Practical Application of Integrated Water Resources Management in the Chikwawa District, Malawi

An economic and social evaluation of locally available resources

(14,599 words)

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I hereby declare that I am the sole author of this work and that I have fully acknowledged and referenced the ideas and work of others used in this dissertation.

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ABSTRACT

Being guided by the paradigm of Integrated Water Resources Management, this dissertation explores the extent to which communities in rural Chikwawa, Southern Malawi can pursue the path of sustainable development by maximising utilisation of local resources. Within that approach, channelling wasted borehole water into borehole gardens does not only reduce breeding grounds for malaria-carrying mosquitoes but also assists to regain the resource's otherwise lost value by boosting permaculture borehole gardens. Further following the IWRM notion, producing eco fertiliser derived from human manure would not only eliminate potential groundwater-contaminating faeces from the ground but would also provide an alternative to chemical fertiliser, which supports unsustainable farming practices due its detrimental effects on soils and related natural systems. The third aspect of this dissertation captures distance and time savings between 2011 and 2014 that women involved in water-collecting duties gain due to an increased borehole density. While women use attained time for cleaning and recreational purposes contributing to improved sanitation and well-being standards; undertaking income-generating activities in permaculture gardening can provide an effective tool to gain independence over gender-related inequalities. Quantitative and qualitative research was undertaken in Timbenawo, Chikwawa and Blantyre City between May 31 to July 10. Findings suggest that the Chikwawa District has a vast economic potential to integrate resources under IWRM, however social barriers will need to be tackled in order to wholly exploit this potential prospectively.

Key words:

IWRM - Permaculture - Sustainable Development - Local Resources - Boreholes - Eco Sanitation - Gender - Community level - Chikwawa District - Malawi

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Acronyms

EC	Electric Conductivity
Ecosan/Eco sanitation	Ecological sanitation
FLOW	Field Level Operations Watch
GV	Group Village
GWP	Global Water Partnership
ICESCR	International Covenant on Economic, Social and Cultural Rights
IGAs	Income-generating Activities
IPM	Integrated Pest Management
IWRM	Integrated Water Resources Management
MKW	Malawian Kwacha
UN	United Nations
UNDP	United Nations Development Programme
USDA	United States Department of Agriculture
SADC	Southern African Development Community
TA	Traditional Authority
WPC	Water Point Committee

Chapter 1
INTRODUCTION

"To waste, to destroy our natural resources, to skin and exhaust the land instead of using it so as to increase its usefulness, will result in undermining in the days of our children the very prosperity which we ought by right to hand down to them amplified and developed."
— Theodore Roosevelt (in Maczulak, 2010:120)

Following Roosevelt's quote, this dissertation is to explore the capacity that rural communities in the Chikwawa District, Southern Malawi hold to pursue sustainable development by maximising the use of locally available resources. Within that notion, the extent to which the concept of Integrated Water Resources Management (IWRM) is entrenched at community level in rural Chikwawa shall be investigated. Furthermore, it is aimed to identify opportunities that the region holds to further consolidate the IWRM paradigm within the region's future development progress. Following the research topic identification, this chapter provides a rationale outlining this dissertation's academic relevance by identifying region-specific study needs. The use of two key terms and concepts that frame this dissertation are then defined in order to create a basis for emerging discussions within the following chapters and lastly, this dissertation's structure shall be outlined.

1.1 Topic identification

The focus of this research lies on identifying opportunities for the Chikwawa District to make efficient use of a selected number of local resources that currently remain widely untapped. To do so, this dissertation undertakes an economic and social evaluation of Chikwawa's capacity to channel respective resources into sustainable food production following permaculture strategies. In line with that enquiry, this investigation regards wasted borehole water as a resource that can be used to water crops; values human faeces as a resource rather than a waste product that can be converted into organic fertiliser; and views women's reduced travel times for water collecting purposes (due to an increase in borehole density over the past years) as an opportunity for females to become involved in small-scale permaculture projects. Henceforth, this dissertation investigates in the addition and regain of values that otherwise remain lost. The diagram in Figure 1.1 indicates the predicted positive implications that communities can be expected to experience when making effective use of the aforementioned resources.

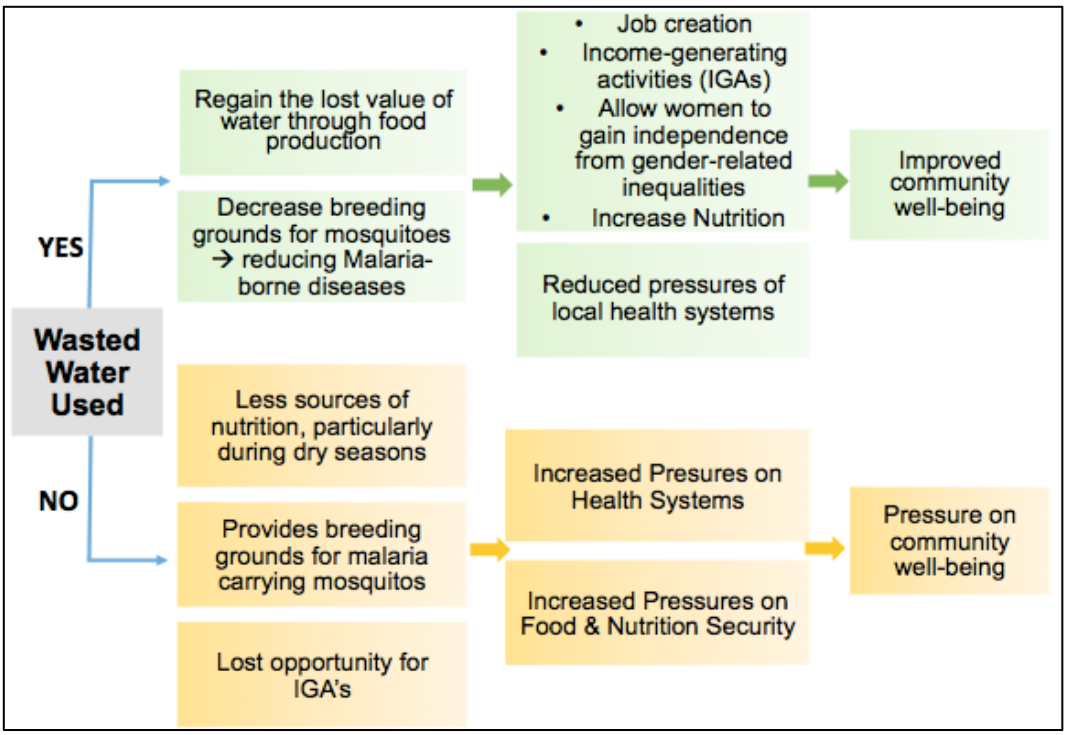

Figure 1.1: Expected benefits from sustainable local resource utilisation

1.2 Clarification of Terms and Concepts

1.2.1 Integrated Water Resources Management

This research is framed and guided by the concept of Integrated Water Resources Management (IWRM), which is a concept that:

> „... promotes the coordinated development and management of water, land and related resources in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.“ (GWP, 2013)

By facilitating decision-making processes to occur at local scale through a community-driven approach, IWRM's cross-sectoral approach manages water demand and supply of all directly and indirectly related stakeholders (SADC, 2009). This bottom-up approach to water management allows carving the path of sustainable development at community level according to communities' individual needs and opens opportunities to improve different yet essential aspects of well-being (SADC, 2009). Yet, there are numerous authors that allege that IWRM's theoretical facet is much more established than its practical application arguing that "[t]here are too few good [best practice] examples of IWRM from which to draw on… " (The Institution of Civil Engineers *et al.*, 2011:13, Olayinka *et al.*, 2014, Morin and Cantin, 2009). Hence, the following Chapter will critically evaluate IWRM's robustness to guide this research, and will subsequently investigate how this dissertation can contribute to add robustness to the practical application of the IWRM concept at community level.

1.2.2 Permaculture

Similar to IWRM, Permaculture also encourages sustaining utilisation of natural resources (Holmgren, 2007). The term was coined in 1978 by Mollison & Holmgren and constitutes a philosophy rather than just a gardening technique promoting decentralised sustainable food production (Veteto and Lockyer, 2008). Permaculture is given significant importance within the framework of this investigation because increased food and nutrition security is absolutely crucial for development and is recognised to form the base for most other aspects of human well-being (Academic Interview Participant C, pers. comm. 10 July 2014; Practitioner Interview Participant A, pers. comm. 27 June 2014).

With respect to this research, permaculture does not only promote the recycling of otherwise wasted resources such as excess borehole water but also endorses to utilise renewable local resources such as human manure "as a renewable source of [soil] fertility" (Holmgren, 2007:15). With regards to the gender-related perspective of this dissertation, permaculture projects throughout Sub-Saharan Africa have proven to counteract gender inequalities. For example, from the long-term Zimbabwean community project named Chikukwa Permaculture Project have emerged women social groups where women of all ages come together to openly share knowledge but also discuss and find solutions for positive or negative matters concerning their lives for example problems regarding domestic violence (Leahy, 2013). Increased food security and gender empowerment through permaculture has also been witnessed in Northern Central Tanzania where:

> "[Maasai] women increase[d] their average monthly incomes throughout the year (around 100USD) through sales of vegetables, creating autonomy and independence for women to provide for their families, improving general health and by proxy reducing disease through the consumption of green leafy vegetables"
> (The Permaculture Research Institute, 2014)

As Figure 1.1 illustrated and as endorsed by the previous paragraphs, establishing permaculture projects within rural Chikwawa can play an integral role to uplifting multiple dimensions of community welfare prospectively. Why the need for sustainable development benefiting from Permaculture and IWRM is vital in the Chikwawa District shall be emphasized as follows.

1.3 Regional Settings

Malawi as shown in Figure 1.2, is a small landlocked country in South-eastern Africa bordering with Tanzania in the north, Zambia in the west and Mozambique embracing from southwest to the east (British Geological Survey, 2004).

Figure 1.2: Map of Malawi and its neighbouring countries
(Source: After British Geological Survey, 2004)

The Chikwawa District (Figure 1.3) is located on the south-western fringe of Malawi. Despite geographic variations, the Chikwawa District's overall climate is tropical where average annual temperatures cluster around 26 degrees and precipitation dominates the summer months (Climate Data, 2014).

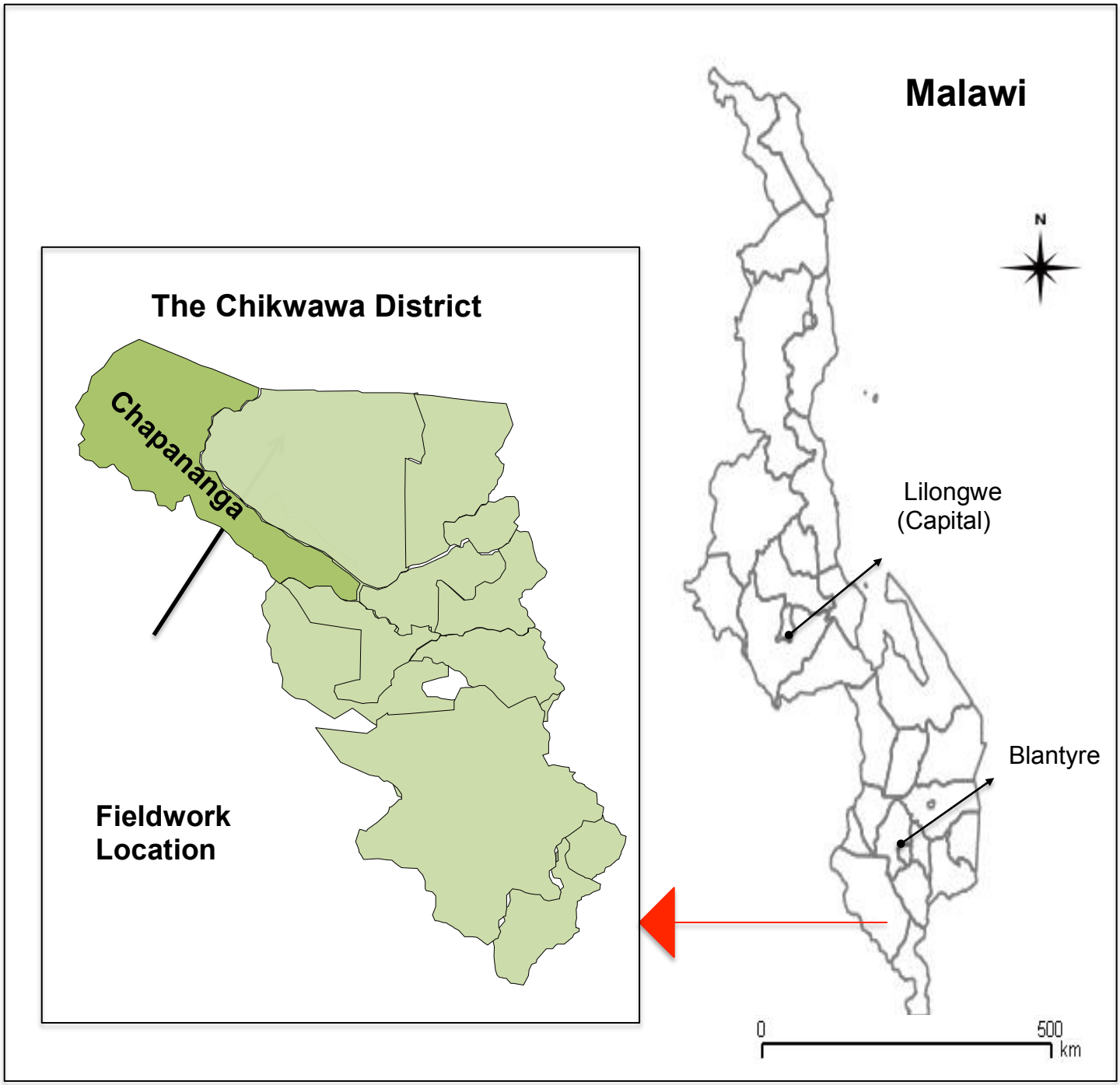

Figure 1.3: Location of the Chikwawa District within Malawi (After Chikwawa District Council, 2011)

Its region-specific settings urge to pursue practices that sustain the environmental, social and economic dimension of sustainable development. Poor farming methods including the use of industrial fertilisers account for topsoil depletion and degradation of nutrition security contributing to the destruction of the communities' habitat and well-being (Denning *et al.,* 2009). In addition, the large dependence on rainfall for food production makes rural communities vulnerability to the impacts of expected extreme weather events. Hence, evaluating a bottom-up approach to counteract environmental but also social and economic degradation becomes increasingly important given the local characteristics.

Fieldwork was undertaken in Malawi between May 30 and July 10. Quantitative data regarding water wastage quantification as well as a series of interviews were undertaken in Timbenawo Group Village (detailed map provided in Chapter 3.3.1), which is located within the Traditional Authority of Chapananga in the Chikwawa District (Figure 1.3). Additional interviews and two topic-relevant workshops were attended in Blantyre City during that time also. Document analysis was undertaken at the office of NGO *Water for People* in Blantyre, whose staff hugely contributed to the completion of this dissertation. Detailed consideration regarding data collection and processing methods is elaborated in Chapter 3.

1.4 Dissertation Outline

This dissertation revolves around potential for value addition following IWRM principles within the Chikwawa District. Chapter 2 facilitates understanding as to why this research channels attention towards exploring the alternative of a bottom-up approach for future development and subsequently evaluates the robustness of the IWRM concept to profoundly guide this community-driven attempt to sustainable development. Furthermore, this chapter will clarify why grey

borehole water, eco sanitation and gender were selected for this research to undertake an economic and social evaluation regarding the regions potential to pursue to sustainable development at local level. Chapter 3 will consequently reveal the methodological framework that was employed to approach this enquiry, outlining and justifying the choice of methodological tools that were tapped into for data collection and analysis purposes.

Chapter 4 will academically summarise and discuss results that have emerged from the conducted fieldwork. Within the scope of that chapter, the economic potential that each of the analysed local resources (grey water, eco fertiliser derived from human manure, and gender) possess shall be evaluated and be put into a place-based context that reflect social opportunities and barriers towards the integration of these resources under IWRM. The last section of Chapter 4 outlines ideas for a road map, which have emerged during interviews with a range of stakeholders but also result from field observations undertaken within the case study area.

