculated. Further, it was analysed how many are or have experienced health problems because of the water they use or how many have experienced conflicts concerning water. SPSS served here as a complementary analysing method to the livelihood analysis (explained later) when the expenditure patterns for instance could be analysed quantitatively.

4.4.3 Historical review

The timelines contain information on important events from the beginning of 1900 up until present. The information from these was analysed to summarise the key events and this way produce a historical review. The timelines produced in the Mwatate workshop also contained positive and negative impacts on the community. The historical review provides another method for the locals' perception on the water availability and accessibility to be presented clearly. Also, the explanations for the environmental changes became visible here.

Finally, two timelines for each catchment were assembled from the timelines made by the workshop groups (table 12 and 13). There were some minor contradictions in the timelines but the general process of the events could clearly be understood, as well as how the processes move from one area to another.

4.4.4 Livelihood analysis

In addition to an ethnographic analysis of the data, a livelihood analysis was conducted on the gathered data to find out the assets and vulnerability against the decrease of water flow, which is the main problem in Taita. The livelihood analysis aims to compare on a household level the different social classes in terms of income, indebtedness, size of family, size of landholding, type of house expenditure pattern, crisis management pattern (Sajeev et al. 2012), and in this case access to water. According to Ellis (2000), a livelihood analysis organises the micro policy analysis of livelihoods that identifies the assets and activities. The links between these main components are encouraged to be considered, and ultimately this analysis identifies and formulates policies to overcome constrains that prevent assets to be productively used (Ellis 2000). In rural communities the basic economic decision-making unit is the household (NAFRI, NAFES, NUOL 2009), which is why a livelihood approach in this study area is necessary. This type of analysis diagnoses the whole livelihood system by investigating from where the household gains its income and what the household members buy with the revenue from selling surplus production of what they grow in their fields.

Also, future plans of the households are considered. Do the members want to grow only cash crops or produce all their food by themselves (NAFRI, NAFES, NUOL 2009)? Wealth ranking was a central analysing method for the livelihood analysis. Scoring of the households were completed as table 9 shows. All the households were categorized into four categories according to equal intervals of scores:

1. Rich
2. Medium
3. Poor
4. Very poor

The equal intervals were calculated with the following formula: Correction factor = (Max. – Min.) score) / wealth category.

Table 9 Scoring criteria for wealth ranking of the households.

Variable	3 points	2 points	1 point	0 points
Household size	2-4 persons	5-6 persons	7-14 persons	
Livestock owned	> 1	1		0
Extra plots		> 1 plot owned somewhere else than around the house	1 (cultivate land somewhere else than around the house)	0 (Only own land around the house)
Expenditure patterns	farmer + buys commodities with revenue	farmer + buys staple foods with revenue	"hand to mouth"	
Type of toilet	Flush	"Asian"	Pit latrine	No toilet
Payment for water		regular payment (monthly)		no regular payment
Livelihood	farming + employment	farming + funding from family members/casual work	"only farming"	

The livelihood analysis is closely linked with sustainable livelihood approach (SLA) that is based on five capitals of sustainable livelihood: natural, human, financial, physical and social capital (Morse, McNamara & Acholo 2009). These are examined in the vulnerability context in which these assets exist (Table 10). These five capitals are the basis for calculating the water poverty index (WPI). Morse et al. conclude that SLA is a significant step forward in development thinking and as an intervention should be founded on holistic thinking. SLA is an integral part of IWRM that accentuates the multi-stakeholder and interdisciplinary water resource management. In this study the livelihood assets of the respondents from a sustainable development point of view were examined through scoring system similar to the wealth ranking scoring criteria.

Table 10 The assets of the households represented in the study, comprising Mwatate and Wundanyi catchments.

Physical capital	Infrastructure to acquire access to water Maintenance and management of natural capital stocks
Financial capital	Economic assets for purchasing water
Human capital	Skills and knowledge of water provision Good health Gender mainstreaming Community self-assessment of needs Decision-making based on all the above mentioned
Natural capital	Water availability and scarcity Forests Catchment protection
Social capital	Access to water determined by wealth Social barriers (tribal or/and social class) Activity in CBO:s

Each respondent were given scores for how the different capitals promote a sustainable lifestyle (Table 11). The idea was to compare the capitals in different catchments and sub-locations. 0 points indicates that it does not contribute to a sustainable use of the water resources and land. 5 points is the maximum value of a sustainable water or land in these local settings. Each indicator has a maximum of 5 points and a minimum of 0 points in order to calculate comparable averages for locations or gender. There are gaps in the scoring criteria because of the maximum-minimum values that could not be filled with the available data, and also some questions are answered by yes or no. This type of asset scoring is completely subjective, since the criteria are built by the researchers in the analysis phase. Sometimes livelihood asset scoring is done in a participatory manner where locals themselves score their lifestyle (Morse, McNamara & Acholo 2009). However, in this study the livelihood analysis is a complementary method and provides a framework for the ethnographic research. The livelihood capital scoring that resulted in 'spider web'-diagrams (Fig. 17−20) gives an insight into the factors that affect the use of the water resources.

Table 11 Scoring criteria livelihood capitals from a sustainable development point of view.

Indicator	Scoring	Assumption
HUMAN CAPITAL		
▪ Education	0 No education 1 Enrolled in primary 2 Finished primary school/enrolled in secondary 3 Finished secondary school/vocational school 4 Graduated from college 5 University degree	Higher education increases sustainable water resources use
▪ Ecological awareness	0 No ecological awareness 1 2 Sceptic towards scientific explanations/ Christian or Muslim view of environmental changes 3 View that cutting trees affect the water resources 4 Modern scientific awareness 5 Activity in environment group	Modern scientific ecological awareness supports sustainable water resources use. Active participation in environmental group operation is considered to put this awareness in action.
▪ Household size	0 > 12 1 11–12 2 9-10 3 7-8 4 5-6 5 2-4	Larger household size increases water consumption and makes sustainable water use more difficult.
▪ Knowledge of farming practices	0 Earlier generations are not farmers/no training 1 Partly farmers in earlier generations 2 Learned skills through cooperation with other farmers 3 Farmers in earlier generations 4 Participated in training sessions 5 Environmentally friendly farming	Good knowledge of farming and environmentally friendly farming practices supports sustainable and integrated water and land resources use.
▪ Age	0 71-80 1 61-70 2 51-60 3 41-50 4 18-30 5 31-40	
+ Health	-2 p unable to work -1 p mental disorder/family member ill	Younger people are those who deal most with water and other natural resources use. Especially people who have finished studying and are settled down has a high capacity to affect the resources

			use.
SOCIAL CAPITAL			
▪ Conflicts with other water users	0 1 2 3 4 5	Often/normally there are conflicts Sometimes conflicts No conflicts	Conflicts indicate unsustainable use and unequal distribution of water resources
▪ Contacts with officers	0 1 2 3 4 5	No contacts with officers No contacts personally, but a close relative does have Contact with only 1-2 officers/farming training Contacts with more than 2 officers	Officers are considered to possess knowledge on sustainable farming and water use practices
▪ Group membership/farmer cooperation	0 1 2 3 4 5	No cooperation/not member in any group Contacts with big farming companies Unorganized cooperation with other farmers Member of livelihood, other group or water project Member of WRUA Member of environmental conservation group	Interaction with other community members increases potential to use water resources sustainably
+ Political connections	-3 -2 -1 -1	Strong political connections, at least MP level Interest in politics (candidate) Current/former village chief Current/former village elder	Strong political interests are often related to corruption and misuse of power in Kenyan context, which do not support sustainable water resources use and management
▪ Migration	0 1 2 3 4 5	Immigrant (from another country) Immigrant (from another Province of Kenya) Born in Coastal Province and lived short time in Taita Born in Coastal Province, but lived long time in Taita Has lived all her/his life in Taita Was born in Taita and lives there now, but lived somewhere else during his/life	
▪ Marital status	0 1 2 3 4 5	Divorced parent Single parent Widow/er Fertile age single, non-parent Married, husband/wife works elsewhere Married, lives with husband/wife	Strong relations and good knowledge of the place of residence are considered to enhance sustainable water and land resources use. On the other had, experience from other places is considered to bring additional knowledge and broader perspective.
▪ Number of children	0 1 2 3 4	>6 6 5 3-4 0	

	5	1-2	Higher social status is considered to give better opportunities to use water resources sustainably. This ranking of statuses was confirmed with a local informant.
			High number of children is considered to make sustainable water use more difficult. On the other hand 1-2 children may be beneficial, because children are able to help their parents and bring new knowledge from school.
FINANCIAL CAPITAL			
▪ Livelihoods/ expenditure patterns	0	Sometimes suffers from hunger	A person who can afford commodities, is also more likely to be able to take care of water sewage infrastructure. On the other hand wealth may allow also wasting of water.
	1	Subsistence farming or unemployed	
	2	Buys staple food with revenue or salary, casual work funding from other family members	
	3	Only farming, buys commodities with revenue	
	4	Buys commodities with revenue or salary/ farmer + employment	
	5	Employment+buys commodities	
▪ Payment for water	0	No regular payment for water	Payment for water reduces wasting of water.
	3	>10 Ksh /month	
	5	> 100 Ksh /month	
▪ Time used on average per day to fetch water	0	> 2,5 hrs	Time used for fetching water reduces time from other income generating activities
	1	> 30 min up to 2,5 hrs	
	2	5-30 min	
	3	Unreliable tap, fetches almost daily from some other source	
	4	Rationing, occasionally fetches from some other sour or secondary source is < 10 min away	
	5	Constant supply to household	
PHYSICAL CAPITAL			
▪ Infrastructure	0	No infrastructure / tap but no water in it	Proper water infrastructure saves

	1	Can't afford to pay for available infrastructure / plans to get connected to water network	water and makes water distribution more effective.
	2	Water from kiosk or vendor	
	3	Fetches from neighbours' tap / unreliable tap	
	4	Shared tap/ predictable or rare rationing	
	5	Working tap in household	
▪ Irrigation/fish pond	0	Fish pond	Fish ponds need a lot of water and expose it to evaporation. There is not enough water for irrigation. Automated irrigation systems waste water.
	1	Irrigation system	
	2	Irrigation with man-power	
	3	Partly irrigate with recycled water	
	4	Irrigation using recycled water / flat bed terraces	
	5	Rain-fed	
▪ Waste water			
	0	No waste water system	
	1	Waste water used for washing	
	2	Pit	Lack of waste water system increases risk of spreading diseases.
	3	Open drainage	
	4		
	5	Soak pit or/and septic tank	

NATURAL CAPITAL			
▪ Water sufficiency	0	Not enough water ever	
	1		
	2	Enough water only during the rainy season	
	3	Sometimes lack of water during the dry season/ irregularly enough water	
	4	No problems, but during the dry season water level g down	
	5	Enough water throughout the year	
▪ Land ownership	0	No land to cultivate	
	1	Landlord/government owns the land	
	2	Parents/grandparents/in-laws/relatives own land	
	3	Husband/wife owns the land	
	4	Owns the land just around the house/parents own lan around the house, but owns land somewhere else / dead parent owns the land	
	5	Owns the land around the house and owns or rents ex plots	
▪ Soil quality/what can be grown	0	No cultivation	
	1	1 crop	
	2	2 crops/1 crop+ small vegetabes	
	3	>2 different crops not incl. small vegetables or fruits/ 2 crops incl. Small vegetables	

	4 >3 different crops incl. small vegetables or fruits 5 >3 crops + small vegetables + diverse cultivation (fruits, intercropping)	
▪ Livestock	0 >3 livestock 1 3 livestock 3 1-2 livestock 5 no livestock	Livestock consumes a lot of water and food resources.
▪ River/spring in compound	0 No river or spring in compound 5 River or spring in compound	Existence of a river or a spring on own compound is considered a possibility to affect water resources directly
▪ Water quality	0 Dirty water and health problems/no treatment 1 Chemical treatment/water from the ministry 2 Water is boiled 3 No health problems/no purification methods but doub 4 Drinking water clean natural, but water used for other purposes unclean 5 Clean river/spring /water project tap water all the time	

According to Nicol (2000), a livelihood analysis must contain a gender analysis together with an institutional and policy analysis. Therefore, a gender analysis on for instance asset-ownership and control in water-relevant fields was conducted (Doss, Grown & Deere 2008). The institutional analysis is being left out from this thesis because it is conducted by the two other master students within the subproject of Taitawater. In order to create sustainable water management plans, it is widely acknowledged that gender has to be considered (Hawkins, Seager 2010). In most of the rural communities in African countries the water collection is done by women and children. The Dublin Principles (1992) underlines women's role in provision, protection and management of water resources. However, women are often absent from all the decision-making in water management. There is a gendered nature of environmental and resource relationship, which has already been much studied. The livelihood assets were compared according to gender but also according to location or sub-location to see if the sustainable lifestyle differs spatially.