The final segment of this dissertation, Chapter 5 summarises the Academic Literature Review, the Methodology as well as the Results & Discussion chapters, which comprise the main argument of this dissertation and reflect each other likewise. From the insights of these Chapters, the extent to which this dissertation was able to answer the underpinned research questions shall be analysed. The need for future study that emerges from this final discussion shall be addressed and be used to close this dissertation.

Chapter 2

LITERATURE REVIEW

Following the introduction of Chapter 1, this chapter provides the rationale describing the significance of this research by examining relevant academic literature. In this respect, it shall firstly be outlined why this dissertation considers the possibility of a bottom-up rather than a top-down approach to assist Chikwawan communities to pursue sustainable development. The second part of this Chapter explores and justifies the potential that wasted borehole water, eco fertiliser and gender-derived labour hold to contribute to a sustainable future in the Chikwawa District.

2.1 The Chikwawa District: A Need for Sustainable Farming Practices

2.1.1 Local settings

Agriculture is Malawi's largest economic sector with over 70% of all cultivable land being used for maize production, which is predominantly grown on smallholder farms (Asfaw *et al.,* 2014; SADC, 2012). Although not exclusively, extensive maize production has largely compromised soil fertility and superseded agricultural diversity at district level entailing dismal implications including malnutrition among local communities due to its low nutritional content (AMPP, 2013; Edwards et al., 2010; International Federation of Red Cross and Red Crescent Societies, 2013; Gilbert, 2012). In addition, irrigation systems are

widely absent causing unfavourable conditions for farmers where successful crop production largely depends on consistent rainfall during the rainy season. Denning *et al.* (2009) debate that these characteristics will continue to make Malawi extremely vulnerable to the implications of climate change, which is expected to increase extreme weather events such as floods, droughts, and dry spells.

2.1.2 Depletion of Arable Land

The 'Hunger Density Map' in Figure 2.1 below shows that Children (0-5 years) in Southern Malawi are more affected by undernourishment than those living in the northern part of the country. However, Figure 2.2 shows that Southern Malawi has available some prime land, i.e. highly fertile soils that are classified by the United States Department of Agriculture (USDA) as holding a high potential for sustainable development. Interpreting the assertions of Figure 2.1 & 2.2 proves that Malawi's most severe malnutrition partially occurs on prime farmland (University of Columbia, 2007; USDA, 1996). This can be accredited to poor farming practices and asks for a revolution of the agriculture sector. Sustainable farming techniques must be adopted that enable local communities to mitigate their vulnerability to future changes in climate events but also ensures sustainable year-round food and nutrition security at community level. With the IWRM philosophy being designed to facilitate communities to attain sustainable development (see Chapter 1.2), it is crucial to apply these principles as a leverage at community level to attain a balance where communities can lead a self-sustaining life supporting the well-being of the people and related natural resources.

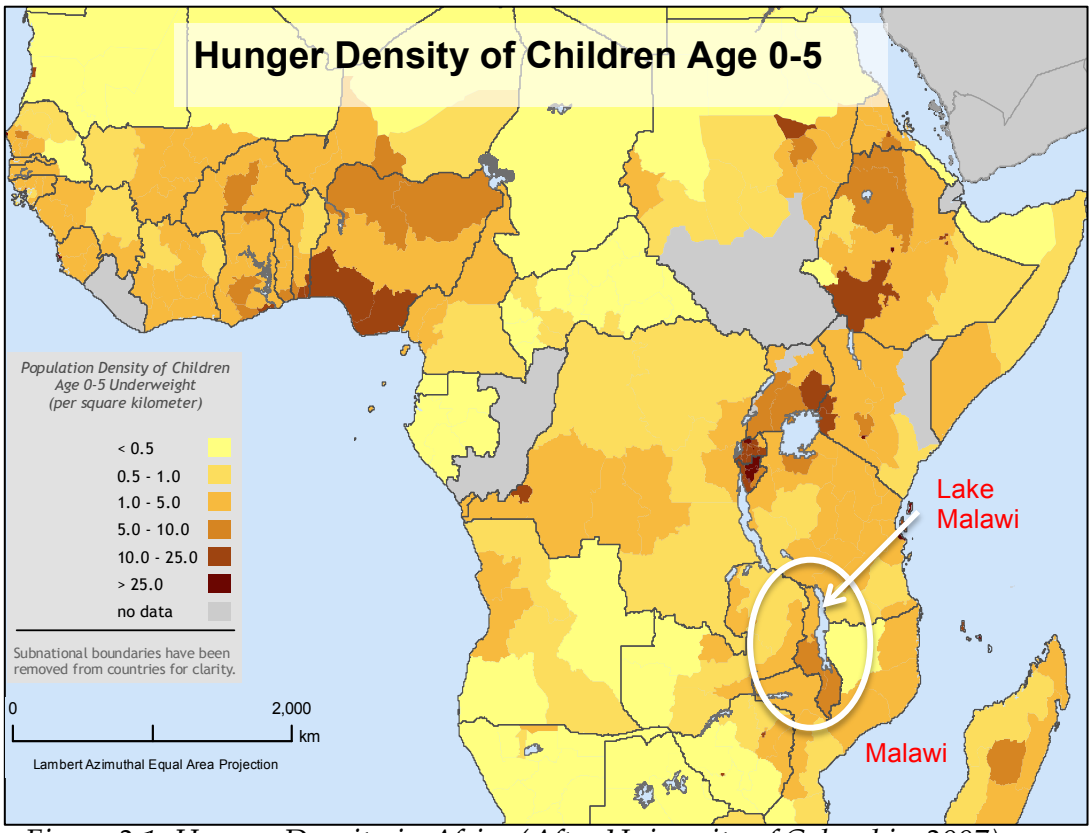

Figure 2.1: Hunger Density in Africa (After University of Columbia, 2007)

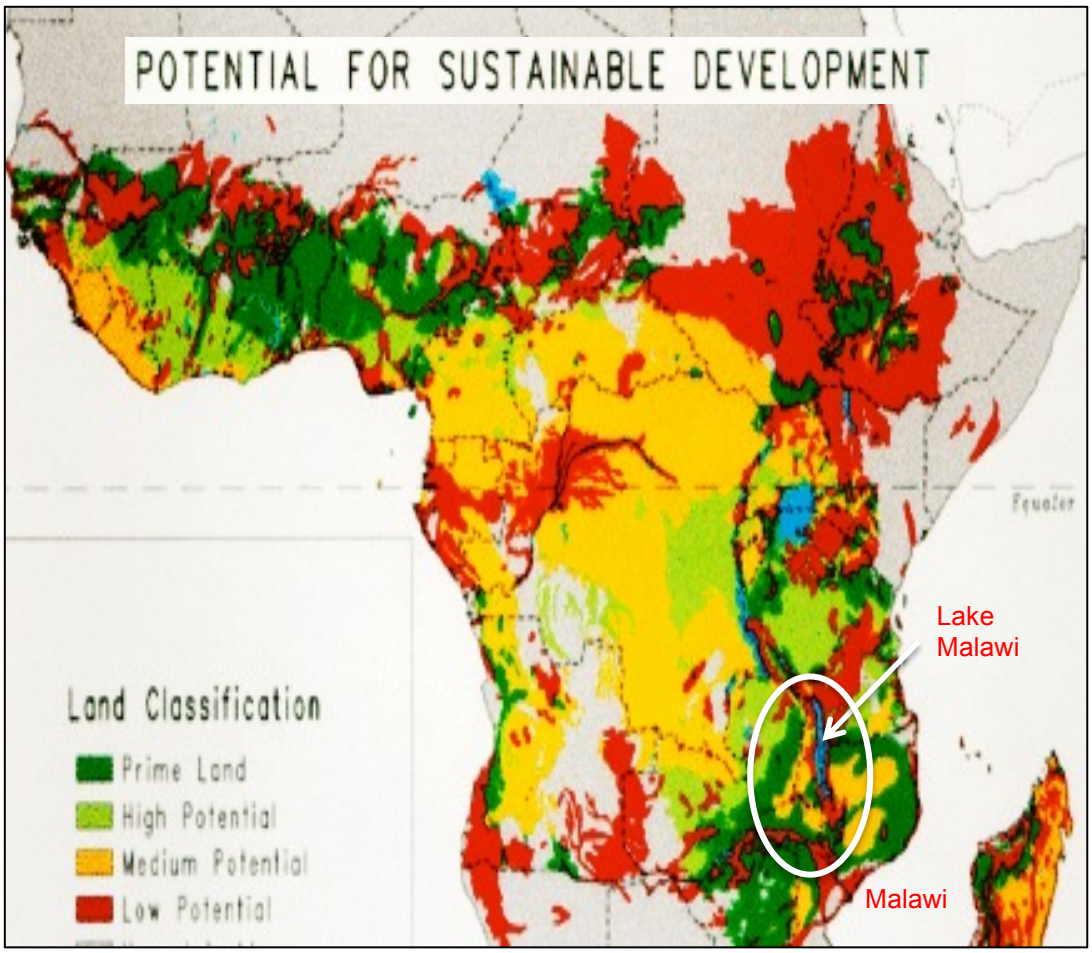

Figure 2.2: Potential for Sustainable Development in Africa based on soil fertility (After US Department of Agriculture, 1996)

2.2 Envisioning Positive Change

2.2.1 Questionable Robustness of IWRM Effectiveness at Community Level

Rahaman and Varis (2005) allege that challenges of IWRM continue to be closing the gap between theory and practical application of IWRM in the field. Within that notion, the authors (2005) find that profound sector integration creates a substantial barrier that hinders successful implementation of IWRM on the ground. However, the idea of utilising locally available yet widely untapped resources as investigated in this dissertation strongly depends on an interdisciplinary approach for its successful implementation. Therefore, quantifying the potential that the case study area holds regarding the integration of grey borehole water, eco fertiliser, and labour favouring sustainable food production provides an opportunity not only for local communities to gain economically, socially and environmentally, but also provides an opportunity to feed into an existing body of literature that invests research into IWRM best practice development at community level. Henceforth, respective literature examining a bottom-up approach to attain sustainable development, where motivation for positive change originates from within communities, shall be investigated as follows.

2.2.2 Bottom-up Approach Favours Sustainable Development

Swedish economist Erixon (2005) writes that „[i]n spite of more than US$1 trillion in aid to Africa over the last 50 years, the big push in development has yet to occur“. Erixon (2005) adds that the long history of aid has created a dependency where aid-receiving countries did not manage to establish themselves sustainably. Despite Malawi being a strong donor-influenced country where a large amount of financial aid has been received historically, Malawi still remains classified among the ten least-developed countries in the world (UNCTAD, 2013). This supports Erixon's (2005) assertion that argues that aid alone will not be instrumental to developing countries. The question that consequently arises is whether Malawi can attain positive development through a bottom-up approach.

Withdrawing financial aid from Malawi would likely cause a reallocation of power within societal structures. While a top-down approach is often regarded as crucial to communicate sustainable development from national to local level (UNESCO, 2009); Holmgren (2014) disagrees arguing the point that a grass-roots approach to bring about positive change will likely be more fruitful. In his approach, Holmgren (2014) argues that encouraging authorities to enforce policies favouring sustainable development at local level has shown to become increasingly difficult. Instead, Holmgren (2014) proposes the importance of community action. Applying this to the case study context, Holmgren (2014) recommends to implement and replicate large numbers of small-scale permaculture projects (Holmgren, 2014). Connecting Erixon's (2005) and Holmgren's (2014) approach with this research, the bottom-up approach that regards the use of local resources to boost permaculture facilities as a way to attain self-sustaining development can be expected to give local communities a certain extent of autarky that lowers communities' dependency on donor countries to provide financial aid.

2.2.3 Permaculture: A Tool to Entrench Integrated Water Resources Management at Community Level

Being a strand of IWRM, permaculture is more than merely an organic gardening technique. Rather, it appears as a philosophy that weaves interdisciplinary aspiration for sustainable living into its design principles (Holmgren, 2007). As discussed earlier in this Chapter, this dissertation aims to identify the potential that the Chikwawa District holds to integrate grey borehole water, eco sanitation and gender equality into sustainable food production. In doing so, it is likely that boosting permaculture not only allows for local communities to increase their environmental, social and economic wellbeing; it also provides an opportunity for IWRM practitioners to gain further knowledge regarding the practical application of the IWRM concept, as this has been argued to lack integrity (Rahaman and Varis, 2005).

2.3 Appreciating the Value of Grey Water

Section 2.1 of this Chapter outlined that rainwater availability in Malawi constitutes a major determinant for successful crop production due to the general absence of irrigation systems (Denning *et al.,* 2009). With the ramifications of climate change being predicted to become increasingly prevalent (Asfaw *et al.,* 2014), this strengthens the motivation of this dissertation to consider wasted water as a valuable resource that can contribute to a year-round sustainable and decentralised food production.

Adding grey water as a resource in permaculture gardening would widely prevent water from remaining stagnant on the ground. This is important as stagnant water provides breeding grounds for malaria-carrying mosquitoes (Ecological Society of America, 2011). With malaria being among the top leading causes of death in Malawi (Bowie, 2011), channelling water into gardens where plants' roots soak up excess water therefore means that the risk of malaria infections could potentially be drastically decreased. Once malaria-borne diseases are being lowered, this would consequently be expected to decrease pressures of local health care systems.

Furthermore, using otherwise wasted borehole water favouring food production also leads to a further value addition of the resource. Halcrow (2013) predicts that the Chikwawa District has the potential to yield a monetary profit worth more than US-$1 million after a decade if 136 permaculture gardens were established (Halcrow, 2013). These calculations however do not yet comprise social health benefits that communities would experience from diversifying and stabilising their dietary intake. In addition, borehole water is in most cases available at a daily basis, which makes communities independent of local rainfall patterns for food production at borehole scale.

2.4 Ecological Sanitation

2.4.1 Integrated Water Resources Management to Contribute to Positive Millennium Development Goals Outcomes

There is a limited yet growing body of academic literature that suggests investigating the interrelations between the Millennium Development Goals (MDGs). The MDGs are eight global aims addressing the needs of the world's poorest communities such as targeting to eradicate hunger and poverty, ensuring access to safe drinking water and basic sanitation, or combating widespread diseases like HIV/AIDS or malaria (UN, 2014). MDG 7.C advocates for halving "… the proportion of the population without sustainable access to safe drinking water and basic sanitation" (UN, 2013). For rural Chikwawa this means that the density of boreholes and pit latrines likewise drastically increase within villages.

Studies however have found that increasing the amount of boreholes and basic sanitation facilities within villages as encouraged by MDG 7.C allows potential groundwater contamination from faecal matter to occur (Banerjee, 2011; Chiroma *et al.*, 2007; Graham and Polizzotto, 2013; Olayinka *et al.*, 2014). Within the Malawian context, this has the potential to cause future epidemics and further environmental challenges because not only more than 80% of the population use pit latrines for sanitation but also over 80% of the country's population relies on groundwater for potable water (Graham and Polizzotto, 2013). In fact, a study conducted by Olayinka *et al.* (2014) in the Nigerian city of Abeokuta detected faecal coliform, Escherichia coli, Salmonella ssp., high concentrations of nitrate and acidity in hand-dug wells within 15 metres of pit latrine facilities indicating point source faecal contamination of tested groundwater sources. The authors consequently debate for awareness raining campaigns and institutional capacity building to effectively prevent groundwater contamination through low-cost sanitation facilities to occur prospectively (Olayinka *et al.*, 2014).

The need for an IWRM approach arises subsequently. IWRM's interconnected approach has the potential to ensure that the MDG outcomes do not foster trade-offs or cumulative negative outcomes in spite of the successful achievement of each goal in itself. Integration of IWRM principles helps "… aligning and integrating interests and activities that are traditionally seen as unrelated or that, despite obvious interrelationships, are simply not coordinated" (Muller, 2006:1). The potential groundwater-contaminating nature of human faeces accumulation in pit latrines justifies why this dissertation focusses research on human manure over for example animal manure. Hence, valuing human faecal matter as a resource for eco fertiliser production does not just help to regain the value of a resource that is otherwise lost; it also eliminates a potential point source groundwater contaminator from environmental systems.

2.4.2 Chemical Fertiliser Eradicates Nutrition Quality of Plants

Another reason why research is channelled into producing eco fertiliser from human manure is due to the unsustainable characteristics that chemical fertilisers possess. Despite chemical fertiliser holding adequate nitrogen, phosphorus and potassium contents, which are important for plant health, it lacks to include other vital minerals (e.g. magnesium, calcium or iodine) that enrich the nutritional quality of plants and consequently humans who consume those plants or their fruits (Wilkins, 2011). Furthermore, although applying chemical fertiliser yields increased crop production initially, it is an unsustainable farming method because the amount of chemical fertiliser applied to soil must be increased every year in order to attain consistent crop outputs until a point where the soil becomes completely sterile (Gautschi, 2011). Gautschi (2011) continues to allege that eco fertiliser achieves the opposite; it build up the soils, and yields continue to increase over time while fertiliser input can be progressively decreased due to enhanced soil fertility. As it was previously explained that the Chikwawa District experiences progressing soil degradation, which is partly due to current

farming methods (Chapter 2.1), this justifies the importance of this dissertation to consider alternative methods of soil fertilisation that assist instead of aggravate sustainable development at community level in the Chikwawa District prospectively.

2.5 Gender-related Inequalities in the Water Sector

2.5.1 Beyond Water Poverty: Gender-sensitive Ramifications

It is women and girls that are mainly responsible for water collection in many rural areas in Sub-Saharan Africa. Many of these females travel far distances to collect water, which often exposes them to risks that compromise their personal security as well as physical and mental health (Pereira *et al.*, 2009). From carrying heavy loads of water, women are prone to chronic spinal injuries, and are at mercy of physical attacks including rapes when travelling through marginalised territory (Nalivata and Matiya, 2008). The importance of gender-related inequalities in IWRM can therefore not be overemphasized. Differences in access to managing water resources include for example managing domestic water supplies at household level, deciding over productive uses of water, access and control of the resource and decision-making (Thomas *et al.*, 1997).

2.5.2 A Global Emphasis: Crucial, but Sufficient?

The previous paragraph highlighted women's interests to become involved in water policy decision making in order to attain gender equality. In fact, over the last three decades there is a rising number of international declarations and resolutions that call to adjust gender differences in the water sector (UN Water Conference 1977, E.77.II.A.12UN Art. II(a); Johannesburg Plan 2002, Art. 25(a); ICESCR 2002, E/2003/22 Art. 29; UN General Assembly Resolution 2010, 64/292 Art. 2; Human Rights Council 2010, Resolution 15/9 Art. 3; World Health

Assembly 2011, Resolution 24 Art. 1(3)). Giving gender inequalities a global perspective is vital for achieving related equality at a national, regional and local level as these documents stress governments to weave appropriate measures into national policies. However, a thorough analysis of Malawi's Water Resources Act (2013) shows that Malawian policy makers have widely failed to address measures to achieve gender equality in the national water sector. This shows that although there is a large international emphasis on gender-related issues, this still remains to be reflected in Malawi's national water policy.

International development goals that however did become widely incorporated into Malawi's development agenda are the Millennium Development Goals (MDGs). In 2012, the United Nations Development Programme (UNDP) stated that MDG 3, which encourages the promotion of gender equality, is unlikely to be achieved by 2015 (UNDP, 2012). In addition, the UNDP (2012) alleges that achieving gender equality will automatically facilitate Malawi to achieve all other still unachieved MDGs, which highlights the importance to attain gender equality for Malawi's development progress. The extent to which gender-related differences in the water sector have been mitigated as part of the MDGs and how this can assist to implement the IWRM vision that is researched by this dissertation shall be explored in Chapter 3 and 4 as follows.

Chapter 3
METHODOLOGY

Having explored the theoretical notion of Integrated Water Resources Management (IWRM) in the previous Chapter, the overall research aim guiding this investigation is to comprehend its adaptive capacity at community level in rural Chikwawa, Malawi. This dissertation critically evaluates the idea of channelling wasted borehole water, eco fertiliser derived from eco sanitation and manpower into permaculture gardens for sustainable food production at community level to improve the overall environmental, social and economic well-being of local communities in rural Chikwawa. This Chapter examines the methodological framework that has been employed to unravel this enquiry. With the research questions largely guiding the content of this Chapter, the following sections reveal the choice of methods for data collection and processing wherewith the research questions were tackled.

3.1 Research Questions

Guided by IWRM principles, this research aims to capture the potential for a bottom-up approach to sustainable development at community level by 1) undertaking an economic evaluation of wasted borehole water and eco sanitation in Timbenawo Group Village; 2) measuring distance & time changes that women invest to collect water; and 3) identifying conditions that are tied to using those resources to boost community borehole gardens supporting permaculture principles. The research questions that emerged accordingly are outlined in Table 3.1.

Table 3.1: Research Questions

Research Questions
- In what quantities on a monthly basis is borehole water in Timbenawo GV wasted, and what is the equal economic value of this water? - What is the economic potential of producing eco fertiliser from human manure in Timbenawo GV, and what are related social barriers? - What are the changes in distance and time that women invest to collect water between 2011 and 2014 based on the FLOW borehole mapping data? - How can grey borehole water, eco fertiliser, gender and permaculture be successfully incorporated under Integrated Water Resources Management in rural Chikwawa prospectively?

3.2 Mixed Methods Approach

From the research questions arises the need to apply a mixed methods approach where both quantitative and qualitative research methods are combined. Field research was carried out in Blantyre City and Timbenawo Group Village in the Chikwawa District, Malawi between May 30 - July 10 2014. Relevant qualitative and quantitative data was collected parallelly yet separately as suggested by Kelle and Erzberger (2004). Findings from both types of datasets were then cross-related adding robustness to this dissertation's argument. While quantitative data was collected to economically appraise the potential that the case study area holds, qualitative data collection techniques were employed to identify respective opportunities and challenges of implementing this economic potential within the case study area. The following sections outline how data collection was approached.

3.3 Quantitative Research

Following the aspiration of valuing grey borehole water and eco fertiliser from human manure as locally available yet economically widely untapped resources, quantitative research methods were employed to quantify the financial value of both resources. Furthermore, FLOW borehole mapping data from 2011 and 2014 provided by the Chikwawa District Council (2011; 2014) was analysed in order to make assumptions regarding the distance and time changes that females invest into water collecting duties. This section outlines how data collection and analysis were approached.

3.3.1 Quantifying Grey Borehole Water

Data Collection

Grey water in this context is referred to as water that is not used efficiently after being extracted from boreholes. This usually occurs when borehole areas are cleaned, empty water buckets are washed, or when water is extracted for on-site drinking purposes. The notion of this research is hereby not to undermine the importance of such activities, rather, ways in which this water can be utilised in order to regain its otherwise lost value are suggested. Although some communities use excess water to grow crops or pass water on to local businesses for brick production, observations indicate that there is yet a vast untapped potential for maximising the value of wasted water.

Figure 3.1 shows the fieldwork location of Timbenawo Group Village (GV). Timbenawo GV contains of four villages named Lackson, Timbenawo I, Timbenawo II and Mlaliki. The yellow pins disclose borehole locations from which relevant data was collected. The red pins show important facilities such as schools and health centres. Data was gathered from June 13 – 17, 2014 in the four villages that Timbenawo GV comprises. Site visits however have been undertaken beforehand in order to prepare the upcoming fieldwork. NGO *Water for People* suggested a

key community contact that had been made contact with accordingly. This key contact holds a role as a Health Surveillance Assistant (HSA) within the community and has significantly contributed to the implementation of this fieldwork. Negotiations with the HSA community contact revealed that data could be collected by two community members at each of the 12 boreholes in Timbenawo GV for one full day. The HSA then selected 24 members from the four villages' Water Point Committees who would collect relevant data. The HSA was given instructions by the researcher the day before data collection begun. On the first day of data collection the HSA, the two selected research assistants and the researcher met at one of the 12 boreholes at 5.45am in order to explain respective responsibilities before the borehole opened at 6am.

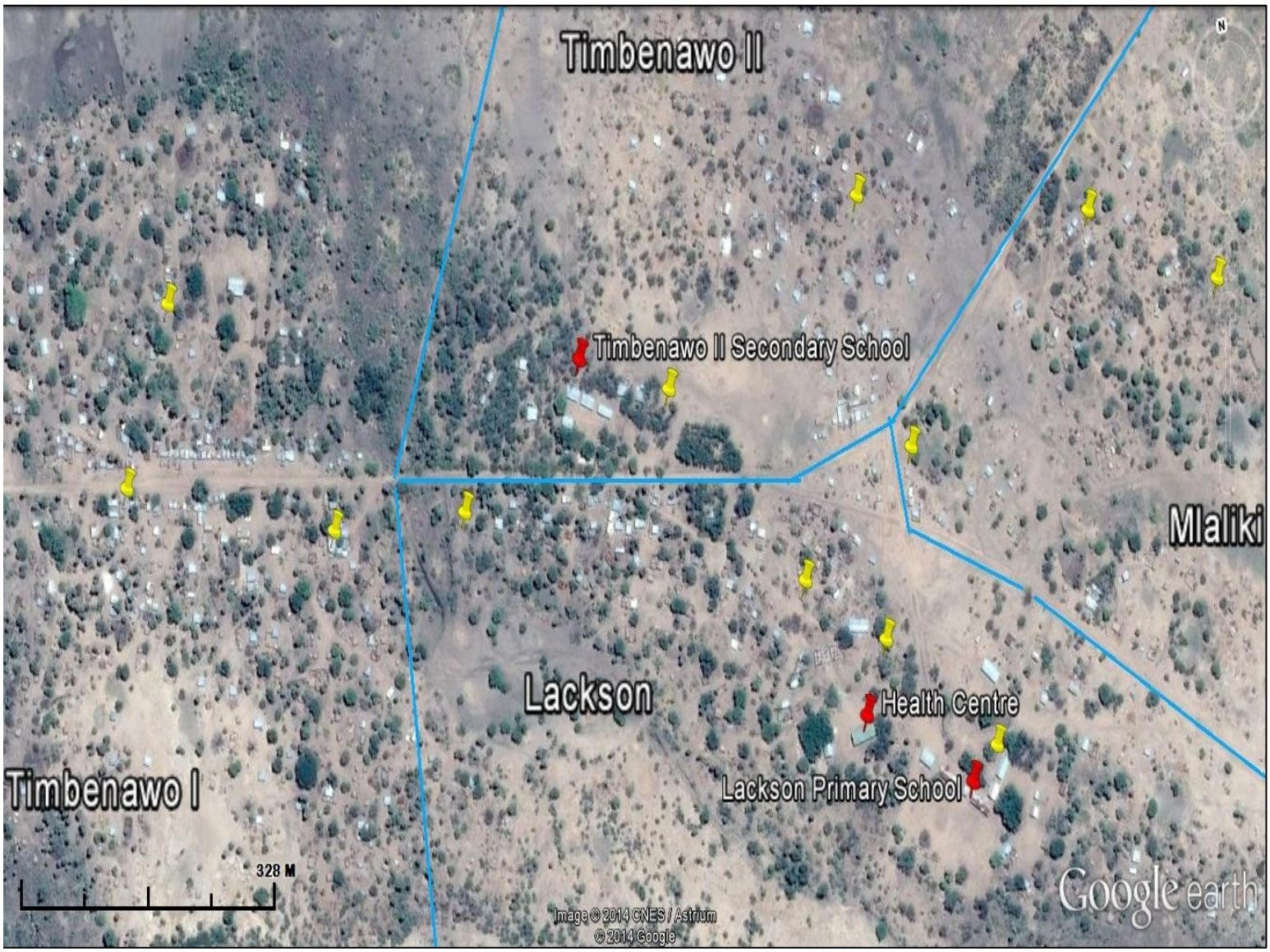

Figure 3.1: Fieldwork Location: Timbenawo Group Village (Source: After Google Earth, 2014)

Once the borehole opened, the research assistants captured on paper the number of pumping strokes that were exercised during borehole opening hours (6am – 6pm). Knowing how many pumped strokes are carried out in one day, and knowing the amount of water that one stroke yields, this allowed calculating the total amount of water that was extracted from the borehole for that particular day.

In addition, the research assistants also captured the number of full water buckets that were taken to the households. This implied capturing the amount of water each bucket holds. Standard bucket sizes range from 5 to 40 litres. Collecting this information was necessary to eventually quantify the total amount of water that is wasted around the boreholes. Box 3.1 summarises the equation that was employed to calculate the amount of wasted borehole water in Timbenawo GV.

Calculating water wastage from boreholes in Timbenawo GV

Extracted amount of water * – Amount of water taken home = Amount of water wastage

* = Amount of strokes carried out during one day x amount one stroke yields (0.33 litres)

Box 3.1: Equation to calculate grey borehole water

Data Analysis

To quantify the amount of extracted water from each borehole in Timbenawo GV, the value of 0.33 litres was multiplied with the amount of strokes undertaken during the course of one day (Box 3.1). From the total extracted amount of water, the number of litres that women carried home in buckets was subtracted. This allowed conclusions drawn about the amount of water that is wasted at each of the 12 boreholes. Table 3.2 below summarises these calculations demonstrating the absolute and relative amount of water that is wasted at each borehole.

Table 3.2: Water extraction data collected in Timbenawo GV

Borehole (BH) Name	Amount of water (in litres)			% of water wastage
	being extracted	taken to household	being wasted	
Mlaliki BH 1	3783.8	3346	437.8	**11.6**
Chimphepo BH 1	7065.3	6175	890.3	**12.6**
Timbenawo II Secondary School	1200	956.5	243.5	**20.3**
Mlaliki BH 2	2065	1555.8	509.2	**24.7**
Timbenawo II BH 1	5252	3935	1317	**25.1**
Lackson Kakoma Health Centre	1160	868.3	291.7	**25.2**
Timbenawo I BH 2	865	639	226.1	**26.1**
Khauni BH 1	4075	2931.6	1143.5	**28.1**
Timbenawo I BH 1	6316.2	4350	1966.2	**31.1**
Chankhonde I BH 1	6885	4720.2	2164.8	**31.4**
Timbenawo I BH 2	7015.1	3850	3165.1	**45.1**
Lackson BH 1	4326	854.1	3471.9	**80.3**
Total per day (in litres)	**50,008**	**34,181**	**15,827**	**30.1**
Total per month (in megalitres)	**1.5**	**1.025**	**0.475**	**30.1**

Table 3.2 shows that the total extracted amount per day adds up to over 50,000 litres per day from which over 34,000 are taken to households, leaving approximately 16,000 litres or 30% of water remaining around the boreholes. Extrapolating these findings to an entire month, Table 3.2 shows that Timbenawo GV has available nearly half a million litres of grey water.

To apply an economic value to the extracted and wasted amount of water, water prizing mechanisms within Timbenawo GV were taken as guidelines. It was revealed that every household contributes a fixed sum with amounts varying between different villages. Table 3.3 outlines the number of households that Timbenawo GV comprises and lists the prices that each household is anticipated to pay monthly for borehole usage. Knowing how much water is extracted and wasted on a monthly basis, and knowing how much money households pay each month for water, an economic value could be applied accordingly (Table 3.4).

Table 3.3: Household data and water tariffs

Village Name	# of Households	Water Price /household/ month (MKW/US-$)	Total Amount paid for water/ village (MKW/ US-$)
Lackson	85	169/ 0.43	14,365/ 36.3
Mlaliki	64	200/ 0.5	12,800/ 32.4
Timbenawo I	61	300/0.75	18,300/ 46.3
Timbenawo II	86	200/ 0.5	17,200/ 43.5
		Weighted Average: 211.71/ 0.53	**Total: 62,665/ 158.4**

Table 3.4: Economic value of extracted & wasted borehole water in Timbenawo

Total extracted water/ month (litres/ MKW/ US-$)	Amount of water wastage/ month (litres/ MKW/ US-$)
1,5 megalitres MKW 62,665 / US-$ 158.4	0.475 megalitres MKW 19,832 / US-$ 50.1

Limitations and Uncertainty

The main challenge encountered was that pumping practices varied between individuals, particular variations have been observed between adults and children, i.e. adults may produce full strokes whereas children produce half strokes. However, Water Point Committees advocate for standardised pumping practices, where one full stroke yields approximately 0.33 litres. The amount of 0.33 litres per stroke has

been suggested by the researcher of this study after observing individuals practicing the suggested standardised pumping method and counting how many strokes were required to fill up 20 litre buckets. Counting stroke numbers necessary to fill up 20 litre buckets has been repeated 60 times at three different boreholes. Results clustered around 0.33 litres enabling the researcher to take this value into account for data analysis. The research assistants however were not given guidelines as to how to account for different pumping methods, it may therefore be that some research assistants counted a small stroke as one full stroke, whereas others may have counted two or more small strokes as one stroke. In addition, the fact that 24 different people spread out across the 12 boreholes were employed, could potentially have led to human errors in data collection. These potential deviations must be considered when interpreting the dataset.