4.3.5 PGIS

Participatory geoinformatics (PGIS) combines semi-structured interviews and community participation with geoinformatics. Also PGIS has its roots in PLA and

participatory rural appraisal (PRA) (Rambaldi et al. 2006) with the aim of combining scientific knowledge with local. PRA is similar to PLA but concentrates on the participatory methods. PLA, with interactive learning in focus can be said to have evolved from PRA.

PGIS has been used since the 1990s in natural resource management (NRM) as a way of giving a voice to indigenous knowledge by using technology that has the respect of decision-makers. GPS transect walks, interviews, aerial photographs and mental mapping are essential parts of PGIS (Weiner, Harris 2008). Combining participatory mapping with GIS creates a widened information and communications technology. However, integrating participatory methods with GIS gives a big responsibility to the researcher to present the data in the most truthful way (Chambers 2006). The GIS skills of the researcher affect the results as there are many steps before the data ends up in a map.

The sketch maps, GPS-points, and the transect walk that verify the sketch maps, form the input data for GIS. This method was tested as a possible tool for transferring local knowledge to the decision-makers in water management planning. The value of the sketch maps that were created in the participatory mapping session, is sometimes dismissed by other scientist and government officials and therefore the aim was to digitalise the maps using PGIS. The purpose of the PGIS is for the maps to work as a matching point for technocrats and the community members.

The data collected from the transect walk was transformed into GIS compatible format, without forgetting the qualitative data that gave additional value to the study. ArcMap 10.1 software was used to produce the maps that show the points locals had mentioned in the workshops and in some of the interviews. These maps (Fig. 21−24) give an overview of the catchments and show vulnerable areas where water is being overused or polluted for people that fetch water from the streams in the lower areas.

5 Results

Firstly, the results of the analysis are presented here. The content analysis resulted in key themes that emerged from the interviews and was complemented by the statistics calculated with SPSS. The historical review resulted in assembled timelines from both catchments. That was followed by a livelihood analysis which resulted in spider-web

diagrams of the livelihood assets that promote sustainable use of the water resources. PGIS enabled to make digitalised versions of the sketch maps drawn in the participatory mapping session, thus providing a visualisation of the locals' perspectives. The analysis is a mix of top-down and bottom-up methods to fit with the interdisciplinary project.

Secondly, it is explained how the analyses help to respond to the four research questions. The results will further be discussed in chapter 6.

1. How are the changes in water availability and accessibility perceived by the local water users and how do these changes affect their lives?
2. How are the causes of environmental change explained by the locals?
3. How is the current water availability and accessibility affecting the livelihoods?
4. How can local knowledge through PGIS support decision-making?

5.1 Results of the analysis

5.1.1 Central themes in the interviews

In Wundanyi, it is common to have a tap in the household and to pay a fixed price of 450 Ksh per month. Some people have a water metre and pay according to how much they use. However, the water is being rationed and so people have to collect their water from the river. Most agree that the water resources are declining but the explanations for this vary. The cutting of trees and increased cultivation in the area are seen as key reasons for decreasing water availability. Another common opinion is that eucalyptuses consume great amounts of water and cause springs to dry up. All over the study area people think that the disappearance of indigenous forest causes a decline in the water levels. A farmer in near Wesu village explained that the forest used to be dense and the rains heavy during the colonial times. At that time, people lived in small communities with dense forest between the communities. After the land demarcation people were scattered into the small *shambas* (plots were people farm). His father used to work in Wesu hospital and claims that the exotic trees were introduced in 1925 after which they spread quickly.

In Wundanyi, most of the respondents indicate that they have enough water throughout the year for domestic use, but very limited amount for irrigation. The following citation describes the water availability and the importance of customary laws in Wundanyi catchment:

Tambaru water project was first an irrigation scheme and was only meant for irrigation. Nowadays, people are also using it for washing. It is not good to drink the water but sometimes we need to do that, because the water from Kidakiwi is not enough. Then we boil the water or use Water Guard (a chemical that is used for purifying water). *The project itself does not have a limit of how much water you can use, but if you use too much people start talking about you.* (Male farmer)

According to the locals, the quality of water is not always good. People think the tap water is clean but often the river water is not. Many are annoyed of the rationing of water which makes the water availability irregular. Some complain about the taste of the tap water that is treated with chemicals. The springs are perceived to have the cleanest water and people prefer drinking spring water over tap water. However, many of the springs are reported to be dry nowadays and people say it is because eucalyptus trees consume all the water. The water providers in Wundanyi catchment are the Ministry, Tavevo Water and Sewerage Company, and water projects. Water projects are all infrastructural settings for water provision. In the Taita Hills there are several actors that set up water projects. They are NGOs (Plan International, World Vision), governmental donors (DANIDA, which is a development cooperation under the foreign ministry of Denmark), WRUA:s (water resource users' associations that act as a link between the government and the locals) and local community groups. The most common way of starting a water project in the Taita Hills is to construct water pipes directly from a water source or to build water tanks from where water is flowing through pipes to the taps. Also shallow wells have been constructed, from which locals can fetch fresh water. The locals call the water company, Tavevo, a water project as well. Tavevo is part of the privatisation of the water and is nowadays selling the water that used to be provided by the local ministry.

In Mwatate, to have a tap in the household is rare. Most people fetch their water from the water kiosks owned by Tavevo or the local ministry in lower Mwatate. During dry spell the water kiosks dry up and water provision falls on the vendors. There are some boreholes as well but they have salty water and so they are used only when necessary. In Upper Mwatate (Dembwa and Ngerenyi) the climate resembles that in Wundanyi and so they are not suffering from drought as bad as in Lower Mwatate. In Mwatate water is mostly paid for per 20 litre plastic canisters that are filled at the water kiosk. The price varies from 5 to 40 Ksh depending on the demand. Water collection in lower Mwatate is

significantly more time consuming than in Wundanyi and Upper Mwatate. The queues to the public water taps are long and sometimes people, mostly women, have to stand in line for several hours. Due to insufficient water adequacy in Lower Mwatate conflicts are more common. According to the locals, the area around the centre of Mwatate is either suffering from drought or experiencing flash floods. Many mentioned soil erosion as a problem as well.

One respondent who lived slightly above the rural centre of Mwatate told us about the family business of selling water. They own water tanks that they store the piped water in. The family business stands on its own without any connection to Tavevo, Coastal water service board or other. The County Council in Mwatate has given them a permit to sell water from the pipeline. The pipeline continues after this point towards centre of Mwatate. There are also other three households that sell water from the same pipeline. Sometimes the pipeline dries up, but they sell as much as they can. Even during the rainy season, people come to buy water from them. People living lower down in the catchment or even in the rural centre of Mwatate complain that there is not enough water left for them in the pipeline. Water has clearly become a business in Mwatate.

In the study area, the difference between the physical catchment and the mental catchment influence the cooperation among different stakeholders. Locals seem to think that the Wundanyi River is flowing down to Mwatate, which would mean that Wundanyi and Mwatate form in fact the same catchment. However, these are two separate catchments and these two areas are not connected by a river. This perception clearly influences the management at the catchment scale, especially when local participation is included. The catchment scale management becomes problematic in decision-making since the villages and districts do not follow the catchment borders. Also, the ground waters are claimed not to follow the catchment borders. The issue with the borders should be taken into account and in order to implement IWRM principles successfully, it furthermore requires devotion to this approach at all administrative levels. Cooperation between catchments is critical and this should be supervised by a higher institution.

It is interesting that many respondents indicated that the rains and seasons have become more irregular. The same issue is mentioned by Bravman in his work that deliberates the life in Taita communities in a time span of 1800-1950 (Bravman 1998). Irregular

rains have been a problem in the Taita Hills for as long as can be remembered and could thus be considered as part of its microclimate.

What was discovered in the interviews was that most of the respondents found it difficult to talk about their future, which is a common thing to do in western countries. Students in western countries always have big plans for their future and consider what impacts their current choices have on their future careers and lives. Many respondents in the Taita Hills replied when asked about their future that it is hard to predict or that "*God only knows".* Clearly, they are not used to contemplating their future at all, which makes it challenging to discuss the conservation of the catchments. It is challenging to assure people about the consequences of depleting the natural resources in the catchments, when the poorest needs to prioritise having food for the family tonight.

Many of the inhabitants mentioned in the interviews and in the workshops the importance of protecting the indigenous forest because it brings more fresh water to them. Often, they blamed people in neighbouring villages of cutting trees and destroying the catchment so that there is no water left for the people living further down in the catchment.

5.1.2 Livelihood assets that promote sustainability

From the livelihood analysis, a comparison of assets in Wundanyi and Mwatate catchments can be seen in Figure 17. The strongest asset in all areas is the social capital that promotes the sustainable use of natural resources. As was mentioned already in the introduction, the infrastructure and financial capital is the stepping stone in a typical rural community in sub-Saharan Africa. Wundanyi seems to have higher scores in all livelihood capitals as expected, except for the physical capital. In Mwatate the physical capital scores mainly consist of the rain-fed agriculture. From a sustainable development view, rain-fed agriculture gives 5 points. Irrigation consumes large amounts of water and is often not sustainable in arid and semi-arid areas.

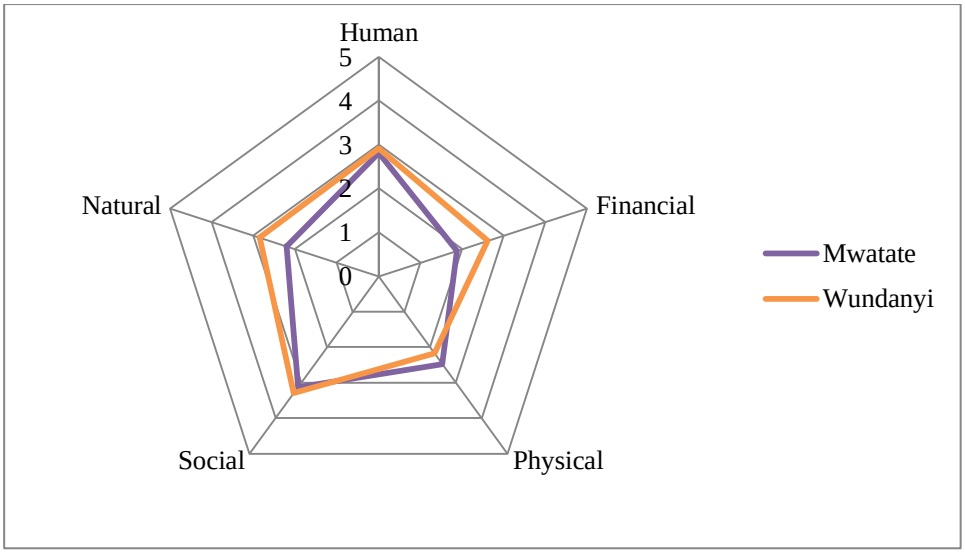

Figure 17 A comparison of the livelihood capitals in Mwatate and Wundanyi.

What was discovered in both Mwatate and Wundanyi was that both men and women participate in the collection of water. However, women are rarely part of the water management although they are members of CBOs and water projects. Women rarely spoke in the workshops or took the initiative to draw or write something on the sheet during the participatory mapping sessions. The presentations in the end were mainly given by men.

The *Taitas*, and most of the other Kenyan tribes, follow a patrilineal system of land heritage, meaning that land is always inherited through the father and divided among brothers. The attitude towards the gendered land ownership was accepting to its nature, because "*that is how it has always been*". In a gender comparison of the livelihood assets, the polygon for females is smaller than the one for males (Fig. 18). The biggest difference between genders concerns the financial capital, which is mostly explained by the time women use for fetching water –not so much the money. Men indicated that they also participate in the fetching of water but they use less time than women. The same applies for the farming. Most of the respondents were farmers and the amount of male and female respondents was exactly the same in Wundanyi. The division between men and women in Mwatate was not quite as even because men often work outside the home in the lowlands. Men say that they participate in the farming, but in many cases they actually spend less time on the farm than the women.