The great deviation in the water wastage of >80% at Lackson BH 1 is likely to be due to the borehole's high salinity, which makes it unsuitable for drinking purposes (Melville, 2014). These changes in borehole usage behaviours where women are likely to only use this borehole for washing or similar purposes, explains the high occurrence of wasted water. At Mlaliki BH 1 where water wastage is low, the electric conductivity of 1,380 EC is relatively low compared to the average of >2,100 EC (range: 856-3650 EC) across Timbenawo GV (Melville, 2014). This might explain the comparably low percentage of water wastage, which is 11.6% compared to the average of 30.1%.

Initially, it was aimed to collect data over a course of seven days in order to capture weekly fluctuation in borehole use. As data collection could however only be arranged for one full day at each borehole, this must be taken into account when making assumptions that extrapolate the given dataset to a greater timeframe. As data has only been extracted once at each borehole, the data results are unable to be compared with each other for accuracy evaluation. Overall however, it is expected that the collected data is robust to provide an overview over water extraction and wastage patterns at group village level and can therefore form the foundation for this dissertation's discussion.

3.3.2 Economic Value of Eco Fertiliser in Timbenawo

Data Collection and Analysis

Academic literature suggests that 7.5 kg of eco fertiliser can be produced from an average Sub-Saharan African adult per year (UNESCO/IHP and GTZ, 2006). In addition, WES-Net India (2008) suggests that children produce approximately half of this amount, i.e. 3.75 kg. Population records of Timbenawo GV are recorded by local Health Surveillance Assistants (HSAs) and have last been updated in March 2014. Table 3.5 outlines population data of the four villages that Timbenawo GV encompasses. As the provided data did not distinguish between adult and children populations, it was assumed that half of the population of Timbenawo GV is comprised of adults, and the other half consists of children. From Table 3.5 emerges the amount of eco fertiliser that each the adult and children population produce, as well as it indicates the total amount of eco fertiliser produced from children and adults combined. Table 3.5 shows that the entire population of Timbenawo GV combined has the potential to produce approximately 13.8 tons of eco fertiliser every year. There are different approaches to appraise the economic value of this resource; these shall be evaluated in Chapter 4.

Table 3.5: Eco sanitation capacity in Timbenawo GV

Village Name	Total Population	Assumed Adult Population	Total amount/ adult/ year (ton)*	Assumed Children Population	Total amount/ child/ year (ton)**	Total amount/year (Adults & Children) (ton)
Lackson	507	253.5	1.9	253.5	1.0	2.9
Timbenawo I	911	455.5	3.4	455.5	1.7	5.1
Timbenawo II	621	310.5	2.3	310.5	1.1	3.4
Mlaliki	421	210.5	1.6	210.5	0.8	2.4
Total	**2460**	**1230**	**9.2 t**	**1230**	**4.6 t**	**13.8 t**

* 7.5 kg = Average amount of eco fertiliser an adult produces/ year (in kg)
** 3.75 kg = Average amount of eco fertiliser a child produces/ year (in kg)

Limitations and Uncertainty

Restrictions arise from the assumption that every adult produces 7.5 kg of fertiliser yearly. The fertiliser production capacity strongly depends on individual diet, consumed food quantities and yearly seasons. Most people would also not solely use their own toilet over the course of a year; in fact, people in employment are expected to frequently use toilets outside their homes. This research however focuses on detecting the eco fertiliser production capacity at group village level and district level rather than at household level, which allows disregarding variations at household level.

3.3.3 Quantifying Gender-related Shifts in the Water Sector

This dissertation's gender-related aspect builds up on a previous project undertaken between January and April 2014 by the author of this dissertation. Within the scope of that project, distances that women travel to collect water in the Traditional Authority of Chapananga (Figure 3.2), Chikwawa District were calculated.

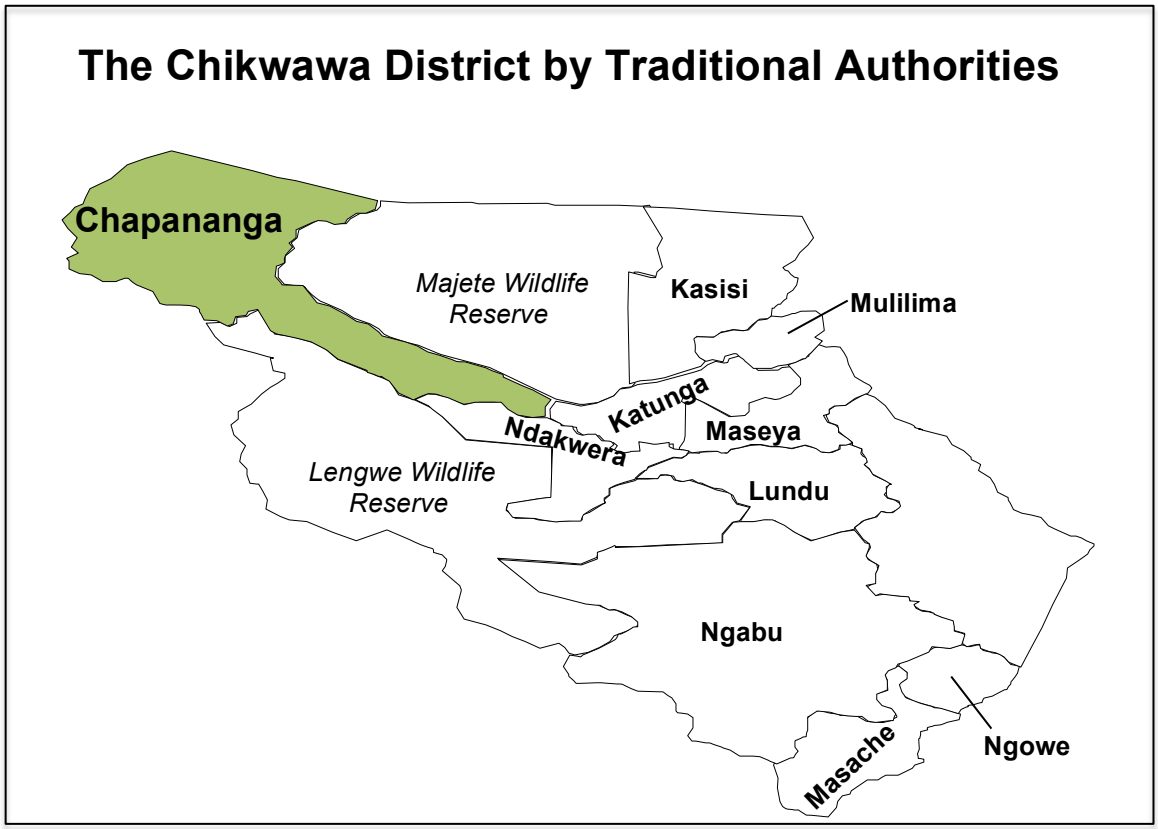

Figure 3.2: Traditional Authorities within the Chikwawa District (After Chikwawa District Council, 2011)

These calculations were based on FLOW borehole mapping data collected in 2011 by the Chikwawa District Council. The same borehole mapping process has been repeated in 2014. Updating the FLOW database is important as each mapping period captures availability and functionality of boreholes only at the particular time the survey is undertaken. Hence, future changes (boreholes becoming non-functional, non-functioning boreholes being fixed and new boreholes being drilled) remain unplotted meaning the validity of collected data decreases as time proceeds. As the second mapping period has been undertaken in early 2014, this provided this dissertation the opportunity to measure differences in distances that occurred between the two mapping periods. Furthermore, a time value was applied to these distances in order to capture changes in travel time that resulted from the two mapping periods.

The Chikwawa District contains 11 Traditional Authorities, which encompass somewhere between three and 43 Group Villages. Each of the Group Villages consists of a number of villages, adding up to over 1000 villages making up the Chikwawa District. (Chikwawa District Council, 2011) The FLOW database (Chikwawa District Council, 2011 & 2014) provides information regarding the number of functioning boreholes for each village, group village and traditional authority in the Chikwawa District. Although every borehole is GPS logged, the boundaries of most villages as well as the locations of households in the Chikwawa District are not currently mapped which leads to the necessity to make assumptions to replace currently unavailable data that is needed for this model. Table 3.6 provides an overview of all required data (available and unavailable) and outlines the required assumptions that were necessary to develop this model.

Table 3.6: Required data for the model development

Data Required		**Assumptions (*)**
Data available	**Data unavailable**	
Population numbers	Age/Gender distribution	50% of the population is female, and all females travel to collect water
Functioning borehole numbers	-	-
Borehole functionality rates	Amount of people relying on each borehole	Each functioning borehole provides enough water for the its population
-	Borehole distribution	Normal Distribution
-	Village sizes	All villages have a 500 m radius
	The distribution of houses in villages	All houses are evenly distributed around boreholes
-	Number of women travelling to neighbouring villages to collect water	Women do not travel to neighbouring villages
Time value of travelled distances (5 km/h as suggested by Malmberg Calvo (1994))	-	-

(*) = Assumptions were made in agreement with Prof R Kalin (University of Strathclyde, pers. comm. 14 July 2014)

Model Development

The Microsoft Office Application *Excel* was used to implement the model. As each group village has available different amounts of boreholes, the average area that each borehole covers was firstly calculated for each group village (Step 1). Once the average borehole coverage for each group village is known, the distances that women travel from their home to the borehole can be quantified (Step 2). A description of these two steps is provided as follows.

Step 1: Calculating the average area boreholes cover at GV level (*)

(*)= N.B. It is assumed that boreholes are evenly distributed within group villages and that each village within the group village has a 500 metre radius.

To quantify the average area that each borehole covers within the 36 group villages of TA Chapananga, the size of every group village had to be identified. This was calculated by multiplying the number of villages each group village contains with the factor 500 (Table 3.7):

Table 3.7: Calculating the average area size boreholes cover at group village level

Group Village (GV)		GV Area (Number of Village x Village Size)	Number of functioning Boreholes	Average area one borehole covers per GV
Name	# of Villages			
Chapatha	2	2 x 500 = 1000 m radius	4	250 meters
Kuntola	3	3 x 500 = 1500 m radius	1	1500 meters
Timbenawo	4	4 x 500 = 2000 m radius	12	167 meters

Step 2: Calculating distances that females travel to boreholes

Now that the average area size that boreholes cover in each group village (GV) is known, distances women travel from their home to the borehole can be calculated. To do so and as explained in Table 3.6, assumptions about the distribution of households around the boreholes

were made. In addition, it is assumed that half of the total GV population is female, and that all females are involved in water collecting duties. Finally, a time value of 5 km/h was applied to the distances as suggested by Malmberg Calvo (1994), which allows measurement of the time that females invest in daily water collecting duties. Table 3.8 summarises the undertaken calculations; the resulting implications for the Chikwawa District context are discussed in Chapter 4.

Limitations and Uncertainty

The developed model made use of a number of assumptions (named in Table 3.6) increasing potential uncertainty of the model's validity. The actual village sizes are unknown which aggravate predictions regarding whether borehole density is sufficient within group villages. As a result, the need for new boreholes in large villages might be underrepresented. This model does also not account for seasonal changes in the water table that may result in borehole drying in low-rainfall months. This influences travel patterns over the course of a year and are not captured by this model. It is therefore suggested to replace the made assumptions with actual data once available.

Table 3.8: Calculations of how far females travel to collect water

GV Name	Female population	Average area one borehole covers per GV (in metres) (see Table 3.7)	25% of the female population travel 20% distance of area one borehole covers (in metres)	30% of the female population travel 40% distance of area one borehole covers (in metres)	20% of the female population travel 60% distance of area one borehole covers (in metres)	15% of the female population travel 80% distance of area one borehole covers (in metres)	10% of the female population travel 100% distance of area one borehole covers (in metres)	Total distance travelled per female population (in metres)	**Total distance travelled per female (in metres)**	**Approximate time value**	
										Per female (in minutes)	**Per female Population (in hours)**
Chapatha	252	250	3,150	7,560	7,560	7,560	6,300	32,130	**127.5**	1.53	**6.43**
Kuntola	571.5	1,500	42,862.5	102,870	102,870	102,870	85,725	437,197.5	**765**	9.18	**87.44**
Timbenawo	1,230	167	10,250	24,600	24,600	24,600	20,500	104,550	**85**	1.02	**20.91**

3.4 Qualitative Research Methods

Accounting for ethical considerations was central to the qualitative dimension of this research. Hence, ethical approval for this research was applied for and consent was obtained from the University of Strathclyde in May 2014. A copy of the ethical application form can be found in Appendix 1. The following sections describe how qualitative data collection was approached.

3.4.1 Semi-structured Interviews

While quantitative data as described in Chapter 3.3 was collected to evaluate the area's potential to increase the utilisation of local resources, qualitative data was garnered to put the collected quantitative data into a case study specific context, aiming to identify context relevant needs, opportunities and challenges that the practical application of this idea implies.

Semi-structured interview techniques allowed developing a loose interview framework within which a series of topics and questions were assembled aiming to enrich the investigation of the research questions (Robert Wood Johnson Foundation, 2008). Employing semi-structured interviews did not only enable the researcher to incorporate questions that have emerged during the interview but also allowed to establish a dialogue where interviewee and researcher share knowledge and learn from each other (FAO, 1990). This was important as the researcher of this study wanted that the interviewees benefit from donating their time to the greatest possible extent. Interviewees were identified with the help of key contacts from the University of Strathclyde, NGO *Water for People*, and a key community contact in Timbenawo GV. Key themes that were covered during interviews revolved around the following topics: Grey Water, Ecological sanitation, Gender and Permaculture (Interview Questions including their rationale to be found in Table 3.9). Interviewees' backgrounds covered a range of expertise providing

insights from academic, practitioner, and community-based viewpoints. Interviews were conducted with individuals and focus groups as listed below (Box 3.2).

Individual Interviewees:

- 1 Health Surveillance Assistant (Timbenawo GV)
- 1 Agricultural Extension Officer (Chikwawa region)
- 1 Community member (Village Timbenawo I)
- 3 Practitioners from two Blantyre-based organisations involved in community-led approaches to subsistence farming and permaculture
- 5 Academics (Polytechnic, Blantyre; University of Strathclyde)
- 3 NGO members

Focus Groups:

- 3 Water Point Committees in Timbenawo GV
- 2 Meetings between Water for People and the Community of 1) Lackson and 2) Timbenawo II regarding the triggering of the Model Villages

Box 3.2: List of Interview Participants

Additional information was drawn from a two-day IWRM training workshop organised by the University of Strathclyde. At this workshop, key stakeholders from the Malawian Government, Chikwawa District Council, NGOs, Industry and Academics came together to discuss region-specific progress focusing on how to incorporate IWRM into structural planning in the Chikwawa District prospectively. In addition, a two-day workshop titled „Establishing Home-grown School Meals in Malawi's Communities" was attended to gather further context-related insights. This workshop was run and organised by Sustainability Centre Pa Nthunzi, Blantyre and was attended by 1 Business Consultant (Chikwawa District), 2 Primary School Teachers (Mulanje District), and 1 Agricultural Extension Officer (Mulanje District).

Table 3.9: Questions directed to interview participants

Topic Theme	Interview Question	Justification
Questions to interview participants in Timbenawo GV		
Grey Water	1 How much & how often do you pay for water, and what happens with that money? 2 Are you happy to pay for water? 3 Do you think that much water at the boreholes is wasted? 4 What happens with that water? 5 What do you think could be done with this water?	In line with Research Question 1, Question 1 aims to find out the price of water in the four villages in Timbenawo GV, and whether the interviewee is happy to pay for water. Emerging from Research Question 4, questions 3-5 are to find out whether the interviewed community members feel managing wasted borehole water is a priority to them.
Ecological sanitation (Ecosan)	1 Have you heard of ecosan before, and what does it mean to you? 2 Do you see a value in ecosan? 3 Are there any ecosan latrines in the group village, if yes, how many are there? 4 Do you use any fertiliser, and if yes, how much in quantity and how much does it cost you? 5 Does the group village experience any problems with soil degradation, if yes how does it affect you and do you take any measures to mitigate soil degradation? 6 Are there any abandoned pit latrines in the GV where food is grown on, if no, why not?	Question 1-3 are to find out the interviewee's state of knowledge about ecosan. In line with Research Question 2 and 4, question 4 & 5 are to find out whether the interviewee uses fertiliser, and what its economic value is. It is also aimed to explore the needs to strengthen ecosan. Question 6 and 7 tap into Research Question 4 aiming to identify whether human manure is used in any other ways. Opportunities and obstacles towards using human manure in community

Topic Theme *(continued)*	Interview Question *(continued)*	Justification *(continued)*
	7 What do you think is the general acceptance in the group village towards using eco fertiliser for community borehole gardens, and what opportunities and challenges do you see regarding its integration? 8 What is the population of the four villages of Timbenawo GV and how many households are there in each village? (Directed to Health Surveillance Assistant (HSA) only)	gardens are also to be explored. Question 8 is needed to appraise the economic potential of ecosan in Timbenawo GV as required to answer Research Question 2.
Perma-culture	1 Can you describe what permaculture means to you, and when & how have you first heard about it? 2 Are you directly or indirectly involved with permaculture in your GV, and do you benefit from it? 3 What types of crops do you grow in existing borehole gardens and what are they used for? 4 Can you grow food all year round, and if not what are the obstacles to do this? 5 Do you currently buy more food than you grow or vice versa? 6 (If no to Q4:) Where do you obtain food supplies when you are unable to grow food yourself? 7 (If no to Q4:) Is there enough food for everyone all year round? 8 (If no to Q7:) When do you experience food shortages and do people in Timbenawo GV suffer from malnutrition during these periods? 9 What do you think needs to happen in the future to solve these problems that the GV currently faces?	With regards to Research Question 4, these questions aim to investigate the extent to which interviewees are involved in permaculture practices, and to judge about the possible positive impact extending borehole gardens can have on the community.

Topic Theme *(continued)*	Interview Question *(continued)*	Justification *(continued)*
Gender	1 What is the women's role in the village? 2 Four new boreholes have been drilled in the last year, do women now travel noticeably shorter distances, and if yes what are women doing with the gained time? 3 Have the increased amount of boreholes evoked any other gender-specific ramifications? 4 Do you currently grow any fruit and vegetables in the group village, and if yes, who looks after them? 5 If permaculture gardens were created around each borehole, do you think women would enjoy taking leadership, i.e. managing the gardens and selling the produce at the market? 6 What challenges and opportunities do you see with that?	Regarding Research Question 3 and 4, these questions are to find out whether women perceive travelled distances to be shorter, how they use their gained time and to find out ways in which women could become involved in community gardening.
Additional Questions	1 Timbenawo Group Village got selected as a model village, what do you think this means? 2 Are there any other issues you would like to raise?	These two questions are to close the interview and to give the interviewee the opportunity to integrate additional ideas, feeding into research question 4.

Topic Theme *(continued)*	Interview Question *(continued)*	Justification *(continued)*
Further Interview Questions directed to additional interviewees		
Grey Water **Eco sanitation** **Additional Questions**	1 What opportunities and challenges do you see in using grey water from boreholes for community borehole gardens in rural Chikwawa? 2 What opportunities and challenges do you see in a) establishing ecosan and b) prizing eco fertiliser in rural Chikwawa? 3 Would you agree or disagree that using locally available resources such as wasted borehole water and eco fertiliser for community gardens is one way to gain independence from the donor focussed mentality which appears quite dominant in Malawi.	These questions are designed to gain more background information putting the idea this dissertation follows into context.

3.4.2 Field Observations

Guest *et al.* (2013:11) allege that „[field observation] can generate insights that other forms of research cannot". Vanderstoep and Johnston (2009) recognise field observation as a technique to enrich data collection procedures. For the scope of this study, field observations were employed to add robustness to the collected quantitative and qualitative data. The purpose of including observations was to understand and identify 1) main reasons that lead to borehole water extraction, 2) to capture whether wasted water is used, and if yes, by whom and how, and 3) identifying opportunities to regain the value of wasted water. Incorporating respective insights is expected to make data interpretation and discussion more specific to the case study context.

3.5 Ethical Consideration

When designing the interview questions, it was ensured that the privacy and anonymity of interviewees is not compromised at any time (Kumar, 2011). Before conducting interviews, the study purpose was delivered verbally guided by the provided Participant Information Sheet, which contains information about the research project and researcher. Thereafter, each interviewee's informed consent was obtained for 1) their participation in this research, and 2) the right to publish emerging results within the scope of this dissertation in a way that does not reveal the identity of the individual participants (Mason, 2002). The participant information sheet and consent form are attached in Appendix 2.

The fact that I am a Caucasian female student may have led to perceived cultural differences among interviewees. Henceforth, such differences were avoided or mitigated where possible. Employed measures included learning basic *Chichewa* language skills and adapting to the local dress code by wearing a *chitenje*, which is a wrap covering hips and legs.

Chapter 4
RESULTS AND DISCUSSION

This chapter offers an attempt to understand and summarise the encountered needs, opportunities and obstacles associated with tapping into local resources by identifying linkages in the data that have been collected as described in Chapter 3. The first three sections evaluate the economic potential of these resources and subsequently place arising prospects into the context of the Chikwawa District. Findings show that social and cultural settings are likely to hinder local communities to utilise the economic potential that the region holds. Therefore, the fourth and last section of this chapter expresses ideas for a road map strategy identifying permaculture as a tool that cannot only assist to regain the value of grey borehole water and eco fertiliser but can also help tackling gender-related inequalities.

4.1 Grey Water

As stated in Chapter 3.3.1, the rationale of this dissertation is not to judge community practices that lead to water wastage, rather, this dissertation aims to assist local communities and Chikwawa District Council planning authorities to use this resource to the best possible extent by quantifying the amount of borehole water wastage in Timbenawo GV, and providing ideas as to how the value of this resource can be reclaimed at community level. The first section provides an in depth discussion of Research Question 1, which required 1) recording the amount of grey water that remains unused after being extracted from boreholes, and 2) asked to appraise the economic value of this resource. The second part of this section provides an attempt to answer Research Question 4 shedding light on the needs, opportunities and obstacles Timbenawo GV faces when planning on integrating the use of grey water under Integrated Water Resources Management (IWRM).

4.1.1 Evaluating Economic Perspectives

Table 4.1 summarises the collected borehole data that has been analysed as outlined in Chapter 3.3.1. It is shown in Table 4.1 that the 2460 people populating Timbenawo GV extract approximately 1.5 megalitres of water per month from 12 available boreholes. This amount has an economic value of MKW 62,665 (based on the weighted average water tariff of MKW 211.71 that each household contributes). With 30.1 % of this water being wasted, i.e. not taken home to households but remaining at borehole sites, this implies a lost monthly economic value of approximately MKW 20,000 hinting the vast potential for the community to use this resource as a prospective source of alternative income.

Table 4.1 Extrapolating grey water availability to TA Chapananga & Chikwawa District

Location	**# of BHs**	**Water extracted/ month (megalitres/ MWK/ US-$)**	**Water taken to household/ month (megalitres/ MWK/ US-$)**	**Water wastage/ month (megalitres/ MWK/ US-$)**	**% of water wastage**
Timbenawo GV	12	1.5 ML MKW 62,665 US-$ 158	1.025 ML MKW 42,832 US-$ 108	0.475 ML MKW 19,832 US-$ 50	**30.1**
TA Chapananga	218	27.25 ML MKW 1.14 million US-$ 2.880	18.6 ML MKW 0.77 million US-$ 1.950	8.6 ML MKW 0.36 million US-$ 910	**30.1**
Chikwawa District	1,500	187.5 ML MKW 7.8 million US-$ 19,700	128.1 ML MKW 5.4 million US-$ 13,500	59.4 ML MKW 2.5 million US-$ 6,300	**30.1**

Extrapolating findings from Timbenawo GV means that TA Chapananga (within which Timbenawo GV is located), having available 218 boreholes (Chikwawa District Council, 2014), potentially wastes over 8.6 megalitres of water on a monthly basis. This equals a lost monetary value of MKW 360,000 or US-$ 910 (Table 4.1). Once *Water for People's* 'Everyone forever' vision is implemented, i.e. if no more than 250 people depend on sharing one water access point, approximately 1,500 boreholes will be present across the Chikwawa District (Water for People, pers. comm., 10 February 2014). Hence, further extrapolating research findings to the entire Chikwawa District suggest that

approximately 59.4 megalitres of water, or over MKW 2.5 million (US-$ 6,500) every month is being wasted. Over the course of one year, this amounts to 712 megalitres of water, or MKW 30 million (US-$ 75,000).

When interpreting Figure 4.1 it is however important to mention that extrapolations are based on field research results finding that 30.1% of all extracted borehole water is being wasted. As Table 3.2 in Chapter 3.3.1 however illustrated, water wastage measured at Timbenawo's 12 boreholes varied somewhere between 11.6 to 80.3%. For each of the aforementioned areas, Table 4.2 therefore gives a nuanced overview describing the range within which grey water quantities are expected to fluctuate; outlining that across the Chikwawa District, water wastage could be as low as 22.89 megalitres but can potentially be as high as 158 megalitres per month.

Table 4.2: Estimated range of grey water occurrence

Location	**Minimum expected grey water occurrence/ month (in megalitres/ MKW/US-$)**	**Maximum expected grey water occurrence/ month (in megalitres/ MKW/ US-$)**
Timbenawo GV	0.183 ML MKW 7,645/ US-$ 19.30	1.26 ML MWK 52,638/ US-$ 132.87
TA Chapananga	3.31 ML MKW 138,280/ US-$ 350	22.94 ML MKW 958,356/ US-$ 2,420
Chikwawa District	22.89 ML MKW 0.96 million/ US-$ 2,413	158.47 ML MKW 6.6 million/ US-$ 16,711

4.1.2 Inclusion of Social and Cultural Settings

Undertaking an economic evaluation of Timbenawo's grey water resources as requested by Research Question 1 highlights the vast opportunities that the case study area has to regain the lost resource value. However, this potential requires to be put into a place-based perspective in order to be able to make predictions towards the extent to which existing opportunities are likely to be tapped into. This section attempts to provide a case study-based discussion

regarding the practical application of grey water summarising opportunities and conflicts that have emerged from gathered qualitative data as elaborated in Chapter 3.4.

Figure 4.1 shows three borehole scenarios from Timbenawo GV where different approaches to managing grey water are being exercised. Picture *a.* shows that excess water remains stagnant on the bare ground indicating that the value of this water is not only lost but it also provides feeding and breeding grounds for malaria-carrying mosquitoes. In picture *b.*, excess water is therefore channelled into a pit in order to discourage mosquitoes from this area. Picture *c.* shows that excess water is channelled into a community garden where otherwise wasted water is used for crop production.

Figure 4.1: Grey borehole water management (Source: Author's own, 2014)

Emerging Opportunities

Observations recommend that the water that remains wasted at borehole sites has in the majority of cases not had any contaminating substances such as soap added, meaning that this water can therefore be directly applied to plants. Some of the visited boreholes already implemented borehole gardens growing a small range of crops that are to be sold at the market (WPC A, 2014). Participants from all three interviewed WPCs agreed on the fact that the borehole areas where community gardens exist are visually more appealing which facilitates community members to care for the garden (WPCs A-C, 2014). Also, the fact that one borehole garden in Timbenawo I has yielded crops worth MKW 5,500 (US $ 14) can be regarded as an incentive for surrounding communities to progress with developing community gardens at respective borehole sites. In addition, the example of Timbenawo I shows that not only the lost value of water is regained, but also indicates that its value can be incremented even more once the grey water is utilised to grow produce which can either be sold at the market, or contribute to the nutrition security of the local communities.

With having only one rainy season per year, using grey water from boreholes for community gardens can revolutionise small-scale agriculture at community level due to the daily availability of water. Three focus group interviews with 25 members from three Water Point Committees (WPCs) in Timbenawo GV show that interviewees strongly agree on the fact that large quantities of water are currently not being used efficiently after extraction from the borehole (WPCs A-C, 2014). This indicates awareness among community members towards water wastage, and may be a result of a more than two yearlong collaboration with NGO *Water for People* who continuously work towards sensitising the community for such issues.

Another incentive emerges from the water tariff system where communities are anticipated to contribute for water extraction on a monthly basis. However, this money collected by respective WPCs, does not technically pay for the water resource; instead this money is spent on maintenance and repair ensuring the perpetual functionality of the borehole (Community member A, 2014). The community has hugely benefited from this system as Community member A (2014) endorses: "... in the past there was no money for fixing the

borehole when it was broken, now there is enough money to fix the borehole". The water tariff system, encouraged by *Water for People*, has strengthened ownership structures where water-related issues become a concern integral to the entire community. Henceforth, quantifying the monetary value of grey water resources in the area may provide an economic incentive to the entire community to better manage their grey borehole water.

4.1.3 Recommendations for Grey Borehole Water Integration

At the time this study was conducted (June/July 2014), three out of Timbenawo's 12 boreholes already incorporated borehole gardens to some extent over the past 12 months when *Water for People* first introduced the idea of community borehole gardens. However, that the development is only at an initial stage show the two pictures in Figure 4.2, where it can be seen that even in the gardens much grey water remains stagnant. This suggests that in Timbenawo GV the central question is not how to introduce the concept of borehole gardens to the community but rather how to distribute water effectively and who takes responsibilities for looking after the garden.

Figure 4.2: Water wastage in community gardens (Source: Author's own, 2014)

The amount of water remaining stagnant in the garden as shown in Figure 4.2 testifies that borehole gardens are too small for the daily incoming amount of water suggesting extensive expansion of the gardens. Land availability in rural areas also favours the expansion of these.

The borehole garden design that appears to be prevalent in Timbenawo GV is that a concrete drain channels excess water into a fenced garden area the size of approximately 6 x 6 metres (Figure 4.3).

Figure 4.3: Example of a community borehole garden in Timbenawo GV (Source: Author's own, 2014)

The problem at this site, and in fact what has been observed at every visited community borehole garden site, is that water distribution inside the gardens appears widely unstructured which results in water clustering at the garden entrance with hardly any water reaching the back of the garden. Recommendations from practitioners have been to create a larger number of channels spreading water from the concrete drain throughout the garden (Practitioner Participants A & B, 2014). While Practitioner Participant A (2014) suggested to introduce a downhill slope for better water distribution, Practitioner

Participant B (2014) recommends to introduce clay channels amongst slightly elevated garden beds. Clay channels avoid water infiltration into the ground but facilitate water to flow through the garden beds. An example of this idea can be seen below in Figure 4.4 (photo taken on Practitioner A's property).

Figure 4.4: Garden beds with channels for water distribution (Source: Author's own, 2014)

4.2 Ecological Sanitation

Promoting eco sanitation under IWRM at community level is particularly substantial because this means to eliminate potential groundwater-contaminating human faeces from the ground and converting those into profitable fertiliser. Eco sanitation in this investigation is regarded as an alternative opportunity to uplifting the economic life of rural communities in Chikwawa. However undertaking an economic analysis of such brings two-folded outcomes. It does not only underline the vast potential that the area holds, but conducted interviews have also emphasized that local context-related settings must be given thorough consideration in order for conclusions to reflect reality accurately. The first part of this section offers an interpretation of the economic model developed in Chapter 3.2.2 extrapolating findings from Timbenawo GV to the Traditional Authority Chapananga, within which Timbenawo GV is located, and to the entire Chikwawa District. This second section subsequently provides a context-based discussion reviewing a number of opportunities but also difficulties that arise with placing a monetary value on eco fertiliser in the case study area.