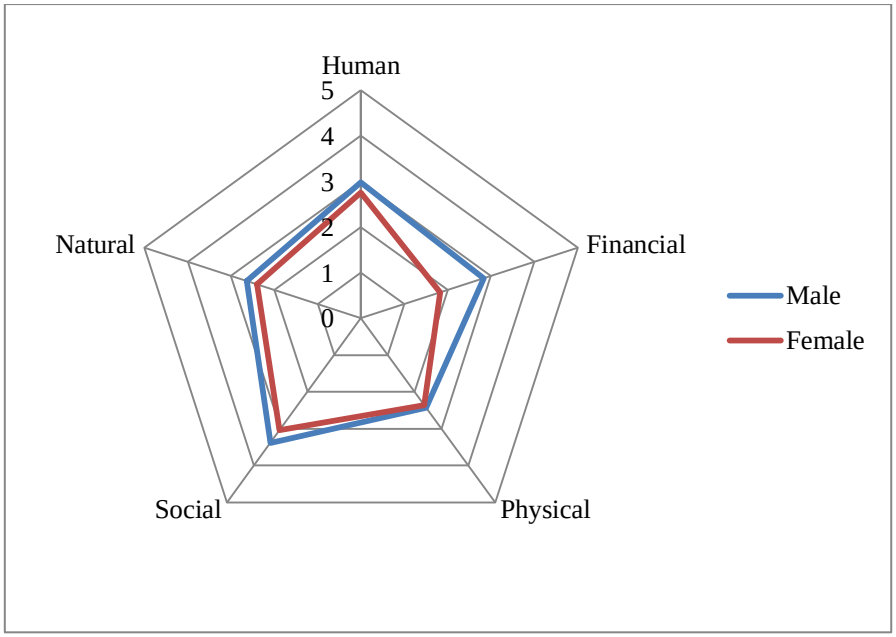

Figure 18 The diagram shows the difference in assets that promote sustainability between men and women in the whole study area.

The livelihood capitals were also compared according to location and sub-location (Fig. 19&20). In Wundanyi, the data was divided into six sub-locations and in Mwatate into three locations. The Mwatate catchment area is larger which is why the data could not be divided into sub-locations. The question of comparability between Wundanyi and Mwatate catchments is further discussed in chapter 6. Spatial differences can be observed from these diagrams and there is a considerable difference particularly between the biggest rural centres. According to our finding, rural centre of Wundanyi using the natural resources the most sustainably and the rural centre of Mwatate the least sustainably. Thus, isolation cannot be used as an explanation for not using water sustainably.

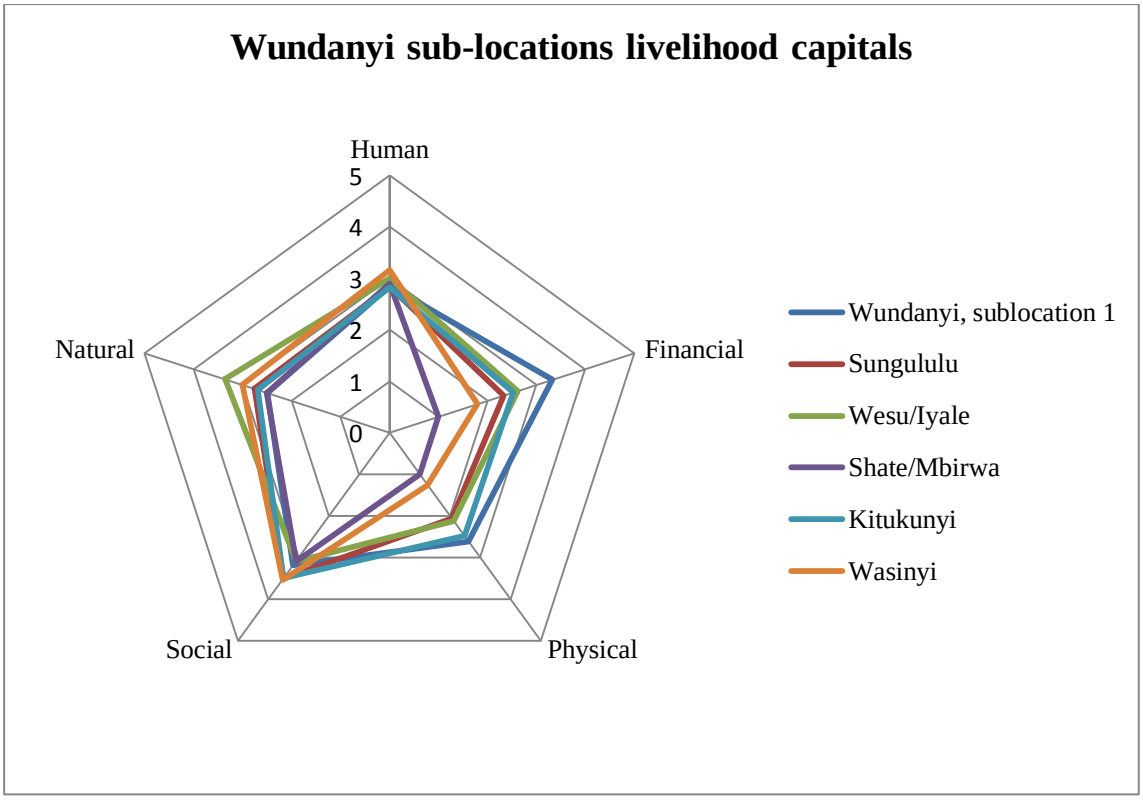

Figure 19 A spatial comparison in Wundanyi catchment of the livelihood assets.

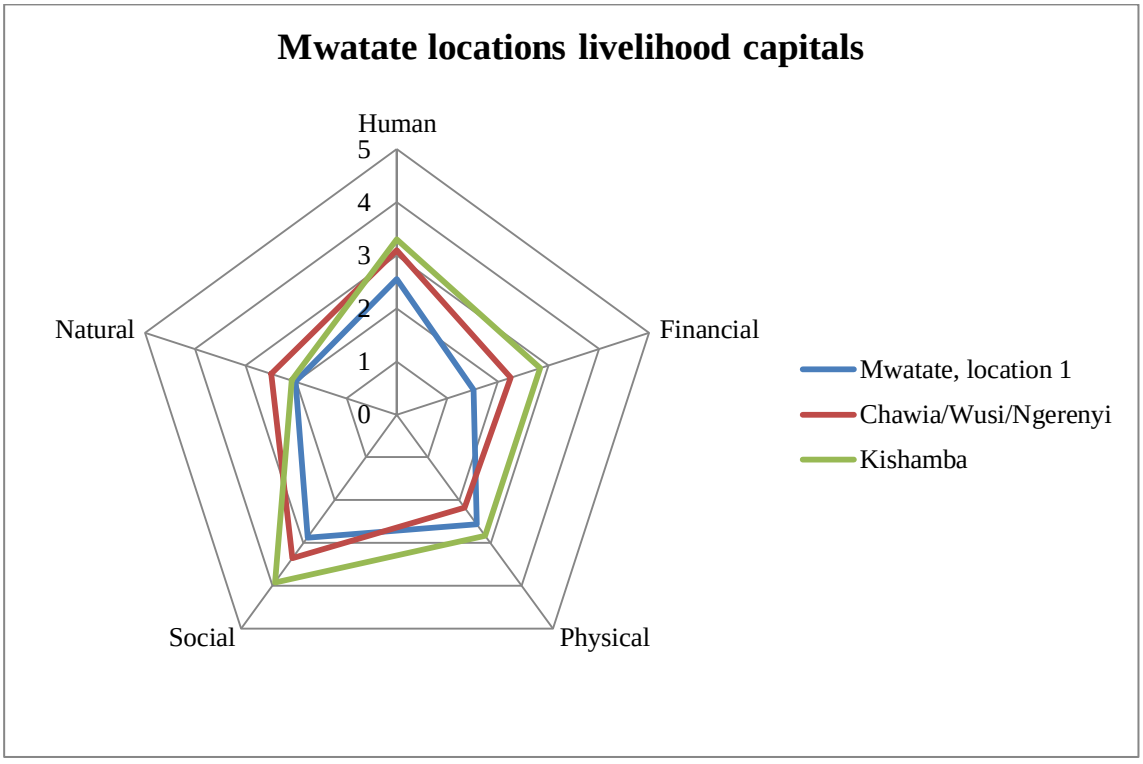

Figure 20 A spatial comparison in Mwatate catchment of the livelihood assets.

5.1.3 Key events that affected the water resources

In the beginning of 1900s large areas were covered with indigenous forest. According to the workshop group from Kidaya and Ngerenyi the lowlands were occupied by wild predators and so the humans lived in the highlands. When the missionaries arrived around the 1920s and introduced Christianity and other cultural changes, many of the *fighis* were destroyed. The *fighis* consist of indigenous trees that some of them were believed to bring rain. New farming methods and crops were introduced and exotic trees began dominating over the indigenous tree species.

The World Wars I and II had a bigger impact in Mwatate than higher up in Wundanyi. Both wars caused poverty but during the Second World War cash crops, such as coffee were introduced in both catchments. Irrigation systems and dams were built to increase the water provision. Coffee production was a major income until the late 90s when the coffee prices dropped. The chemicals that were used in the coffee production are claimed to have polluted the streams.

The timelines show that major famines have occurred almost regularly every 10-20 years (Table 12). El Niño has an impact on the climate in the Taita Hills and heavy rains that create major floods can also result in famine. The reason why locals think that the rains are becoming worse might be because landslides occur easier now that there are fewer trees to hold back the soil.

The turning point for the environmental changes is the land demarcation that reached the different areas different times. Basically, it began from the independence of Kenya in 1963. The land demarcation moved people to new places. As most of the population were farmers, they needed land for cultivation. Large areas were covered with rainforest at those times which means that many farmers got a forested plot. The farmer was had to cut down the trees and replace the forest with agricultural land in order to gain a living. In the lowlands, grazing land was converted into agricultural land, which resulted in grazing further into the forests causing forest destruction (Table 12). The loss of forest cover is seen as the primary reason for decreased water resources.

According to the timelines, the 80s and the 90s have probably been dark decades for the *Taitas.* There was famine, major destruction of forests, declining water levels and water quality, outbreak of diseases etc. The experiences vary spatially and a pattern can be observed that events spread from the lowlands to the highlands. For instance, drought

begins in Lower Mwatate when it is still green in Ngerenyi (upper part of the Mwatate catchment). Eventually, the drought reaches also the upper parts of the hills. During rainy seasons the disease outbreaks start off from the lowlands. The 80s seem to have been the decade when international aid came to the Mwatate area. At least, Danida (the Danish development aid) and Plan International have constructed water tanks and dams.

Although the workshops focused on water issues and how they affect the livelihoods, some positive improvements were also mention by the local participants. Increased awareness, new water projects, better transportation, and formation of CBOs that promote environmental protection. The fish ponds divide the opinions as some think they provide an alternative source of income and others think that the fish ponds pollute and consume the water in the rivers.

The general perception among the locals is that deforestation, soil erosion, decreased water resources, and irregular seasons have become worse ever since they can remember. Today, many CBOs plant trees and people have high hopes for the new government and the recently formed WRUAs that is supposed to be the link between local communities and the government.

Table 12 Assembled timeline from Water and Livelihoods-workshops in Wundanyi.

Decade	*Wasinyi/Kitukunyi*	*Wesu/Iyale*	*Shate/Mbirva*	*Sungululu/Mogho*
1900		Old things that are no more:	Before independence:	
1910		- traditional games - Wunyembo (tattooing of women for marriage) - sharpening of the teeth	- No freedom of speech or opinion - No legal right to own land - Chief's and DC's had a lot of power	
1920		- fetching water with calabashes - grinding maize with stones	- Area was covered with forest - Rains were predictable and more abundant	
1930		- carvings (fuwa for plates) and Nyungus, which were for water storage	- 1950's: Drought and hunger known as 'Nyangira' - Soil was fertile	
1940	1940: Heavy rain led to loss of yields and famine	- no toilets	- Lots of food and healthy animals - Springs and rivers were clean - People respected natural resources	
1950	1950-1956: Locust invasion in Wundanyi. No chemicals. Fishing in Wundanyi River (mudfish).		- Exotic trees were introduced - No transportation	Shomoto Hill was a cultural site. Enough food and water. Coffee production was introduced. Tea was also introduced, but it did not pick up. Blue gums (eucalyptus trees) were introduced.
1960	No fish left in the Wundanyi River because people started cultivating along the river banks and use chemicals			1963: Low number of population. Enough resources. Irrigation was introduced. Cultural erosion due to introduction of Christianity.
	1964-1965: Drought: people were supplied with wheat flour		After independence 1963-:	1967-1969: Land adjudication. Eucalyptus trees were used to dry the swamp in the Wundanyi River valley. Horticultural activities. Population increase.
		Before 2004 many hardships:	- Freedom of speech - Rules set by old people are not obeyed - People can own land and have a title deed - After the demarcation of land areas that were previously used for grazing were turned into farmland and animals had to go to forest where they caused destruction	
1970	Drought. People had money, but there was nothing to buy. People became angry. No food. Myth: Cruel business man slaughtered children for meat	- No roads - walking long distances to fetch water - no communication technology - not enough hospitals and schools - destruction of indigenous trees and reduction of water levels	- Transportation available - Water levels have gone down between 1980's and now - Water quality is questionable	1978: Lawlessness increased. Grabbing of the common land for government uses. Land conflicts. Cultivation of river banks. Deforestation. Ban of harvesting firewood. Excessive power of chiefs and village elders. Cooperative societies were

		- faring around the water sources - cultivation change due to infertility of land and reduction in land size - moles eat the local foods (e.g., pumpkins, sweet potatoes, cassavas, arrow roots) - no freedom of speech - education only for men - selective foods for women	- Big companies have come to provide work, but on the other hand, they have made a lot of heat with their machines, which causes global warming - Deterioration of soils due to human activities - Forest cover has decreased to almost 1% from 10% due to human activities - Exotic trees have spread very fast and they are grown for commercial purposes - Rainfall has become unpredictable.	active.
1980	1980: Bad drought. After that there were extremely heavy rains. Shell petrol station and police station flooded and Wundanyi bridge was destroyed. 1980's: MVITA constructors became involved in water supply and building tanks in Wundanyi			1980: Big drought that affected the whole Taita and Kenya. Food insecurity. Water levels going down. Loss of soil fertility due to rains. Loss of biodiversity. Loss of livestock. Increased population pressure. 1989: Drought. A lot of political activities. Collapse of cooperative societies. Population explosion. Increased prices of goods. Water levels decreased. Insufficient rainfall. Increased deforestation. Increased cultivation on river banks.
1990	Rampant harvesting of river sand when people started to construct modern houses 1999: TAVEVO came to the area	1998: Collapse of coffee farming		1997 or 1998: El Niño rains and flooding. Increased soil erosion. Good harvest in some areas. Dairy farming did well. Decreased water levels. Increased subdivision of land due to inheritance system. Introduction of zero-grazing.
2000	High inflation rate increased the cost of living	2000: Introduction of fish ponds		
2010	2010's: Cost of living is still increasing. Unemployed people have difficult times.	2005- : CDF funding. Improvements in roads and infrastructure, water projects, new schools, rural electrification, boda-bodas (motorbike business), communication technology, reduction of power of chiefs has improved democracy and civilization, freedom of speech, change of constitution, free education, infertility of land		2013: Change of leadership. Increased education. Chiefs' power decreased. Increased cost of living. Decrease of water and land. Increased forestry (planting of trees). Increased awareness. Formation of community conservation groups, e.g. WRUAs

Table 13 Assembled timeline from Water and Livelihoods-workshops in Mwatate.

Decade	*Mwatate/Mwachabo*	*Kidaya/Ngerenyi*	*Chawia/Wusi*	*Kishamba/Modambogho*
1900	Construction of the railway line, which produced job opportunities, improved transportation and opened markets. It also caused forest destruction and workers' exploitation.	1900-1915: Large areas covered by indigenous forests. Susu, Fururu and Mwakivua were grazing areas. Lowland were full of wild predators, so people lived in the hills. People lived in cluster settlements, which caused only little destruction to the environment. Main economic activity livestock keeping, farming subsidiary activity. Land was communally owned. Population was low and there was no competition for resources. Seasons were distinctive and regular.	Missionaries arrived, which affected the traditional practices and caused destroying of shrines.	Construction of railway increased trade, even with the Arabs. Introduction of Christianity led to establishment of churches and Christian schools.
1910	1914-1918: World War I caused poverty		Shrines were respected by elders for cultural practices. Making of rain, control of theft. Good water conservation trees.	Major famine. Major rains (Makanyanga) led to creation of hills, gullies and swamps. 1914-1918: World War I: information from the outside war by war veterans.
1920		Arrival of missionaries and settlers, which caused cultural change. Grabbing of land by settlers for creating institutions. Increased greed for land led to deforestation. Taxes were introduced. Exotic trees begun to dominate over the indigenous trees. World War I. Introduction of exotic trees. Introduction of new farming methods and crops.	Planting of African crops like bananas, Miwa Maduma, along the rivers, which prevented further cultivation along the rivers	Sisal estate is established and sisal introduced as cash crop. Coffee is also introduced along with chemicals. Living with different tribes.
1930			Planting of exotic trees in Susu forest	Major famine (Kibaba), because of heavy rain. Locust invasion. Introduction of relief food and communal work.
1940	Start of mining increased destruction of the environment and risked lives. Construction of Mwatate Dam displaced local people, but increased availability of water. Exotic trees were introduced.	World War II. Introduction of dams, horticulture, cash crops, new farming systems (e.g., farrow irrigation, new farming tools), currency and new education systems		World War II. Construction of Mwatate dam. Introduction of schools. Lifestyle of people has changed.

	1944-1948: World War II caused poverty 1946: Sisal Estate brought job opportunities, but was also hazardous to human beings			
1950		Fighting for independence. Customary laws were still intact (mostly regarding marriage). Subdivision of land begun.	Clear cutting in Susu. Farming in sacred areas. Ngulu dam was dug. Springs dried up. Water harvesting.	Struggle for independence begins, which brings all tribes together. Mining of graphite leads to siltation of Ngulu dam.
1960	Rice farming produced enough food, but brought diseases like malaria and bilharzias 1968: Tarmac road from Voi to Wundanyi made communication easier	Independence. Introduction of government laws and policies. Demarcation of land. Introduction of infrastructure (e.g.., roads, telecommunications). Increased rural-urban migration.	Destruction of old practices of planting African crops along the rivers. Population growth. Water levels went down.	Independence. Government came up with several development projects including water projects. Josa water project starts. Establishment of ranchers' cooperatives. Famine called Nyangira. Relief from USA.
1970	Rice farming continues. Ranches were started, which made the owners rich, some people lost land. 1972- Destruction of fighis started, which caused lack of rainfall and cultural erosion 1975-1976: Drought and famine caused poverty and profit to entrepreneurs	Destruction of dams. Massive horticultural and cash crop production. Economic growth. Increased use of agrochemicals. Formation of farmer cooperatives. Increased soil erosion.	Planting of blue-gum in Chawia forest. Indigenous trees were replaced with exotic ones in Chawia. Land consolidation. Climate change. Destruction of water. Forest degradation. Soil erosion. People were allocated land on steep areas. High temperatures. Mosquitoes. Rainfall pattern changes.	Construction of Voi-Wundanyi road. Land demarcation. Soil erosion and siltation. Pressure on forests for construction materials. Introduction of Harambee schools.
1980	Construction of water harvesting tanks and grain stores by DANIDA and Plan International improved living standards 1982: Local brew (mratina) was banned, which increased family responsibility, but caused a lack of market for sugar canes 1984: Major forest fires	Large drought, famine and disease outbrakes. Destruction of forests. Increased cost of living. Increased poverty. Massive soil erosion. Decreased water levels. Collapse of cooperatives and cash crop farming. Dictatorial leadership led to massive corruption in both local and national levels	Building of water tanks for rain water harvesting and building of toilets by Plan International. Improved sanitation. Poor environmental management in Chawia. Forest guards came.	Drought and famine. Water resources dry up. Poor food production. Major forest cuts. Climate change.
1990	1996: Drought and famine	Introduction of NGOs and multi-partyism. El Niño rains. Massive erosion and landslides. Plant, animal	Drying of Mwaroko shallow well. Deforestation. El Niño rains. Agriculture went down. Less	El Niño rainfall and floods causes soil erosion. Overgrazing in ranches.

	1997: El Niño: enough food, destruction of settlements, spread of diseases	and human diseases. HIV/AIDS menace. Increase in cost of living.	farming than before. The forest dried up and its value went down. Land degradation. Erosion and floods. 1998: Mining was started by Chawia Change Colour group.	Charcoal burning for sale.
2000	2000: Onset of chemical farming, which has caused water pollution and decreased harvest 2009: Construction of Ziwa LaNg'ombe community water pan		Forest fire in Susu forest caused by community. Building of Mkolonge/Rong'e tank and water catchment protection. 2000: Chawia environmental group and Mawono group were started. 2001: Ngulu dam. Later it was protected by planting indigenous trees. 2000-2002: Mwaroko shallow well was dug with the support from DANIDA Training on soil conservation and terracing in Chawia. Construction of Iyombonyi Sinai water project	Revision of Water Act. Awareness of water management.
2010	High inflation has increased poverty 2012: TAVEVO has done water rationing	Start of water projects. Increased awareness of the environment and resources' management. Formation of environmental groups. Revival of dams. Return to traditional methods of crop husbandry. 2010: Introduction of new constitution in quest for devolution in government. People rely on government institutions. NGOs and Self-help groups. Creation of awareness by civil education.	Reforestation of Chawia forest by DANIDA and Cross Border (Biodiversity) Youth for work planted indigenous trees in Susu forest, but the trees were burnt.	Introduction of WRUAs. Protection of water resources and the river banks. Ownership of water resources by users.

5.1.4 Digitalised sketch maps

Participatory mapping in the workshops resulted in 9 sketch maps (Figures 6−14). In order to digitalise these, transect walks were needed. When combining these two methods figures 21 and 22 show a digitalised version of the locals' perception on the water resources and how they are used. The maps are based on the land cover classification by Pellikka et al. 2005. There are several water tanks, but they are gravity-fed and people who live above these tanks have to fetch their water manually from a stream. The water tanks are located near forests, as are also the pipe water sources. According to locals, these sources are drying due to the replacement of indigenous trees with exotic tree species. Therefore, indigenous forests are very much valued by the local population but in certain cases people do not have a choice to between protecting the catchment by letting indigenous trees grow and cutting the trees for agricultural land. Agricultural production is also an ecosystem service that is highly valued, because it brings food to the table.

From the map (Fig. 21) it can be seen that there are several fish ponds. Building fish ponds has in the recent years become popular and the amount has increased drastically. Fish ponds are a new alternative type of livelihood that requires a starting capital that not many can afford. However, in Wundanyi catchment many fish ponds are owned by the ministry, CBOs or even the prison. The fish ponds divide opinions. The people who own them say that it is a good source of income and that it prevents them from using pesticides in their fields because it would kill the fish. Others say that fish ponds use way too much water and that it makes the rivers eutrophic, and that it pollutes the water that people lower down use for drinking and cooking. The vegetation becomes a problem in the riverbeds as it blocks the water from flowing freely.

It is evident that the forest covered area has drastically decreased and as the map shows (Fig. 21) the agricultural land has taken over. It is not surprising that most of the locals think that the decreased water levels are due to loss of forest. They have many examples of springs that have dried up when eucalyptus has been planted nearby. Not many mentioned that they would believe in the sacredness in some of the forests, called *fighis*, and that these would directly bring rain, but they spoke of indigenous forest in general and think those trees attract rain.