4.2.1 An Economic Evaluation

Appraising the economic value of eco fertiliser derived from ecological sanitation proves to be complex, largely due to the controversial social discourse surrounding the application of human manure as fertiliser. A number of interview participants were consulted in order to evaluate appropriate pricing mechanisms for eco fertiliser in the Chikwawa District. Before opening this discussion however, it shall be reminded that any utilisation of eco fertiliser will result in automatic savings when replacing industrial fertilisers due to its low production costs.

As found in Chapter 3.2.2, Timbenawo GV has the potential to produce 13.83 tons of eco fertiliser based on its current population size. According to Practitioner Participant A (2014) one has to apply 40 times as much eco fertiliser as opposed to industrial fertiliser (8 ml of industrial fertiliser per planting station; 300 ml of organic fertiliser per planting station). This is due to the high chemical

concentration industrial fertiliser holds. Practitioner Participant A (2014) also continues to state that in Malawi, „[eco fertiliser] would still be profitable since organic fertiliser is about 55 times cheaper than synthetic fertiliser and it has a long lasting benefit to the soil while synthetic fertiliser is detrimental to the life of the soil and it causes acidity". In Chikwawa, the average cost for 1 kg of industrial fertiliser equals MKW 270 (Academic Participant A, 2014; Community Participant B, 2014). Box 4.1 calculates financial implications that gaining monetary value from eco fertiliser could have on the case study area.

Calculating the economic value of eco fertiliser in Timbenawo GV

The capacity of eco fertiliser production in Timbenawo GV comprises 13.8 tons per year. This amount has the ability to replace 0.35 tons of industrial fertiliser. In order to purchase 1 kg of industrial fertiliser, one has to pay MKW 270 (as of June 2014).

Henceforth, 0.35 tons of industrial fertiliser has an economic value of ***MKW 93,404*** (US $ 240). With eco fertiliser being around 55 times cheaper than industrial fertiliser (i.e. MKW 4.9/1kg), 13.8 tons eco fertiliser replacing 0.35 tons of industrial fertiliser, cost around ***MKW 69,804*** (US $ 175). This would contribute to a financial yearly saving of MKW 23,600 (US $ 65).

Box 4.1: Economic value of eco fertiliser in Timbenawo GV

Table 4.3 extrapolates the notion of the findings outlined in Box 4.1 to the Traditional Authority of Chapananga and the entire Chikwawa District showing the vast potential to make use of a local resource that everyone produces, yet most people do not appreciate its value. It shows that if everyone at district level utilises their manure in order to produce eco fertiliser and if the entire amount of eco fertiliser would be used to replace industrial fertiliser, the combined amount could lead to savings over a year of MKW 5.5 million (US-$ 14,200).

Table 4.3: Extrapolating ecosan capacity to TA Chapananga & Chikwawa District

Location	Population	Eco fertiliser production capacity (tons/ MWK)	Potential to replace industrial fertiliser and implied cost (tons/ MWK)	Yearly Price Savings
Timbenawo GV	2,460	13.8 t MWK 69,803	0.35 kg MWK 93,403	MKW 23,600
(household level)	8.3 (average)	0.047 t MWK 235	-	-
TA Chapananga	99,668	560.6 t MWK 2.75 million	14 t MWK 3.78 million	MKW 1.03 million
Chikwawa District	539,051	3,032 t MWK 14.86 million	75.8 t MWK 20.5 million	MKW 5.61 million

According to the assumptions made by this model, Table 4.3 suggests that each household can earn MKW 235 yearly when selling their manure as fertiliser. This figure however assumes that each household on average consists of 4.15 adults and children likewise. This assumption however contains an uncertainty regarding the composition of households. Table 4.4 therefore offers a scope within which earnings will be likely to range; scenario one assuming that households on average consist of two adults and 6.3 children, and scenario two assuming that households averagely consist of 6.3 adults (i.e. two sets of grandparents, one set of parents) and 2 children.

Table 4.4: Range of eco fertiliser capacity at household level

	Average Household Population	Household Distribution	Eco fertiliser capacity/month (kg/ MKW/ US-$)
Scenario 1	8.3	2 adults 6.3 children	39 kg MKW 191 / US-$0.48
Scenario 2	8.3	6.3 adults 2 children	55 kg MKW 270 / US-$ 0.68

The content of Box 4.1, Table 4.3 & 4.4 suggest that each household has the opportunity to undertake income-generating activities through either 1) selling manure as eco fertiliser to entrepreneurs or local farmers, or apply fertiliser to community or backyard gardens in order to boost the nutrient content of soils increasing crop output which further uplifts the value of this resource. The extent to which it is feasible to tap into this potential from a social viewpoint shall be discussed in the following section.

4.2.2 A Social Discourse

There are a number of limitations that hinder tapping into the vast economic potential outlined in the previous paragraph. Sets of opportunities and limitations have emerged during conversations with interview participants; the concluding insights will be critically approached as follows.

A Village's Perspective

Conducting interviews with community members in Timbenawo GV did not reveal any major obstacles that the local community sees regarding the establishment of eco sanitation; perhaps because eco sanitation is still rarely observed in the area. Rather, the community has depicted the benefits that eco sanitation holds outlining that fertiliser produced from human manure assists plant growth. Furthermore, every interview participant stated that Timbenawo's communities encounter increasing problems with soil degradation (WPC A-C, 2014; Agriculture Extension Worker, 2014; Community Participant, 2014). Subsequently, WPC B (2014) stated that „... manure makes the soil soft and this makes it easier for water to enter the soil". This does not only outline the need for environmentally friendlier sources of fertiliser, it also shows that linkages between perceived disadvantages of soil degradation and the benefits of eco fertiliser are being made by the community. Finally, WPC C (2014) showed further interest and expressed an enquiry to *Water for People* asking for eco sanitation training where the community is taught how to construct ecosan pit latrines. These conversations suggest that the community recognises the value attached to eco fertiliser, however, requires assistance in adopting this technology.

In response to this enquiry but also responding to the overall previous paragraph, NGO Participant A (2014) remarks that interview participants in Timbenawo GV may have focused on raising only positive aspects because the community may feel that if they would state challenges, e.g. perhaps not feeling comfortable about applying human manure as fertiliser for their gardens, they might fear that their support from *Water for People* would be reduced. Henceforth, to attain clearer results a bigger sample of community members, including gardeners and farmers, should have been polled in individual interview sessions regarding their attitude towards utilising eco fertiliser. However, initial discomfort among ecosan technology users can be expected. Therefore, expertise and perspectives from academic and practitioner interview participants were consulted in order to better understand challenges that may hinder tapping into the vast economic potential of eco sanitation as revealed in Chapter 4.2.1.

Social Barriers

Practitioner Participant A (2014) points out that the time may not yet be ripe for an economic appraisal of Chikwawa's eco sanitation potential and questions the validity of this approach reinforcing that „[n]o Malawian that I know of will be willing to use recycled human manure in their fields, not to mention paying for it". Despite the fact that this statement invalidates what interviews within Timbenawo GV have found, Practitioner Participant A's (2014) statement has to a certain extent been endorsed by a number of other interview participants (Practitioner Participant B, 2014; Academic Participants A-C, 2014, Agricultural Extension Officer A, 2014). NGO Participant A (2014) recognises that using one's own manure as fertiliser for crop production is a mind-set issue and emphasises the importance for NGO's to deliver an understanding of the benefits to communities in order to attain behavioural change among ecosan users.

However, a major hindering factor as revealed by NGO Participant A (2014) and Academic Participant C (2014) is that communities themselves do not prioritise the establishment of eco sanitation in their community. This is likely to be due to other basic problems at household level that families encounter on a

daily basis. Meeting basic needs of survival such as focusing on obtaining food and water, homes having broken roofs and struggling to pay for school fees gain higher priority. Acknowledging these social settings, Academic Participant C (2014) argues that:

> „... these issues have to be solved first, improved sanitation will come automatically once other related and unrelated challenges that are in the way of successfully implementing ecosan are eliminated“ (Academic interview participant C, 2014).

Market Opportunities

Insights from the previous section reveal that challenges many households face (e.g. paying for meals, house reparation, schools fees) are related to financial poverty. Hence, quantifying the economic potential of human manure (Table 4.2 & 4.3) can provide an incentive at household level to exploit this locally available resource. However, intervention from NGOs and District Authorities may be required to initiate a market for eco sanitation. Potential market opportunities have been outlined by Water Point Committees (WPCs) A and B (2014) who have stated in interviews that local farmers rather than individual community members use (industrial) fertiliser for farming practices; indicating an opportunity of trade for eco fertiliser between community members as producers and local farmers as customers. The fact that this market opportunity is currently widely untapped is, according to NGO Participant A (2014), generally due to social barriers where 1) the community does not recognise the benefits, 2) governmental staff does not sufficiently promote the establishment of a market for ecosan. Academic Participant B (2014) agrees and alleges that extensive promotion campaigns are needed in order to „... show the communities the benefits and values of eco sanitation“.

As it has been revealed within this section (Practitioner Participant A & B, 2014; Academic Participant A & B, 2014), reluctance towards handling one's own manure embodies the greatest social barrier towards sound implementation of eco sanitation. This however creates a great business opportunity where eco sanitation entrepreneurs empty household's pit latrines and sell the final product

of eco fertiliser either back to the community or to local farmers. This saves households from having to handle their faeces but also prevents households from having to sell their manure to people within their own community, which also has been named as a major challenge towards the successful integration of eco sanitation (Academic Participant B, 2014).

It arises that the right context that makes ecosan pit latrines become an integral part to rural communities' daily life has to be created and supported from a top down approach. With industrial fertiliser currently being subsidised by the Malawian Government, this makes industrial fertiliser more affordable for farmers, drastically reducing the feasibility of a market for eco fertiliser (Agricultural Extension Officer, 2014). However, it also indicates that when the subsidy for chemical fertiliser is being phased out due to its unsustainable nature (see Chapter 2.4.2), this would provide a great incentive for communities to produce eco fertiliser but also for local farmers to apply it (NGO Participant A, 2014; Practitioner Participants A & B, 2014). Instead of subsidising industrial fertiliser, perhaps the Malawian Government could prospectively assist households financially to build eco sanitation toilets as the price of ecosan toilets ranging between MKW 17,000 – 30,000 (US $ 45 - 75) is currently not compatible with traditional pit latrines of which the production costs relatively next to nothing.

4.3 Quantification of Changes in Borehole Density, and Gender-related Implications

Tackling gender-related inequalities constitutes a crucial strand in *Integrated Water Resources Management* (IWRM). In Malawi, farming is a male-dominated field where women's involvement is minimal. When Water for People's 'Everyone Forever' vision becomes implemented, which implies an extensive increase in borehole density, this will result in significant time savings and physical as well as social relief for females. The question of how females use this gained time immediately arises. Under IWRM, offering females to become involved in permaculture practices provides opportunities for females to pursue income-generating activities such as working in gardens, selling produce on markets, or running entire businesses revolving around sustainable food production. How this can be achieved will be elaborated in more detail in Chapter 4.4. As requested by Research Question 3, the first part of this section quantifies distance and time savings for the Traditional Authority (TA) Chapananga by analysing the FLOW data from the two mapping periods 2011 and 2014. The second part of this section provides a context-based discussion analysing how changes in borehole density impact gender roles in rural Chikwawa.

4.3.1 Quantifying Distance and Time Changes of the FLOW Data

While detailed figures and tables regarding the results of the model developed in Chapter 3.3.3 are elaborated in Appendix C, Table 4.5 below summarises the occurred changes in the FLOW mapping data. Please note that the cumulative figures of these calculations assume that each female within the respective area travels once per day to collect water from the nearest borehole. It is therefore suggested that future study investigates in travel behaviour at household level, i.e. how many females are involved in water collection responsibilities, and how often per day do those responsible travel; these figures are then to replace assumptions made within the scope of this research.

Table 4.5: Total changes in the FLOW data between 2011 & 2014 in Chapananga

Total Changes in the FLOW Data for TA Chapananga between 2011 & 2014			
Average daily distance reduction per female (one way / return)	Cumulative daily distance reduction for Chapananga's entire female population* (one way / return)	Average daily time gain per female (one way / return)	Cumulative daily time gain for Chapananga's entire female population* (one way / return)
574 metres 1.1 km	25,930 km 51,860 km	7 minutes per day 14 minutes per day	5,186 hours (216 days) 432 days
*= Chapananga's female population according to this model comprises 45,175 females			

Table 4.5 states that the overall distance reduction for each travelling female amounts to 1.1 km on average (range: 137 metres one way (or 274 metres return) additional travel distance to 5,049 metres one way (or 10,098 return) travel distance reduction). For the entire female population in TA Chapananga (45,175 females), this results in cumulative time savings of over 50,000 km each day equalling 432 days' worth of travel that Chapananga's entire female population saves in travel distance in one day.

Extrapolating these values to the entire Chikwawa District, it emerges that the increased density in boreholes led to significant travel distance and time savings. Between 2011 and 2014, daily travel time worth 2,578 days were gained by Chikwawa District's female population through decreased distances between households and boreholes (Table 4.6). In line with the Millennium Development Goals (see Chapter 2.4), borehole density is likely to further increase as time progresses. This suggests that further research within the framework of IWRM must focus attention towards respective gender-related implications.

Table 4.6: Total changes in the FLOW data between 2011 & 2014 in the Chikwawa District (Extrapolation)

Extrapolating Total Changes in the FLOW Data to the Chikwawa District			
Average daily distance reduction per female (one way/return)	Cumulative daily distance reduction for Chapananga's entire female population* (one way/return)	Average daily time gain per female (one way/return)	Cumulative daily time gain for Chapananga's entire female population* (one way/return)
574 metres 1.1 km	154,707 km 309,414 km	7 minutes per day 14 minutes per day	30,941 hours (1,289 days) 2,578 days
*= Chikwawa's female population according to this model comprises 269,525 females			

The time value of 5 km/h that was applied to the distances however assumes that females travel in linear lines between households and boreholes. However, this is unlikely to reflect reality correctly due to obstacles existing on the ground (e.g. houses, trees, farms etc.), hinting that distances as well as time investments are likely to be longer than it is presumed by this model. A monetary value could not have been applied to the calculated distances and time values because investigations have revealed that the majority of the population in rural Chikwawa does not have available stable salaries with incomes largely depending on profession and season of the year (Community Participant B, 2014).

4.3.2 Shifting Gender Roles

Interviews conducted in Timbenawo GV highlighted that the drilling of new boreholes had noticeable implications on gender roles, bringing positive as well as negative change to the females in Timbenawo. Emerging insights unravelling ways in which gender roles have shifted in the GV are summarised within the following paragraphs.

While every female of the three interviewed Water Point Committees (WPCs) agreed that the implementation of new boreholes had led to significant time savings (WPC A-C, 2014), one female member of WPC B further elaborates on related gender implications. She alleges that the increased density of boreholes in her village did not only bring benefits that are directly related to reduced travel distances, but the close proximity to boreholes implies further indirectly related benefits too. She continues to reveal that many women now multitask meaning that they start to cook food on the stove before going to collect water. She says that in the past when they had to travel much further distances to collect water from the river, they could not have left food cooking on the stove while going out. (WPC B, 2014) This has led to further time savings in many women's daily schedules contributing to further value addition of the newly drilled boreholes in Timbenawo GV.

In response to the question *How do females use the gained time?*, common responses suggest that females predominantly use the gained time to clean their houses and bathrooms more thoroughly (female community members WPC A-C, 2014). Academic Participant C (2014) alleges that this is likely to increase the sanitation standards of the local households, which is directly connected to uplifted community health. The gained time is however also used for extra meal preparation time. More time is also spent with the family especially with the family's children, but is also used for leisure purposes (WPC A, 2014). Women also noted that they are generally more rested; this is due to the fact that they now sleep longer in the mornings. Instead of waking up in the early morning hours, sometimes as early as 2 or 3 o´clock in order to collect water from far away water sources; these days, women generally begin their day at 6am in the morning which is the time boreholes becomes unlocked (WPC C, 2014; Community Participant B, 2014). The insights gained within the previous paragraphs provide crucial feedback on gender-related implications of work undertaken by *Water for People* highlighting the strong positive correlation between increased borehole density and improved health and well-being of Timbenawo's female population.