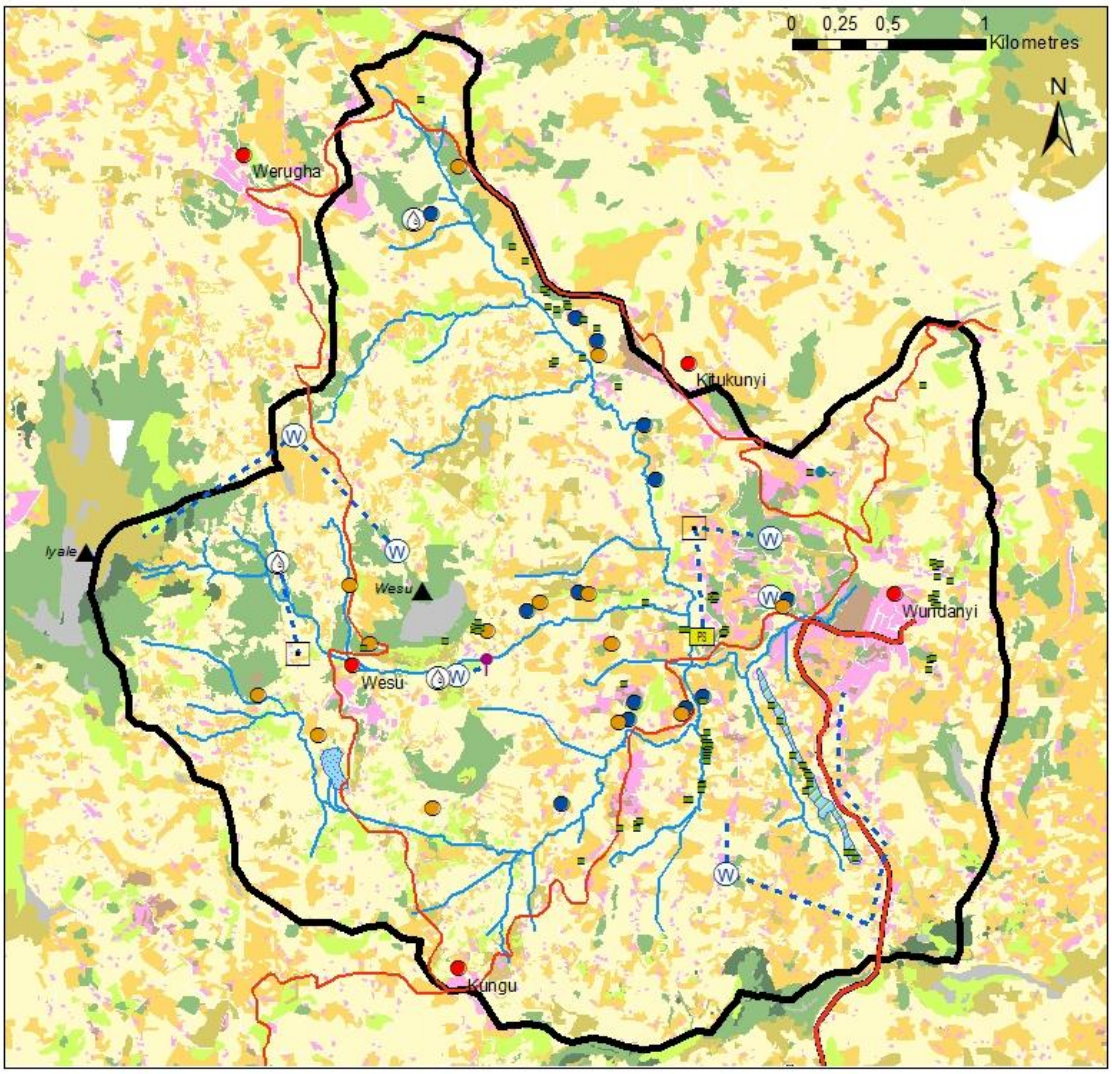

Figure 21 The digitalised map of the Wundanyi catchment based on data from participatory mapping and transect walks visualised on existing land cover data.

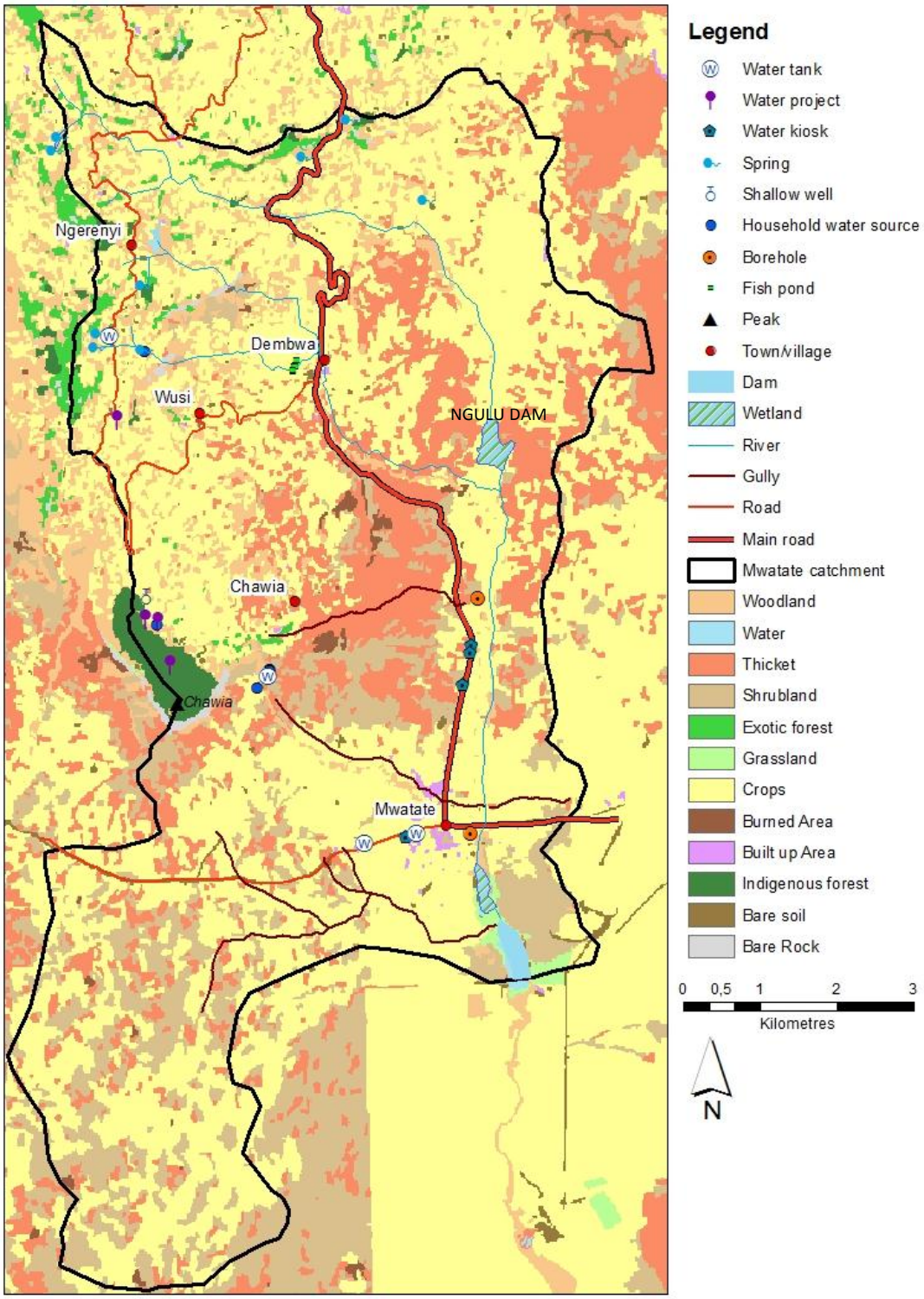

Figure 22 The digitalised map of the Mwatate catchment. The sisal plantation is visible in the south-eastern corner of the map where crops are evenly distributed. Sometimes gullies are called seasonal rivers, because during rainy season, water flows in them. Gullies have been created due to soil erosion.

In Wundanyi, issues that concern the whole catchment are also mentioned. These are not shown in the map because it would be confusing with the issues that only concern a specific area. One of the mentioned issues was that each household is responsible for managing the waste. Often this means that it is burned or dumped in a pit. The rural centre of Wundanyi has collection points for destroying the waste but there is no lorry to move the waste from the villages to a town. It also remains unclear how the waste is destroyed in the rural centres of Wundanyi and Mwatate. Burning the waste seems to be the most common way of getting rid of it.

In the Mwatate catchment, there is only one indigenous forest left in Chawia. In the north-western part the forested areas are very scattered. The rivers originate from these forests and do not have much water anymore. Two wetlands are visible: one next to the sisal estate and another one in Kishamba called Ngulu dam that is located north from there. Both wetlands are shrinking drastically. In the workshop it was presented as follows:

> *It is a God-made, natural dam, it has been there always. When the land was demarcated, it was allocated 40 acres of land, but now it's less than 30 acres because of human. People are there because there is some water around. People are planting there yams, bananas, vegetables and so on. That is a very big problem. We also had a community there that tried to put a fence around the dam, but because of shortage of that money it was not enough.* (Kishamba – Modambogho group)

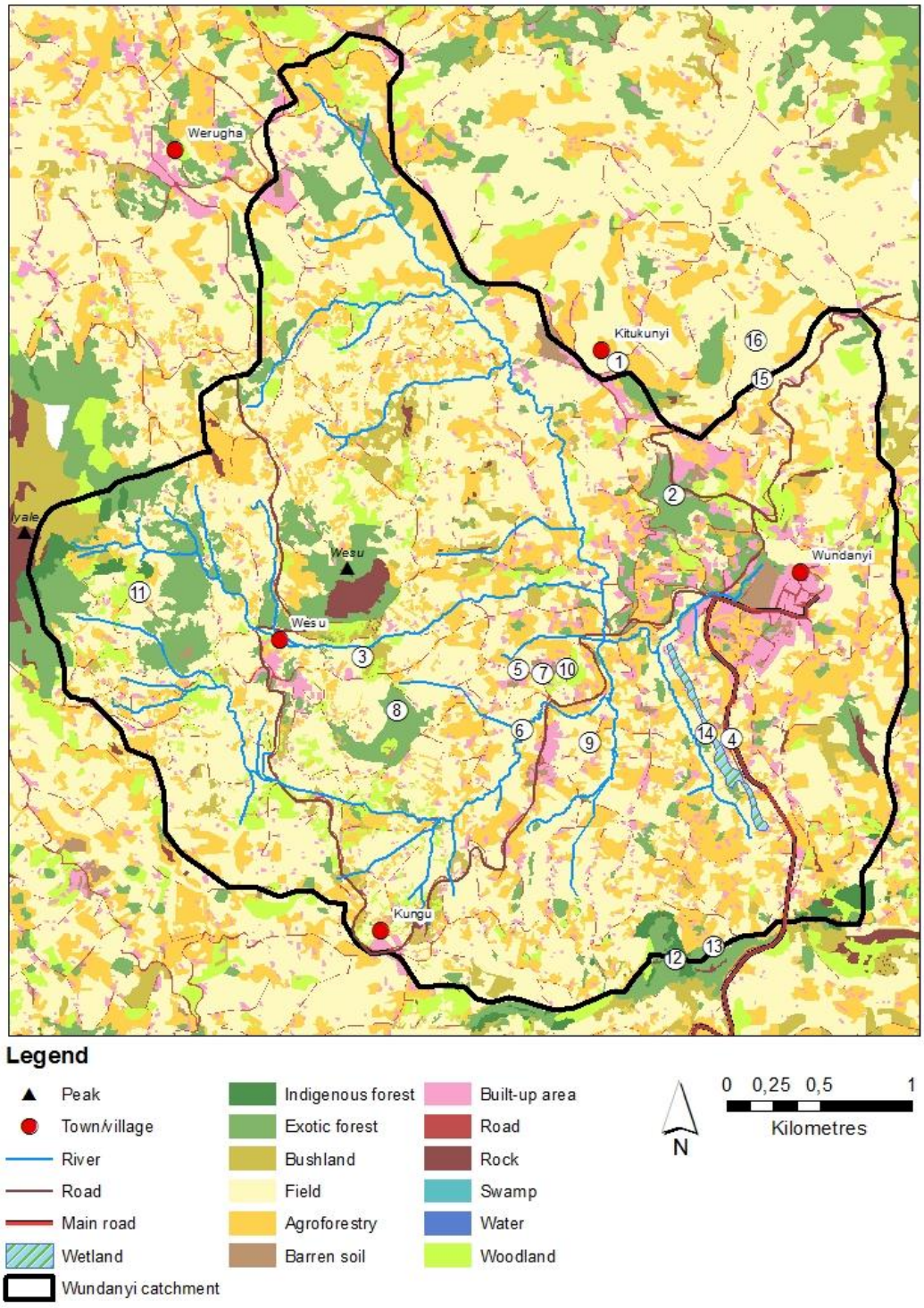

Figure 23 The issues that were mentioned in the Water and Livelihood workshop in Wundanyi are visualised on the map. The legend continues on the following page.

Legend (Figure 23)

1) Lack of water and firewood, soil erosion, alcohol and drug abuse among the youth
2) Monkeys destroy crops
3) Toro water project: lack of storage tanks and pipe network. There is enough water but it cannot be tapped properly.
4) Road impassable during long rains
5) Poor quality of seeds, lack of farming manure and transportation, problem of marketing the farming products
6) River polluted because people bathe and wash in it
7) Not enough water, theft, drug and alcohol abuse among the youth
8) Eucalyptus trees reduce the river flow
9) Kiziki forest destroyed causing rivers to dry up
10) Hilly landscape causes soil erosion during rainy season. Cultivation impossible. Reduced soil fertility.
11) Lack of agricultural knowledge and how to maintain the catchment, desertification, overgrazing, lack of water due to eucalyptus, lack of roads, theft, vandalism, soil erosion and soil infertility
12) Logging for firewood and selling, pulling out stones for selling leaving loose soil that is washed away into the rivers. No activities benefit the community (research, beehives, grass harvesting for cattle)
13) Difficult to get the river water up to the hills through gravity and pumping
14) Mbirwa wetland is not surveyed, people around claim it is theirs
15) Rocks falling and landslides during heavy rains
16) Lack of proper knowledge regarding conservation and agriculture, lack of land.

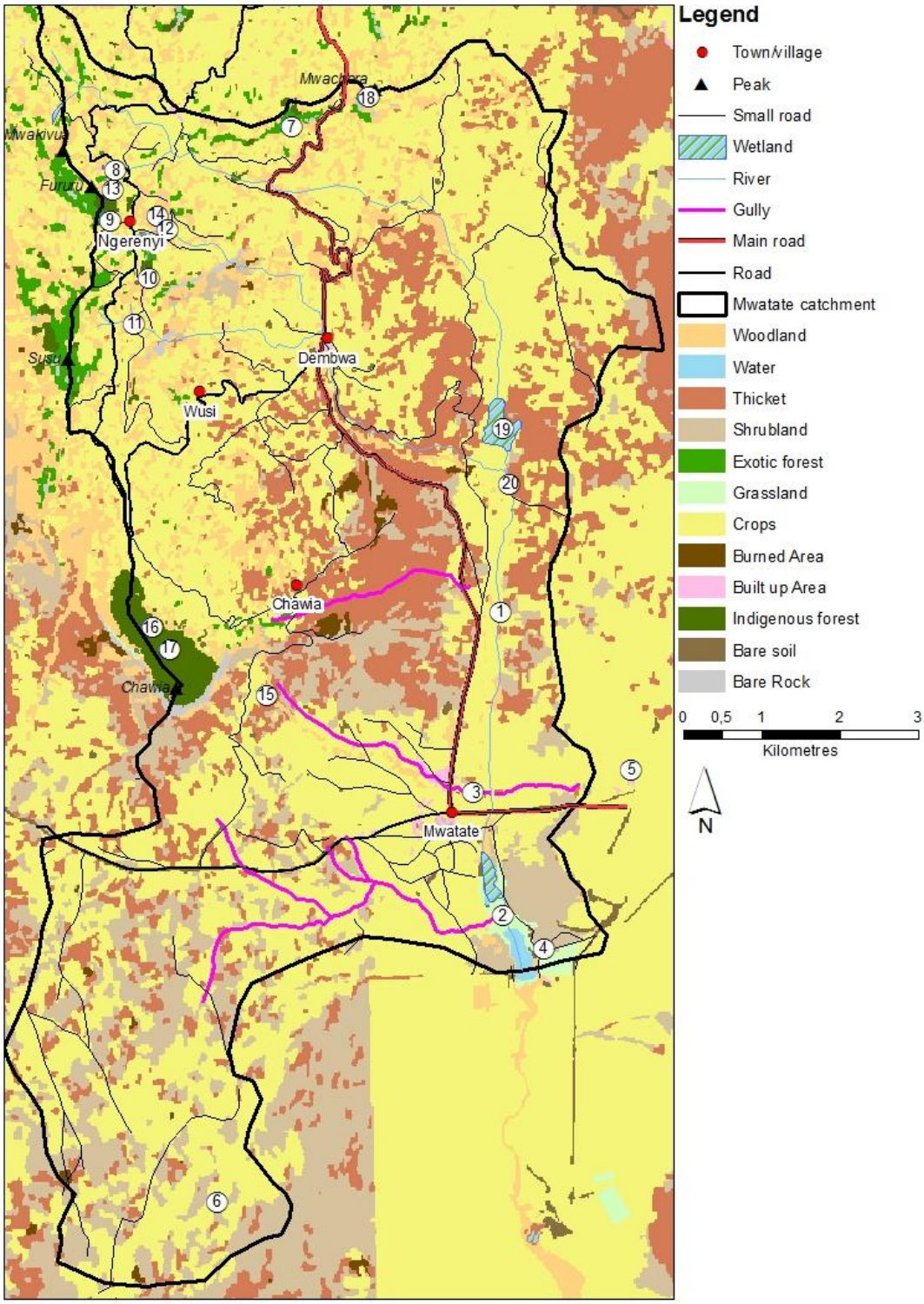

Figure 24 The issues that were mentioned in the Water and Livelihood workshop in Mwatate are visualised on the map. The legend continues on the following page.

Legend (Figure 24)

1) Intensive farming on the river banks, deforestation, crop theft
2) Siltation, livestock and elephants are destroying crops. Lack of proper guidelines for sand harvesting
3) Poor cultivation techniques, lack of farming equipment, conflicts over water use.
4) Lack of official land use
5) Water harvesting and storage equipment, timing and poor seed type, crop diseases and pests e.g., Weevils and termites
6) Bush fires and smoke, indicating charcoal burning activities
7) Mostly exotic forest, not fenced, illegal tree harvesting
8) Illegal firewood harvesting and logging, exotic trees causing drying of springs
9) Unfenced forest, bird ringing and butterfly farming and local tourism
10) Replacement of indigenous with exotic trees, unfenced
11) Soil erosion, population increase, logging, lack of water
12) Mismanagement of the water project
13) Massive government sponsored deforestation
14) Siltation of the dam, massive deforestation, loss of cultural site, encroachment of wetland for farming, encroachment of wetland for farming
15) Unoperational tank built by DANIDA
16) Mwaroko natural dam nearly dry
17) Encroachment, invasion of eucalyptus, overgrazing, animal disturbance of the water source, forest guards do not do their job, mismanagement of water projects
18) Abandoned shrines after Christianity was introduced and land demarcation
19) Ngulu dam silted an encroached from 40 to less than 10 acres
20) Extensive irrigation, water sources encroachment, demand for firewood and building materials and river bank encroachment

5.2 Water as a social issue from a local perspective

5.2.1 The water availability and accessibility

There is a significant difference in the amount of water when comparing the two catchments Wundanyi and Mwatate. There is more water in the Wundanyi catchment and upper Mwatate than in lower Mwatate. In addition to the differences in water quantity, the water accessibility is dependent on social issues. There is an unequal access to water as those with good political connections can influence the decision-makers to their own benefit. A local man in this position said in the interview that he would not have a tap in his house unless he did not have the right contacts. The access to water is defined by power relations and this includes the unequally gendered land ownership. Women own land only through marriage because land is inherited from father to son. As men own most of the land they are in a position to decide who can use the springs and rivers that are in their land. However, women put more time on fetching water as men are more likely to be employed. In the study area, the respondents indicated that everyone in the family participate in collecting water, which was also observed when visiting water collection points.

Currently, water provision is being privatised which is putting people in an unequal position as not everyone can afford paying for the water. Some of the respondents had a tap in their backyard, but no water in it because they had failed to pay their bill. The community funded water projects can provide water for a considerably cheaper price but of course the water supply is highly dependent on rainfall as the water pipes come directly from the source and not via water tanks. Water tanks and dams have also been installed by NGOs or foreign government agencies. However, according to locals the maintenance of these installations is insufficient. The office of Plan International in Mwatate closed recently and after that, the dams built by them are becoming silted and will probably not work for long. In community funded projects, the maintenance falls on the community members themselves who often do not have the technical knowledge or tools to repair the water installations (Fig. 25). There have been some improvements as well. For instance, in Chawia a new shallow well (Mwaroko) has been built for humans. Before, animals and humans used the same water source which was considered unhygienic.

Figure 25 In many cases the maintenance falls on the community members themselves, who might not have the technical knowledge or tools to repair the water infrastructure. These pipes on the top of Kiangungu hill were leaking and a group of drunken men came to fix it since their village had been without water for 3 weeks. (Kivivuori 2013)

Figure 26 Abandoned tap in Ronge on the way down to Mwatate from Chawia. In the neighbourhood there is also a water tank, funded by Danida that has never contained water. (Kivivuori 2013)

Locals often complain about the rationing of water and wonder why the water providers do it. Some have water tanks in their households and can store water and have a constant water supply. Those who cannot afford the storage tanks have to fetch water from the river or a spring. How far they go depends on the season. At the time of the fieldwork period there was a bad drought in Mwatate. Not a single tap lower than the centre of Mwatate had water in it. People travelled far to get water and used salty water from boreholes for cleaning. The drought even reached Wundanyi and town dwellers told that they have water once a week in their tap.

When the heavy rains eventually begin, the informants told that many water-borne diseases, such as diarrhoea and typhoid spread among the population in the lowlands in particular. The staff of the hospitals and health centres confirmed this information.

5.2.2 Explanations for the environmental changes

The most common explanation heard on the field for the changes in water adequacy and rains, is the planting of exotic tree species and the destruction of indigenous forest. Older people remember how there used to be so much more forest around. Cultivation right next to the rivers are also seen as contributing factors for decreased water levels. Although, people claim that conservation of the river banks should be enhanced, many have to cultivate there because the plots are becoming smaller after every generation. A few respondents indicate that global warming and climate change are the reasons behind the environmental changes and others say that climate change is not true at all. Religion plays a big role in the perception of the environmental changes. Some indicate that only God knows the reason for the changes, or then people go back to the traditional beliefs and say that the ritual of rainmaking has stopped, resulting in less rains. Surprisingly, many do not know the reason at all and are annoyed by the water rationing. Particularly in Wundanyi, people say that there is plenty of water and that they cannot understand why it has to be rationed. They blame the ministries and Tavevo for rationing without any reason. One respondent said that he thinks the water management is corrupted and that the leaders prevent the people to have good water.

Population increase, together with the increased use of water due to higher standard of living is seen as reasons behind the environmental changes as well. When more people have moved to the area, trees have been cut for agricultural land and water demand has

increased simultaneously when water levels are declining because exotic fast growing trees are planted for timber. In certain areas, especially in the lowlands, people are desperate to find new livelihoods and are cutting even the fruit trees for timber. This proves their need to prioritise everyday sustenance over potential future livelihoods.

5.2.3 Impact on livelihoods

This study shows together with many others, that the strongest asset of the rural communities in sub-Saharan Africa is the social capital. The weaknesses lie in the infrastructure and financial capital. The social capital should be considered in the development strategy plans in order to develop the community at all aspects and levels. In this study, the asset evaluation was conducted with a perspective of sustainable use of natural resources, mainly water. The starting capital for building infrastructure for water seems to be the main problem, without forgetting the cost of maintenance (fig. 25 and 26). At the moment, the focus is still on supply-side management as the plans are to construct new dams to provide water for irrigation.

In Mwatate, it can clearly be seen that people are more vulnerable to drought since the water provision has been privatised. They are completely dependent on water kiosks and vendors, and need money from mainly agricultural activity to pay for water. During drought nothing is growing, which brings them to be dependent on food aid. Nicol (2000) brings up the impact on human capital by increased access to water, which increases the demand, and in turn results in greater demand of labour power at a household level. More time is spent on collecting water as a result of improved access.

In the lower parts of the Taita Hills, in Mwatate area, the groundwater is already salty which creates considerable challenges for people's everyday lives. The world's biggest sisal estate is located next to the rural centre of Mwatate and uses enormous amount of water for irrigation which is a fact that cannot be ignored. There have been land conflicts between the sisal estate company and the local population because in the 50s, the British government built the plantation and grabbed the land from the locals. Up until today, the sisal estate is managed by Europeans, who constructed a closed area for the sisal estate workers. There are schools, shops, and houses to attract workers from all over the country and there are in fact people in Mwatate saying that they grew up on the sisal estate and have never seen anything else. During the time a few weeks before the elections it was difficult to agree on an interview with the manager. It is understandable

that they were extremely careful in all their statements and before speaking to us, wanted to make sure that our report would not be published before the elections. For the people who do not work at the sisal plantation, but live in Mwatate, do not benefit from the business. The sisal estate is a closed area and as it is owned by Europeans, the profit does not stay in Mwatate. The workers do not even shop in Mwatate because they have their own shops inside the estate. In addition to this, it remains unclear whether the sisal estate mainly uses their boreholes or the Mwatate dam for the production. The dam was constructed at the same time when the sisal estate was founded in the 50s. The manager claims that they let cattle come down to the dam for water at dry spell. Otherwise the dam does not benefit the locals in terms of small-scale irrigation in the fields of the locals.