Despite the abovementioned rather positive sounding impressions, one community member revealed perceived negative impacts. She stated that when water had to be collected from the Shire River, girls that are at least 15 or 16 years old used to gather in groups together with women and walk to the river collectively to fetch water. This was due to the potentially unsafe journey, which forced females to leave their community. These days however, boreholes are located within the village borders, which makes it safe for girls as young as five years of age to become involved in water collection duties (Community Participant C, 2014). It can be assumed that carrying heavy loads of water at such a young age may evoke detrimental physical damages on children's developing bodies. From a social perspective, becoming involved in water collection at school age may compromise girl's school attendance or might at least reduce their capacity to study when having to do water collecting chores before and/or after school. Under the IWRM paradigm, having disadvantages over boys in school is likely to lead to a higher economic vulnerability over men in women's adulthood. Henceforth, when encouraging women to participate in communal permaculture activities, this may open up new possibilities for women to escape potential financial or social dependencies.

4.4 A Road Map

Chapter 4 so far has described the multifacetedness that water management at community level holds and outlined the need for a holistic approach that combines interdisciplinary expertise in order to promote environmental, social and economic sustainability at community level. This Chapter's final section summarises collected impressions from interviews and observations in Chikwawa but also elsewhere in Malawi with the aim to express ideas for a road map strategy that can facilitate integration of the three previously discussed topics under IWRM in the case study area.

4.4.1 Progressing from Water Point Committees to Integrated Water Resources Management Committees

Contemporarily, WPCs manage boreholes and handle any related issues (collection of monthly water tariff fees, borehole cleaning, maintenance and reparation, care taking of existing borehole gardens etc.) (WPC C, 2014). However, in order to 1) efficiently manage such great quantities of grey water (nearly 500,000 litres monthly in Timbenawo GV, see Chapter 3.3.1) and 2) up-scaling currently existing community borehole gardens to fruitful gardens that follow permaculture principles in order to provide enough food to uplift the nutritional and/or economic needs of the community, the notion of WPCs needs to be extended. Perhaps IWRM Committees can emerge dividing labour and responsibilities among a greater amount of trained community members (Academic Participant D, 2014).

4.4.2 Integrated Pest Management (IPM)

IPM has to be an integral part of permaculture from as early as the planning process. Observations have shown that animals such as cows, goats and pigs in Timbenawo GV roam around freely often breaking fences to community borehole gardens in order to obtain food and/or water (Community Participant B, 2014). At Thunga Primary School in Thunga, Thyolo District, bamboo was

employed as a live fencing species effectively keeping animals from entering and consuming plants in the school gardens (Figure 4.6). Barbwire fencing was also suggested as an alternative fencing method that is likely to be resistant to animal invasion. Discouraging animals from garden areas can also be promoted through providing drinking troughs outside garden areas. It was also found that animal food is currently not grown in the village encouraging animals to feed on human's food sources (Community Participant D, 2014). Therefore, it is vital that designated animal food is grown in the village prospectively to discourage animals away from permaculture gardens.

Figure 4.6: Live fencing at Thunga Primary School, Thyolo District (Source: Author's own, 2014)

4.4.3 Effective Grey Water Management

Grey borehole water must be managed more efficiently in order to maximise its otherwise lost value. Proposals for better utilisation included the introduction of clay channels distributing water between the garden beds (Chapter 4.1.3). Furthermore, establishments of water collection and storage facilities have been suggested (Practitioner Participant A, 2014). While water tanks are often financially unaffordable, dug holes in the ground laid out and covered with plastic sheets therefore provide a cheap alternative (Practitioner Participant B, 2014). Academic Participant C (2014) argues that grey water could also be channelled into wells. Community Participant C (2014) supports this idea stating that the community could extract grey water from the wells for gardening purposes with watering cans. When managing grey borehole water, it is however vital to take into consideration the large amount of animals that use grey borehole water as their main source of drinking water. Hence, when stagnant water is eliminated, alternative drinking sources for animals need to ensured.

4.4.4 Implementing the Philosophy of Permaculture

An Interdisciplinary Approach

The existing community borehole gardens provide a first stepping-stone towards the integration of permaculture principles into current gardening practices. As elaborated in Chapter 2, permaculture endorses crop and nutrition diversity whereby gardens in Timbenawo GV focus on growing a small range of crops, predominantly cocoyam, maize and bananas. The need for educational programmes teaching permaculture principles arises. Therefore, it shall be suggested that *Water for People* enter collaboration with local permaculture experts such as Pa Nthunzi Sustainability Centre, Blantyre. This would not only extend the spectrum of knowledge and expertise offered to Timbenawo´s communities but would also add robustness to a holistic integration of IWRM at community level accordingly.

Expanding Existing Gardens

Due to the significant amounts of water flowing into borehole gardens on a daily basis (Chapter 4.1.1), it is suggested to expand existing gardens. Practitioner Participant B (2014) recommended moving from boxed garden patches to extensive garden areas where for example a ring of houses around the borehole could act as a garden boundary. For these gardens it will also be important to incorporate a range of fruit trees that provide shade for the community but also for smaller plants and to help retain moisture in the soil. Perhaps permaculture experts could assist with developing a model garden within the GV that could be replicated to other boreholes in the future. This idea would however also need to be supported from the District Authorities and communities.

Investing in Future Generations

Teaching permaculture in schools has the potential to make a significant impact on improving nutrition security in the future. Conversations with primary and secondary school children in Timbenawo delivered the notion that

pupils enjoy sharing learnings from environmental and gardening lessons (Figure 4.7). In addition, implementing school permaculture gardens and introducing permaculture lessons into curricular also equips children with valuable skills from which the community can directly benefit (Practitioner Participant B, 2014).

Figure 4.7: Children teaching about irrigation methods

Permaculture as a Market Model

Permaculture provides a holistic approach to small-scale sustainable gardening through which communities in Chikwawa can establish a self-supporting economic business model. Hybrid seeds are currently prevalent in the area forcing communities to continuously buy new seeds. Therefore, the aim should be to introduce native seedlings where the mother plant when going into seed provides a large number of replantable seeds. Acquiring native seedlings is often expensive however money should be invested into quality seeds as this will result in financial savings long term. Permaculture experts who help communities to kick-start permaculture could initially sell non-hybrid seeds to the community. Excess seeds could eventually be sold on market days or directly at the respective garden facility. In fact, these facilities could become garden centres were seeds, seed vaults, plants or produce is sold or exchanged among community members.

Once such facilities are established enough to significantly contribute to the year-round nutrition security of local communities, constant labour input will be required for maintenance, selling produce, finance management etc. Chapter 4.3 has outlined the vast labour capacity that females of the region can potentially contribute to this model. When women invest that extra time in permaculture activities, may this be at household or borehole level, women would not only participate in income-generating activities that boost the local economy but this would automatically change social hierarchies at community level hinting the need for thorough integration and application of IWRM principles.

4.4.5 Identifying Leaders to Encourage Behavioural Change

NGO Participant A (2014) argues that identifying a small number of passionate people is vital for the successful implementation of visions, as long as these visions are also prioritised by the local communities. Academic Participant B (2014) adds that transferring practical skills such as permaculture gardening techniques to motivated individuals increases the chance that the delivered skills will be applied and self-sustained once the NGO finishes their community support. In fact, experience of NGO Participant A (2014) proves that "donors and NGOs created a belief system that they can solve all problems for the community when really they should only be facilitating". This has also been observed by Academic Participant C (2014, see Chapter 4.2.2), who stated that NGO's messages are not self-carrying and sustaining if they are not in line with communities' priorities. This however shall not undermine the work of NGOs because as NGO Participant B (2014) notices, "sometimes the community does not know the goodness of it, and we can teach them how to use skills and knowledge for their advantage". For the creation of permaculture gardens, this means to make community members understand how implementing permaculture principles can assist the community to increase 1) nutritional security, 2) counteract soil degradation by building up soils through crop diversity, mulching, and organic fertilisation, 3) empower females to gain independence from gender-related inequalities, and 4) boost the economy of the local region by maximising the use of local resources.

Community members depicted examples such as solar borehole pumping systems that have helped the development process of communities from other areas in Chikwawa or other regions in Malawi (WPC A, 2014). Exchange visits with such communities for knowledge sharing were subsequently requested (WPC A & C, 2014; Community Participant B, 2014). Under IWRM, promoting communication through knowledge exchange visits can help NGOs to spread their message, but can also help problem solving and encourage ecological thinking at community level. Hindering factors that may occur and must be settled beforehand regard organisation, financing and evaluation of such activities.

4.4.6 Future Investigation Required for Eco Fertiliser Feasibility

From the discussion in Chapter 4.2 emerges that the concept of producing and applying fertiliser derived from human manure is still relatively new to many and the path to its successful implementation holds obstacles. Depending on size and number of users, ecosan pit latrines can be harvested after approximately one year from when they first got used. In Timbenawo GV, three demonstration ecosan toilets have been built in 2012 by a NGO, and still had not been harvested at the time this investigation was conducted (June/July 2014) hinting that the NGO that constructed these toilets did not support the three volunteering households from beginning to end, i.e. from the construction to harvesting process. For these reasons, this research suggests to channel further research effort into the implementation of eco sanitation in rural Chikwawa. It should also be given consideration to the possible usage of urine only for fertiliser production due to its faster and easier application. Further research needs will be elaborated in Chapter 5.3.

Chapter 5
CONCLUSIONS

Derived from the discussions that have enriched this dissertation's arguments, this final chapter intends to summarise the core assertion that this dissertation had debated. While the first section of this chapter summarises key points, the second part shall assess the extent to which the Research Questions outlined in Chapter 3.1 have been answered and what remains as unanswered. From this discussion emerge future study needs, which represent the closing part of this chapter and dissertation likewise.

5.1 Dissertation Summary

The prime aim of this research was to identify the potential for bottom-up sustainable development that the Chikwawa District in Southern Malawi holds using locally available resources. Following that enquiry, this dissertation appraised the economic potential of channelling grey borehole water into community borehole gardens producing diversified foods that ensures communities' food and nutrition security. In addition, further value addition occurs by removing stagnant water from the ground eliminating breeding grounds for malaria-carrying mosquitoes, which is expected to reduce malaria infections. Successful implementation of this strategy is likely to mitigate communities' vulnerability to climate changing extreme weather events that are expected to increasingly affect local communities as time progresses. Quantitative research in Timbenawo, a group village that encompasses four villages in Chapananga, Chikwawa District showed that almost 500,000 litres or 30% of all extracted water is not taken to households outlining the vast capacity for on-site food production.

The second focus of this dissertation lies on eco fertiliser derived from human manure. In line with the Millennium Development Goals, basic pit latrines as well as increased amounts of boreholes have been implemented within rural geographies such as the Chikwawa District as a global approach to increase water accessibility and sanitation standards within poverty-stricken communities. Scientific evidence however show that these infrastructure changes have led to a high underground concentration of human faeces within close proximity to boreholes inducing potential contamination of groundwater resources which >80% of Malawians rely on for their drinking water. To process human manure into eco fertiliser therefore not only supports environmental sustainability by proving a sustainable and renewable alternative to chemical fertiliser but also removes potential groundwater contamination. With a population of over 2,400, Timbenawo GV has the potential to produce almost 14 tons of eco fertiliser yearly, which has the ability to replace 0.35 tons of industrial fertiliser. The need for eco sanitation business models arise where eco fertiliser exceeds the application in permaculture community gardens but where entrepreneurs buy latrine contents from households and sell the composted product as eco fertiliser to local farmers.

The increased amount of boreholes as explained in the previous paragraph also led to significantly decreased travel investments among many women responsible for water collection. Borehole mapping data from 2011 and 2014 gathered within the Chikwawa District by the Chikwawa District Council was analysed in order to quantify distance and time changes that occurred between both mapping periods within the Traditional Authority of Chapananga. Results indicate vast time gains that women have available in 2014 compared to 2011. It is expected that channelling gained time or proportions of such into income-generating activities through permaculture food production projects has the ability to provide women with an alternative source of income which can assist women to counteract gender-related inequalities at household level.

5.2 Dissertation achievements

The economic evaluation of the aforementioned resources as asked in Research Question 1-3 outlines the vast potential that the District holds to tap into locally available yet often wasted resources. Guidance and recommendations from interviewees were taken into account to the best possible extent throughout the development of models and calculations appraising the economic value of the respective resources. Qualitative research comprised of semi-structured interviews and field observations was employed were quantitative research could not answer the Research Questions. It was found that social aspects can favour communities to tap into the outlined potential, but also showed that it can provide barriers hindering their effective use. How communities exploit opportunities strongly depends on their motivation as well as other related or unrelated factors such as development stages, education status and/or physical and social well-being.

The importance of Integrated Water Resources Management (IWRM) becomes obvious within the aspiration to successfully interweave the appraised resources in order to maximise all stakeholders' outcomes and mitigate any occurring trade-offs. However, as Chapter 2 had questioned the functionality of IWRM on the ground, it was argued in Chapter 4 that the results of this research not only benefit local communities and planning authorities, but also provides opportunity to feed into a greater body of academic literature where best practice experiences derived from the Chikwawa District can be shared.

5.3 Unanswered Themes and Future Study

The particularly complex nature of the local social settings that the research questions requested to explore made it impossible to identify representable solutions that can be applied at household level, let alone standardised solutions that can be replicated across the entire District. Exploring social opportunities and perceived barriers focused on the implementation of each resource individually rather than evaluating how the named resources can be integrated with each other. Hence, it is suggested to invest future research

efforts into the interdisciplinary approach that is needed for the integration of wasted borehole water, eco sanitation and gender into permaculture gardens following IWRM principles. More precisely, it should be identified how big permaculture gardens can be at each of the boreholes, how many people can it benefit and who takes leadership over it. It should also be evaluated how NGOs as well as a national and international perspective can facilitate communities to make use of the largely lost value of local resources in order to increase their social and economic welfare without compromising environmental sustainability. It is also suggested to investigate exactly how IWRM can benefit sustainable development at community level, and who takes leadership responsibilities within that approach.

5.4 Concluding Thoughts

Implementing the IWRM paradigm in combination with permaculture principles can lead Chikwawa's communities to effective sustainable change that improves community health and well-being through a community-led approach. That IWRM becomes entrenched at community level in rural Chikwawa can be seen in the example of Timbenawo GV. Three out of 12 boreholes use grey borehole water for food production, and one garden already generated income through the selling of garden produce. This achievement is likely to accelerate the replication of community gardens across the group village in the near future. However, for a holistic IWRM approach it will be vital to integrate permaculture practices in the future as these allow for maximising the potential and sustainability of current borehole gardens. Nevertheless, reinforcing Roosevelt's quote from the beginning of this dissertation, this is the first successful step of many along the path towards sustainable development that the Chikwawa District will have to take in order to pass on prosperous land and opportunities to future generations.

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Appendix A: Ethical Application Form

Ethics Application Form

Please answer all questions

1. Title of the investigation
Practical Application of Integrated Water Resources Management in the Chikwawa District, Malawi - An economic and social evaluation of locally available resources
Please state the title on the PIS and Consent Form, if different: -

2. Chief Investigator (must be at least a Grade 7 member of staff or equivalent)
Name: Prof Robert M Kalin ☒ Professor ☐ Reader ☐ Senior Lecturer ☐ Lecturer ☐ Senior Teaching Fellow ☐ Teaching Fellow Department: Civil and Environmental Engineering Telephone: 0141 5484649 E-mail: Robert.Kalin@Strath.ac.uk

3. Other Strathclyde investigator(s)
Name: - Status (e.g. lecturer, post-/undergraduate): Department: Telephone: E-mail:

4. Non-Strathclyde collaborating investigator(s) (where applicable)
Name: - Status (e.g. lecturer, post-/undergraduate): Department/Institution: If student(s), name of supervisor: Telephone: E-mail: Please provide details for all investigators involved in the study:

5. Overseas Supervisor(s) (where applicable)
Name(s): - Status: Department/Institution: Telephone: Email: I can confirm that the local supervisor has obtained a copy of the Code of Practice: Yes ☐ No ☐ Please provide details for all supervisors involved in the study:

6. Location of the investigation
At what place(s) will the investigation be conducted Chikwawa District and Blantyre City, Malawi
If this is not on University of Strathclyde premises, how have you satisfied yourself that adequate Health and Safety arrangements are in place to prevent injury or harm? A health and safety assessment has been undertaken.