Rural development as a concept cannot be considered to cover the development in the Taita Hills, since the mountains have affected the development over the years. Mountains create isolated villages with their own dialect. Decisions on catchment protection are taken without any cooperation with the other villages in the catchment or in the neighbouring catchments. Agriculture requires adaptive methods for steep hills and the critical part of it is to somehow keep the water on the fields and prevent landslides and land erosion. In the Taita Hills, it was mentioned several times that the community lacks financial assets to make long term investments in sustainable agricultural methods, such as flat-bed terracing.

Looking at the general wealth figures and from what was observed, it seems that the higher you go, the wealthier the area is, up to a certain point where the hills become too steep and vegetation cover reduces. Water does not stay in the highest areas and these areas are also remote with isolated people. The interesting part is to discover the ideal altitude. The livelihood analysis show that Wundanyi is better off than Mwatate and that the rural centre of Wundanyi has the strongest assets when it comes to a sustainable lifestyle. This is a very subjective way to look at development, but from observations and interviews it can be pointed out that Wundanyi centre in fact is wealthier and have better access to water compared to the other sub-locations and locations.

Basically, the reduced water resources and unpredictable rains hit hard on the farmers. Their main livelihood is less profitable every year and locals must look for alternative livelihoods. Some of the respondents said they do small-scale business, get financial

support from their children who are employed, or other casual work that they can find. Fish ponds are presented as a new form of livelihood that is easy to practice next to farming. Fish ponds are becoming more popular, but they still require a relatively big starting capital that many do not have. There are some fish ponds that have shared ownership to share the costs.

5.2.4 How can local knowledge through PGIS support decision-making?

To return to the last research question, the digitalised maps work as a bridge between technocrats and the locals. The maps enable decision-makers to understand how the people living in the area perceive the water resources and the impacts of certain events on them. Maps are a concrete way of showing the environmental changes and where problems occur. In the Taita Hills these maps show how small the indigenous forests have become and which areas should be protected in order to provide potable water also in the future.

In figures 23 and 24 the issues mentioned in the Water and Livelihoods –workshops are digitalised from the post-its placed on the sketch maps. The idea with these maps is to bring the local knowledge of water-related problems and their solutions to the attention of the people outside of the community. Hence, this study with its results links the locals' perception with governmental institutions on which the water management falls. The persons in charge of the local water management are not familiar with the area and need exact maps and figures on the issues. The link between the locals that are affected by worsening water quality and adequacy, and the government is deficient. One of the reasons is the lack of means of communication concerning water management. Other reasons could be corruption, untrained officers, lack of detailed guidelines for each county and district etc. The involvement of the locals in the decision-making is particularly important in the Taita Hills where the locals can offer significant information on the water resources.

6 Methodological discussion and the social aspect of water

This chapter combines the results with the presented theories and discusses how appropriate the methodology is in the attempt to answer the research questions.

6.1 The reliability of the results

In this thesis the methods used were semi-structured interviews, participatory mapping, transect walks, timeline drawing, group discussions, and PGIS. The combination of these methods is discussed here in the light of the reliability of the results obtained.

In ethnographic research conclusions are drawn from the interviews and observations from the interview sessions (see analysis in chapter 4.3). This brings up the question about the quality for the ethnographic and field research (Sangasubana 2011). Power relation between the interviewer and the respondent was already touched upon earlier, and the kinds of relations that existed in the field work are discussed here. Much research has been conducted in the Taita Hills and the villagers are used to having researchers around their houses. The problem with this is that locals have worked out a way how to respond to an interviewer and they have learned what kinds of answers are wanted. It was obvious that some respondents had participated in research before and knew how to please the researchers, sometimes in hope for compensation. This is a fair expectation towards the Western researchers, as the results should benefit the communities to avoid exploitation of information, but the responses do not always reflect the reality. The politics played a big role in the attendance of the workshops. Political parties offer food and even money at their events and so locals sometimes thought that our workshops had to do with the on-going elections and were delighted to participate because of the food and money. We only offered food and covered their travel costs. In the group discussions, knowledgeable persons affected the other participants' opinions because they wanted to show our Western research team that they are aware of the issues in their area and their causes. One local facilitator in the Mwatate workshop clearly helped the other group members to respond in a certain way.

The validity of the research is assured through collaboration with other team members of the Taitawater project, and the locals who are reading the project reports to check if the local perspective is accurately presented from the data. Sangasubana (2011) points out that objectivity can be difficult to obtain in ethnographic research because the ethnographer spends long periods of time on the field. The field work for this thesis only lasted for two months and the respondents were mostly people we had not met before. Therefore, there was not a risk of losing the objectivity during the interviews. Of course, towards the end of the field work period the culture became more familiar, resulting in a risk of becoming too attached to the people and their concerns and become more a participant, rather than an observer of the everyday life (Sangasubana 2011).

The livelihood capital scoring for Wundanyi and Mwatate catchments is rather difficult with the data that was gathered. The data from the Wundanyi catchment was divided into sub-locations and the data from the Mwatate catchment only into locations. The size difference between the two is considerable (Fig. 3), but still there were more respondents in Wundanyi catchment. This means that fewer respondents represent a larger area in the Mwatate catchment, which was also the case in the workshops. However, the respondents from the Mwatate catchments can be considered key informants; at least those represented in the workshop because they were from active community groups and represented the people in their home village. The livelihood assets were scored similarly in both catchments. However, in the Wundanyi catchment sub-locations were compared, when in the Mwatate catchment comparison could only be done at a location level. More interviews would be needed in the Mwatate catchment, but still it was reasoned that the results would not change much from what has been seen from the existing data. For future research not as many interviews are needed from one catchment as in this study from Wundanyi. Key informants are more time efficient and workshops are an informative method to gain information about the locals' perceptions.

The scoring of the livelihood capitals (Table 11) is completely subjective, which should be noted when interpreting the spider-web diagrams. The criteria must reflect the local culture and norms, not the Western ones. To be sure of the scoring criteria we consulted the local research assistant in Taita, who were with us in all the interviews and who was born and raised in Taita.

The livelihood capital scoring is clearly a top-down method as it was not done in a participatory manner in this study. The livelihood analysis in the context of rural development is only one way of presenting the data and completing the ethnographically analysed parts. The main difference between the two is that ethnographic research gives a voice to the locals compared to the livelihood asset scoring where the scores are calculated quantitatively looking at the community from an outside perspective.

Methodologically, this research can be considered multidimensional and although the livelihood analysis is very subjective it supplements the ethnographic data well. Participation was a main part of the data gathering and will be completed by distributing

the results back to the participants in Wundanyi and Mwatate. The research team will travel to the study area in February 2014 and will organise a seminar where local farmers, business women/men, village chiefs, ministries etc. can join and be informed of the findings. They will still have a chance to comment on the results that will be written in the final project report.

6.2 Enough water for everyone and the accessibility to it

The unequal access to water is based on the social relations. The poor cannot afford to pay for the water. Those who can pay might be able to install a tap in their backyard, but even money is not enough. The personal contacts to the decision-makers provide the most reliable water supply to the household. In the upper parts of the Taita Hills it has been observed many times that there is plenty of fresh water. As the upper area is supplying water for the lowlands as well and the surroundings it is the responsibility of the people living there to protect the catchment and leave enough water for the people in the lowlands. At least avoid polluting the rivers.

In the upper parts of the Taita Hills, the access to water is often determined by social networks between the water users. When it comes to the lower areas the relation between upper and lower parts becomes determinative. This research shows that the social aspect of the water issues is even more crucially divides the access to water among the locals. Many respondents in Wundanyi said that there is plenty of water, and that they have no problem with getting water. On the other side of the hill people are complaining that they have to rely on river water that is sometimes very dirty. The water availability varies much locally due to the hilly landscape but most importantly is determined by the decision on where water pipelines are dug. Poverty hinders the installation of a network that would cover the whole area. Gravity-fed water systems limit the water provision as well and new technique should be developed for those areas that are above the water tanks. The water resources firstly should be fairly shared among people.

The need to prioritise short-term investments over conservation of the water resources is a second social issue that limits the water availability and accessibility. There is knowledge on catchment protection and the link between indigenous forest and water among the locals. This can be proved through the numerous CBOs that exist in the Taita Hills. These are active groups that promote the importance of indigenous forest and

even plant trees. CBOs have little connection with the decision-makers and can therefore not expand their activity to for instance organise educational events for local farmers. There is also knowledge about the traditional farming methods that in many cases seem more appropriate for the climate. However, changes in the seasons must be taken into account and many informants told that farmers need further education on how to farm in the changing circumstances. The empowerment of the locals in order for them to gain access to water is essential in order to make catchment protection activities possible for them. Through this research one step towards empowerment has been taken as the locals' voice is turned into scientific information.

The interest towards ecosystem services differs between local stakeholders and global actors, as the latter seem to value biodiversity more than the locals who value the resources provided by the forests (Ruuska 2012). To this I would like to add that there are differing interests between public and private actors as well. The public actors, being the government and the ministries, value biodiversity more than the private ones. This applies for all environmental protection and here also the protection of the water resources. Before Tavevo came to the area it was the ministries that took care of the water provision. A privatisation of the water resources is a global trend and seems to be reality also in the Taita Hills.

Investing in rain-fed agriculture (Rockström et al. 2010) brings a fresh side to the discussion about solutions that would benefit everyone and that would not deplete the water resources. Developing the farming methods for rain-fed agriculture sounds more logical and cheaper than to build new dams and irrigation schemes. However, in the workshops promoting rain-fed agriculture was not mentioned by anyone. The common interest lies in developing better irrigation systems so that the agricultural production can be increased. For further research it would be interesting to answer the following questions: how much water can be used for irrigation so that there still is enough water for domestic use? Is irrigated agriculture the solution for bringing in money to the community so that better water providing systems can be installed to increase the availability and accessibility of water?

7 Conclusions

This thesis has investigated the reasons for decreasing water availability and accessibility from a local water user's point of view. In this investigation, the aim was

to assess how the Taita population experiences the current water resource managements and how they explain the environmental changes. Methodologically, the thesis aims to test the suitability of PGIS for water management purposes and how it can bring local knowledge and bureaucracy together. Further, the aim was to discover how local knowledge could be integrated with scientific knowledge in institutional policies, such as the Water Act 2002.

Returning to the questions posed at the beginning of this study, it is now possible to state that the perception on the water resources and the decline of water levels are explained differently according to the livelihood assets. Through a livelihood asset scoring and wealth ranking from a sustainable development point of view, it is clearly visible that the stronger livelihood assets a person or a community has, the more scientifically the environmental changes are explained. In the other end, among people and communities with weak livelihood assets, religion plays a more significant role in the everyday life and the environmental changes are explained by God's will. The main differences in the sustainable lifestyle promoting livelihood assets can be found between gender, catchment, and even at a sub-locational level. The location is especially crucial in the mountainous area where the amount of rain and vegetation varies. The altitude determines the water adequacy and quality. Most water can be found in the valleys of the Wundanyi catchment. The villages located higher up are isolated and the soil is eroded due to forest cuts, which means that the soil cannot hold back the water.

To summarise, the main results were that the local population in the Wundanyi and Mwatate catchments perceive declining water levels to be a result of forest cuts, more specifically the destruction of indigenous forest. Population growth and a religious reasoning are common explanations for the environmental changes as well. The access to water is unequal in the sense that people with political connections can influence the decision-makers for their benefit. The gendered nature of land ownership also sometimes limits the access to water for women. The decreased availability of water pushes the inhabitants to look for alternative sources of income as the rain-fed agriculture is not profitable anymore. Fish ponds are becoming more popular next to agriculture. Many rely on casual work and support from employed children. PGIS allow technocrats and locals to understand each other through the digitalised sketch maps. As a result, more detailed action plans for water management can be composed. The most obvious finding to emerge from this study is the conflicting mental and physical

catchment. Locals see that the river from Wundanyi flows down through the Kishuche valley to centre of Mwatate. This inaccurate perception is dominant even among the people in higher positions. The local water and environment groups operate very locally in relatively small areas and there is little cooperation between the sub-locations and catchments. Currently, the inhabitants of the locations blame people in another location for destroying the catchment and there is a lack of understanding for certain acts between the locations. The Water and Livelihood-workshops brought together people from all over the catchments and representing different stakeholders. In a common discussion, interests of all participants were explained in order to achieve a common understanding of the main interests of different stakeholders. Through the participatory mapping session with its presentations it was quite well achieved.

The results of this case study support the idea that PGIS is a useful tool for bringing decision-makers and the local population closer to each other. PGIS can bring the local knowledge into decision-making on higher institutional levels when it is visualised in a map.

The current study was limited by the different amount of respondents in the two catchments and also by the significant size difference in the catchment areas. In future ethnographic research in the area, the amount of the informants should be the other way around in the catchments. The Mwatate catchment could actually be divided in two: Upper and Lower Mwatate, as it is divided administratively. For future research that includes interviewing and other participatory methods, it would be advisable to choose another area, since this one is becoming somewhat over researched. There are some remote villages in the Taita Hills where people have not yet had a chance to share their thoughts on the environmental changes that affect their lives.

This case study contributes mainly to the research related to issues concerning the water resources, but also to the research on land cover changes that up until now has used mostly remote sensing-methods. It is important to gather data from the ground as well and to involve the local population in the research. By a diverse use of methods a multi-dimensional overview of the Taita Hills can be achieved and the Taitawater-project is one channel to work on this. The development of the local communities should be the priority in all research conducted in developing countries.

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Appendix: Questionnaire form

Date:_____ Time:_____

Location:_____(x:_____, y:_____, z:_____)

ID code:_____

Interviewer(s):_____

Permission to record the interview: a) yes, b) no

Tunaomba kunasa mazungumzo baina yetu na wewe? a) Sawa, b) Hapana.

Name of the respondent */ Jina* (optional):

_____

Background questions: / *Maswali ju ya ufahamu/kufahamikiana:*

1. Gender: a) female, b) male, c) other / *Jinsia: a) mke , b) mume , c) ingine*
2. Year of birth / *Mwaka wa kuzaliwa*:_____
3. Place of birth / *Pahala wa kuzaliwa*:_____
4. Nationality / *Uraia wako:*_____
5. Tribe / *Kabila lako* or ethnic background / *Maelezo kuhusu jamii au ukoo wenu:* _____
6. Number of years in Taita */ Umeishi Taita kwa miaka ngapi:* _____
7. Education: a) no formal education, b) primary school, d) secondary school, e) vocational school, f) university, g) other, what? / *Elimu: a) sikusoma, b) shule ya msingi, c) shule ya upili, d) chuo cha ufundi , f) chuo kikuu, g) Chuo kingine kama kipi?*_____
8. Occupation/job title / *Jina la taaluma/kazi yako:*_____
9. Marital status: a) single, b) married, c) divorced, d) widow/er
   Hali ya ndoa: a) Hajaolewa na ana watoto, b) Ameolewa ,c) wameachana d) amefiwa na mpenzi wake
10. Religion: a) Christianity, b) Islam, c) Hinduism, d) Atheism, e) Other_____
    *Dini: a) Mkristo, b) muislaamu c) muhindu ,d) traditional believers [wapenda utamaduni] e) ingine*_____
11. Number of children a) at home:_____, b) at school, c) at work_____ */ Idadi ya watoto na umri wao*_____
12. Do the children's grandparents live with you?_____
13. Are there any other people living in your household?_____
14. Animals and livestock owned / *Wanyama na Mifugo iliyoko*
    _____

Water use: / *Matumizi ya Mji*:

15. Can you get water from your own homestead? a) yes, source _____, b) no, c) sometimes, source _____

Waeza pata maji kutoka kwako nyumbani? a) Ndio, yanatoka wapi?_____ b) Hapana c) wakati mwingine, yanatoka wapi?_____

If not, where do you go to collect water?_____

If not, how far do you have to go to collect water? *Iwapo jibu ni la au hapana je ni umbali gani wewe huenda kuteka maji?*

_____

How long does it take for you to go to collect water and come back home? *Nimuda (dakika au masaa) gani wewe hutumia kwenda kuteka maji na kurudi nyumbani?*_____

How often do you need to go there?_____

16. Do you use water from certain sources for certain purposes? (Sources: 1=tap, 2=river, 3= well, 4= spring, 5= borehole, 6= vendor (bottled water), 7= rain water, 8 = dam, 9= other source, which?)

Niwapi hasa munapata maji kwa matumizi yafuatayo: (chaguo: 1=mfereji, 2=mtoni,3=kidimbwi, 4=chemichemi, 5=yaliyo chimbwa kwa mashine, 6= mchuuzi wa rejareja wa maji,7= maji ya mvua 8=shilanga, 9=njia tofauti, kamagani?)

drinking / *kunywa*_____
cooking / *kupikia*_____
washing the dishes / *kuosha vyoumbo*_____
bathing / *kunawa*_____
doing laundry / *kufulia nguo*____
cleaning the house / *kusafishaa nyumba*____
irrigating the crops / *kunyunyizia mimea*____
giving water to the animals / *kunywesha mifugo*___

Aside from tap or bottled water, do you pay for water you use (coming from other sources)? _____

Kando na maji ya mfereji au yaliyo hifadhiwa kwa chupa, kuna maji mengine wewe hulipia ambayo wewe hupata kutoka sehemu tofauti?

_____

17. Do you believe the water you use is pure and drinkable? *Ni jinsi gani wewe hupata kufahamu kama maji haya ni masafi na mazuri yakunywa?*

_____

18. Do you use any purification method for the water before you use it? a) Yes, always, b) Never, c) Sometimes. Which method? _____

*Kuna njia wewe hutumia kusafishia maji kabla ya matumizi? a) Ndio, kilawakati, b) Hapana kabisa, c) Wakati mwingine. Ni njia Zipi Hizo?*_____

19. How much do you pay for water per month on average? *Kwa kiwango cha wastani au kadri, kwa mwezi mzima wewe hulipa au hutumia hela ngapi kama malipo yako Kwa matumizi ya maji*?_____

Is that a fixed price or calculated according to your water consumption?_____

Do you have to pay the same amount even if you do not get water every day?_____

Do you have a water meter?_____

20. Does your family collect rain water from the roofs of your homestead? a) Yes, always, b) Never, c) Sometimes.
    Je, familia yako huwa ina hifadhi maji ya mvua kutoka kwa paa za nyumba yako? a) Ndio, kilawakati, b) La / Hapana kabisa c) wakati mwingine.

    If you do that, for which purposes you use that water? *Iwapo una fanya hivyo, je maji haya unayatumia kwa matumizi gani?*
    _____

    If you don't do that, why? *Iwapo hufanyi hivyo ni kwa sababu gani?*
    _____
21. Where do you dump your waste water? *Maji taka au machafu wewe huyamwaga au huyatupa wapi hasa?* _____
22. Do you recycle water? a) Yes, always, b) Never, c) Sometimes.
    Kuna vile wewe hurudi kuyatumia maji yako tena baada ya matumizi ya awali? a) Ndio,kilawakati, b) Hapana kabisa au, la, c) Wakati mwingine.

    If you recycle, how do you do it and for which purposes? *Iwapo wewe hurudi kuyatumia maji hayo, Ni mbinu zipi wewe hutumia na maji hayo wewe huya tumia kwa shughuli zipi hasa?* _____

    If you don't do that, why? *Iwapo hufanyi hivyo ni kwa sababu gani hasa?*
    _____

Water related hazards: / *Mambo yanayohusu maji:*

23. Could you describe the problems you have experienced with water?
    _____

    Do you think you and your family have enough water to use for everything you need? a) Yes, always throughout the year, b) Only during the rainy season, c) Irregularly, d) Never
    Wafikiri kua munayo maji yakutosha kama familia kwa matumizi na mahitaji yenu yote? a) Kilawakati kwa kipindi cha mwaka mzima, b) Wakati wamvua pekee, c) si kila wakati [kibahati], d) La / hapana kabisa.

    Have you experienced any health problems because of the water you use? a) Yes, always, b) Never, c) Sometimes.
    Umewahi kupatwa na matatizo yeyote kutokana na matumizi ya maji? a) Ndio, kila wakati, b) La / hapana kabisa, c) Wakati mwingine.

    If you have, what problems? *Iwapo ni ndio, je ni matatizo gani hasa umewahi kumbana nayo?*
    _____

24. Do you know anybody who has drowned? a) Yes, b) No, c) Not sure.

    If you have, why do you think it happened? _____ Where did it happen? _____

When did it happen? _____
Was it because of flood or in normal circumstances?
_____

25. Have there been any conflicts caused by water in this area?
_____

Water management:

26. Which do you think are the biggest threats to the water supply in this area? *Ni changamoto zipi hasa mnakumbana nazo hasa Kama tishio katia usambazaji wa maji eneo hili?*_____

How do you think that affects water resources?
_____

(If mentions cutting down of the indigenous forests:) Were there more indigenous forests in the Taita Hills when you were a child? *Je, kulikuweko na misitu mingi ya kiasili au kienyeji hapa milima ya Taita wakati ulikua mdogo?*

_____

27. What can you do to save water?
_____
28. What can you or your community do to make sure that everybody has enough clean water?
_____
29. Do you belong to any water users' association?
_____
30. Do you know any good sources of water, which could be used more efficiently in your area? (springs, for example)? *Wajua sehemu nzuri maji yapo na yaweza tumika vyema katika eneo lako kwa mfano chemichemi au Mito midogo?*
_____
31. Do you know if there are any water projects in this area? Which projects? What do they do?
_____
_____
32. What improvements you think should be made to a) the water supply system b) waste water treatment system and c) general water resources management in this area?_____
Ni mambo gani wafikiri yastahili kufanywa au kutekelezwa ili kuboresha, a) usambazaji wa maji,b) mambo yanayohusiana na maji taka au maji machafu na, c) usimamizi wa miradi ya maji katika eneo hili?

Land use:

33. In whose name is your compound?
_____
34. Are you allowed to cut down trees from your compound? a) yes, b) no, c) I'm not sure.

    Do you need to get a permission to do that? a) yes, b) no, c) I'm not sure.

35. Are you allowed to do whatever you want on your compound? a) yes, b) no, c) I'm not sure.
36. Is there a river or a spring on your compound? a) yes, b) no, c) I'm not sure. Do you own it? a) yes, b) no, c) I'm not sure.

Are you allowed to cultivate or cut down vegetation from the river banks? a) yes, b) no, c) I'm not sure.

37. Does your family cultivate land? _____

    If it does, where are your fields?

    _____

    What do you grow in your field?

    _____

    What kind of irrigation system do you use?

    _____

    Why do you use that method?

    _____

    What do you think of the traditional irrigation methods?

    _____

38. Does your family practice fish farming? *Je, nyinyi ni wafugaji wa samaki kataki familia yenu?*

    _____

    If it does, where do you get water for the fish pond?

    _____

    How often do you change the water to the fish pond?

    _____

39. Who is involved in farming in the family?

    _____

40. Do you cooperate with other farmers? (e.g. irrigation, tools, association)

    _____

41. Do you use a) pesticides, b) fungicides or c) nutrients in your fields or in your fish ponds? *Huwa munatumia madawa ya kuua wadudu,magonjwa au yakuongeza madini shambani au kwa vidimbwi vya Samaki?*

    _____

42. Are there any rules that regulate what you can grow in your field or how much you can irrigate, use pesticides etc.?

    _____

43. Which are the public officers you need to deal most with?

    _____

44. Do you have a relation with big farming companies?

    _____

45. What is the most difficult resource to get for farming? (water, seeds, nutrients, etc.) Why?_____

    Do you have suggestions to improve your accessibility to those resources?

    _____

46. Do you sell any surplus production of what you grow or do you use it all by yourselves?_____

    What do you get in return? What do you buy with the revenue?

    _____

47. Do you have complementary forms of livelihoods?
    _____

Timeline questions:

48. Has your family been practising this activity for generations?
    _____
49. Have you witnessed any major changes in terms of resource availabilities? (e.g. any natural or political change: droughts, laws, arrival of commercial enterprises etc.)_____

    What are the historical moments that you know have changed water quality and quantity?_____

    Do you think a) flooding _____ b) droughts_____ or c) rainy seasons _____ have changed compared to the past?

50. What do you think is causing the change? *Kwa mawazo yako mwenyewe, nini hasa wafikiri kina sababisha mabadiliko haya?*
    _____
51. Do you think you are richer or poorer than your parents and grandparents?_____
52. How do you see your future? e.g. in 5 years, 10 years etc._____