7. Duration of the investigation

Duration(years/months) : 6 weeks

Start date (expected): 29 / 05 / 2014 Completion date (expected): 12 / 07 / 2014

8. Sponsor

Please note that this is not the funder; refer to Section C and Annexes 1 and 3 of the Code of Practice for a definition and the key responsibilities of the sponsor.

Will the sponsor be the University of Strathclyde: Yes ~~No~~

If not, please specify who is the sponsor:

9. Funding body or proposed funding body (if applicable)

Name of funding body: -

Status of proposal – if seeking funding (please click appropriate box):

☐ In preparation

☐ Submitted

☐ Accepted

Date of submission of proposal: Date of start of funding:

10. Ethical issues

Describe the main ethical issues and how you propose to address them:

Confidentiality: Every interviewee will be ensured that their contribution to the research will be treated as confidential.

Permission for recording the interview: Each interviewee's consent to record the interview will be obtained before the interview. If an interviewee wishes not to be recorded, then notes will be taken instead.

Safety: Each interviewee will be ensured that they will not be harmed in any way by participating in this research.

11. Objectives of investigation (including the academic rationale and justification for the investigation) Please use plain English.

Following the concept of 'Integrated Water Resources Management', the aim of this research is to investigate how local communities in the Chikwawa District can pursue sustainable development by using locally available resources.

12. Participants

Please detail the nature of the participants:

Interviewees will be stakeholders in managing Chikwawa's water resources.

Summarise the number and age (range) of each group of participants:

Number: 25 Age (range) 20-70

Please detail any inclusion/exclusion criteria and any further screening procedures to be used:

13. Nature of the participants

Please note that investigations governed by the Code of Practice that involve any of the types of participants listed in B1(b) must be submitted to the University Ethics Committee (UEC) rather than DEC/SEC for approval.

Interviewees will be stakeholders in managing Chikwawa's water resources. Potential interviewees will be members of the Chikwawa District Council, health committees, water committees, sanitation committees, and permaculture establishments.

Do any of the participants fall into a category listed in Section B1(b) (participant considerations) applicable in this investigation?: ~~Yes~~ No

If yes, please detail which category (and submit this application to the UEC):

14. Method of recruitment

Describe the method of recruitment (see section B4 of the Code of Practice), providing information on any payments, expenses or other incentives.

With the help of Prof R Kalin, potential interviewees will be identified after arrival in Blantyre, Malawi, and will orally be invited to participate in the research. Interviews will be undertaken between June 1st and July 11th at a time that will suit the interviewee. Before the interview, the interviewer will obtain informed consent by the interviewee. No inducement will be offered to interviewees.

15. Participant consent

Please state the groups from whom consent/assent will be sought (please refer to the Guidance Document).
Consent will be sought from all interviewees. No special problems are expected in obtaining informed consent. The interviewees will be introduced to the researcher as well as the research aim and purpose using the PIS.
The PIS and Consent Form(s) to be used should be attached to this application form.
The PIS and Consent Form are attached to this application (Appendix B).

16. Methodology

Investigations governed by the Code of Practice which involve any of the types of projects listed in B1(a) must be submitted to the University Ethics Committee rather than DEC/SEC for approval.

Are any of the categories mentioned in the Code of Practice Section B1(a) (project considerations) applicable in this investigation? ~~Yes~~ No
If 'yes' please detail:

Describe the research methodology and procedure, providing a timeline of activities where possible. Please use plain English.
Semi-structured interviews will be conducted. All interviewees will be asked similar questions, which allows the researcher to analyse the stakeholders' views as to how local resources can best be utilised within the context of the Chikwawa District.

What specific techniques will be employed and what exactly is asked of the participants? Please identify any non-validated scale or measure and include any scale and measures charts as an Appendix to this application. Please include questionnaires, interview schedules or any other non-standardised method of data collection as appendices to this application.
Semi-structured interview techniques will be employed to gather relevant data. Conducting approximately 25 interviews will help the researcher to attain a comprehensive insight to how water resources are managed currently, and how they can be used more efficiently for land and people.

Where an independent reviewer is not used, then the UEC, DEC or SEC reserves the right to scrutinise the methodology. Has this methodology been subject to independent scrutiny? Yes ~~No~~
Sample interview questions can be found under Appendix 2.
If yes, please provide the name and contact details of the independent reviewer:
Dr Elsa Joao, Department of Civil and Environmental Engineering, University of Strathclyde
Level 5, James Weir Building, 75 Montrose Street, Glasgow G1 1XJ, Scotland
Direct line: +44 141 548 4056; Mobile: 0788 443 4438; Email: elsa.joao@strath.ac.uk

17. Previous experience of the investigator(s) with the procedures involved. Experience should demonstrate an ability to carry out the proposed research in accordance with the written methodology.

Semi structured interviews have been undertaken as part of a third year BSc degree course called "Research Methods and Design in Human Geography" at the University of Auckland, New Zealand in 2011. In addition, the course CL 957 "Quantitative and Qualitative Research Methods" at the University of Strathclyde provided further training on that matter.

18. Data collection, storage and security
How and where are data handled? Please specify whether it will be fully anonymous (i.e. the identity unknown even to the researchers) or pseudo-anonymised (i.e. the raw data is anonymised and given a code name, with the key for code names being stored in a separate location from the raw data) - if neither please justify. Recorded interviews will be transcripted and handled by the researcher only. Data will be treated confidentially and will be used solely for the purpose of this research
Explain how and where it will be stored, who has access to it, how long it will be stored and whether it will be securely destroyed after use: An encrypted version of the transcripts will be kept on the researcher's PC for analysis purpose, which is only ever accessed by the researcher. Data will be handled in accordance to the University's Data Protection Principles.
Will anyone other than the named investigators have access to the data? ~~Yes~~ No If 'yes' please explain:

19. Potential risks or hazards
Describe the potential risks and hazards associated with the investigation: Potential risks include the flight to Malawi as well as travel and activities within Malawi.
Has a specific Risk Assessment been completed for the research in accordance with the University's Risk Management Framework (http://www.strath.ac.uk/safetyservices/aboutus/riskmanagement/)? Yes ~~No~~ If yes, please attach risk form (S20) to your ethics application. If 'no', please explain why not: The risk assessment form (S20) can be found under Appendix 3.

20. What method will you use to communicate the outcomes and any additional relevant details of the study to the participants?
The participants will be offered a digital copy of the final thesis or a summary of the results after September 2014.

21. How will the outcomes of the study be disseminated (e.g. will you seek to publish the results and, if relevant, how will you protect the identities of your participants in said dissemination)?
Results are likely to become published; identities of participants will not be disclosed.

Checklist	**Enclosed**	**N/A**
Participant Information Sheet(s)	☒	☐
Consent Form(s)	☒	☐
Sample questionnaire(s)	☐	☒
Sample interview format(s)	☒	☐
Sample advertisement(s)	☐	☒
Any other documents (please specify below)		
Risk Assessment form (S20)	☒	☐
	☐	☐
	☐	☐
	☐	☐
	☐	☐

22. Chief Investigator and Head of Department Declaration
Please note that unsigned applications will not be accepted and both signatures are required

I have read the University's Code of Practice on Investigations involving Human Beings and have completed this application accordingly. By signing below, I acknowledge that I am aware of and accept my responsibilities as Chief Investigator under Clauses 3.11 – 3.13 of the Research Governance Framework and that this investigation cannot proceed before all approvals required have been obtained.

Signature of Chief Investigator

Please also type name here: Prof Robert Kalin

I confirm I have read this application, I am happy that the study is consistent with departmental strategy, that the staff and/or students involved have the appropriate expertise to undertake the study and that adequate arrangements are in place to supervise any students that might be acting as investigators, that the study has access to the resources needed to conduct the proposed research successfully, and that there are no other departmental-specific issues relating to the study of which I am aware.

Signature of Head of Department

Please also type name here

Date:

23. Only for University sponsored projects under the remit of the DEC/SEC, with no external funding and no NHS involvement

Head of Department statement on Sponsorship
This application requires the University to sponsor the investigation. This is done by the Head of Department for all DEC applications with exception of those that are externally funded and those which are connected to the NHS (those exceptions should be submitted to R&KES). I am aware of the implications of University sponsorship of the investigation and have assessed this investigation with respect to sponsorship and management risk. As this particular investigation is within the remit of the DEC and has no external funding and no NHS involvement, I agree on behalf of the University that the University is the appropriate sponsor of the investigation and there are no management risks posed by the investigation.

If not applicable, tick here ☐

Signature of Head of Department

Please also type name here

Date:

For applications to the University Ethics Committee, the completed form should be sent to ethics@strath.ac.uk with the relevant electronic signatures.

24. Insurance
The questionnaire below must be completed and included in your submission to the UEC/DEC/SEC:

Is the proposed research an investigation or series of investigations conducted on any person for a Medicinal Purpose? ~~Yes~~ / No

Medicinal Purpose means:

- treating or preventing disease or diagnosing disease or
- ascertaining the existence degree of or extent of a physiological condition or
- assisting with or altering in any way the process of conception or
- investigating or participating in methods of contraception or
- inducing anaesthesia or
- otherwise preventing or interfering with the normal operation of a physiological function or
- altering the administration of prescribed medication.

If "**Yes**" please go to **Section A (Clinical Trials)** – all questions must be completed
If "**No**" please go to **Section B (Public Liability)** – all questions must be completed

Section A (Clinical Trials)

Does the proposed research involve subjects who are either: Yes / No

i. under the age of 5 years at the time of the trial;
ii. known to be pregnant at the time of the trial

*If "**Yes**" the UEC should refer to Finance*

Is the proposed research limited to: Yes / No

iii. Questionnaires, interviews, psychological activity including CBT;
iv. Venepuncture (withdrawal of blood);
v. Muscle biopsy;
vi. Measurements or monitoring of physiological processes including scanning;
vii. Collections of body secretions by non-invasive methods;
viii. Intake of foods or nutrients or variation of diet (excluding administration of drugs).

*If "**No**" the UEC should refer to Finance*

Will the proposed research take place within the UK? Yes / No

*If "**No**" the UEC should refer to Finance*

Title of Research
Chief Investigator
Sponsoring Organisation
Does the proposed research involve:

a)	investigating or participating in methods of contraception?	Yes / No
b)	assisting with or altering the process of conception?	Yes / No
c)	the use of drugs?	Yes / No
d)	the use of surgery (other than biopsy)?	Yes / No
e)	genetic engineering?	Yes / No
f)	participants under 5 years of age(other than activities i-vi above)?	Yes / No
g)	participants known to be pregnant (other than activities i-vi above)?	Yes / No
h)	pharmaceutical product/appliance designed or manufactured by the institution?	Yes / No
i)	work outside the United Kingdom?	Yes / No

If **"YES"** to **any** of the questions a-i please also complete the **Employee Activity Form** (attached).
If **"YES"** to **any** of the questions a-i, and this is a follow-on phase, please provide details of SUSARs on a separate sheet.
*If "**Yes**" to any of the questions a-i then the UEC/DEC/SEC should refer to Finance (aileen.stevenson@strath.ac.uk).*

Section B (Public Liability)

Does the proposed research involve :

a)	aircraft or any aerial device	~~Yes~~ / No
b)	hovercraft or any water borne craft	~~Yes~~ / No
c)	ionising radiation	~~Yes~~ / No
d)	asbestos	~~Yes~~ / No
e)	participants under 5 years of age	~~Yes~~ / No
f)	participants known to be pregnant	~~Yes~~ / No
g)	pharmaceutical product/appliance designed or manufactured by the institution?	~~Yes~~ / No
h)	work outside the United Kingdom?	Yes / ~~No~~

*If **"YES"** to any of the questions the UEC/DEC/SEC should refer to Finance (aileen.stevenson@strath.ac.uk).*

For NHS applications only - Employee Activity Form

Has NHS Indemnity been provided?	~~Yes~~ / No
Are Medical Practitioners involved in the project?	~~Yes~~ / No
If YES, will Medical Practitioners be covered by the MDU or other body?	~~Yes~~ / No

This section aims to identify the staff involved, their employment contract and the extent of their involvement in the research (in some cases it may be more appropriate to refer to a group of persons rather than individuals).

Chief Investigator		
Name	**Employer**	**NHS Honorary Contract?**
		Yes / No
Others		
Name	**Employer**	**NHS Honorary Contract?**
		Yes / No
		Yes / No
		Yes / No
		Yes / No

Please provide any further relevant information here:

Appendix B:
Participant Information Sheet and Consent Form

Participant Information Sheet

Department of Civil and Environmental Engineering
Title of the study: Practical Application of Integrated Water Resources Management in the Chikwawa District, Malawi - An economic and social evaluation of locally available resources.

Introduction
My name is Janine Schmalfuss. I am originally from Germany but I am currently a student at the University of Strathclyde in Glasgow, Scotland. I am studying towards a Master of Science degree in *Sustainability and Environmental Studies* within the Department of Civil and Environmental Engineering.

What is the purpose of this investigation?
My thesis explores the capacity of local communities in rural Chikwawa, Malawi to carve the path of sustainable development by making effective use of local resources. As literature regards Integrated Water Resources Management and Permaculture concepts as ways to achieve such vision, this study is designed to find out how both concepts can be used to improve environmental, social and economic well-being amongst Chikwawa's communities.

Do you have to take part?
This research is undertaken not to critique the effectiveness of current water management practices, but rather to identify benefits to the communities if water resources were managed following the concept of Integrated Water Resources Management and I would like to invite you to participate in my study. Your participation is voluntary and you are free withdraw from the interview at any time without detriment. I would like to record this interview in order to facilitate my data analysis process, however, you can choose to not have this interview recorded. If you decide that you prefer not to be recorded at any stage during the recorded interview, the audiotape will be stopped immediately. If you wish, I will provide an interview transcript shortly after the interview that you may edit up to two weeks after the interview. If you are interested in the results of my research, an electronic copy of my thesis will be made available to you.

What will you do in the project?

As part of this research, you will be involved in a semi-structured interview that will last approximately 45 minutes. Payment or other types of reimbursement are not provided. The interview will occur between June 1 and July 15 at a time that suits yourself.

Why have you been invited to take part?

I have identified you as a potential participant through your direct or indirect involvement with managing Chikwawa's water resources. Considering your stake in my research will help me to depict opportunities and challenges the Chikwawa District faces to effectively tap into local resources use as accurately as possible.

What are the potential risks to you in taking part?

My research will at no stage pose any risks to you. However, if you feel otherwise, you are free to withdraw from this interview at any given point in time.

What happens to the information in the project?

Your confidentiality will be maintained throughout this research process. I am the sole transcriber of the recordings and you will not be referred to by your name unless you give specific approval for this to occur. You are rather referred to by the nature of your job or involvement in managing Chikwawa' water resources. The information you shared within the scope of this interview will be kept for 5 years after the interview was conducted.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data

Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

The place of useful learning

The University of Strathclyde is a charitable body, registered in Scotland, number SC015263

What happens next?

If you wish to participate in my study, I would like you to sign the attached consent form to confirm this. The results of this study will be made available to, and published by, the Malawian and Scottish Government.

Researcher Contact Details:

Janine Schmalfuss
Level 5 James Weir Building
75 Montrose Street
Glasgow G1 1XJ
Scotland
+44 (0)141 552 4400
Janine.Schmalfuss@uni.strath.ac.uk

Chief Investigator Details:

Prof. Robert M Kalin
Professor of Environmental Engineering for Sustainability
Department of Civil and Environmental Engineering
Level 5 James Weir Building
75 Montrose Street Glasgow G1 1XJ
Tel: +44 141 548 4649
E-Mail: Robert.Kalin@Strath.ac.uk

This investigation was granted ethical approval by the University of Strathclyde ethics committee.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the
University Ethics
Committee Research &
Knowledge Exchange
Services University of
Strathclyde
Graham Hills Building 50 George Street
Glasgow
G1 1QE
Telephone: 0141 548 3707
Email: ethics@strath.ac.uk

The place of useful learning

The University of Strathclyde is a charitable body, registered in Scotland, number SC015263

Consent Form

Department of Civil and Environmental Engineering
Title of the study: Practical Application of Integrated Water Resources Management in the Chikwawa District, Malawi - An economic and social evaluation of locally available resources.

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, without having to give a reason and without any consequences.
- I understand that I can withdraw my data from the study at any time.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being audio and video recorded as part of the project: **Yes/ No**

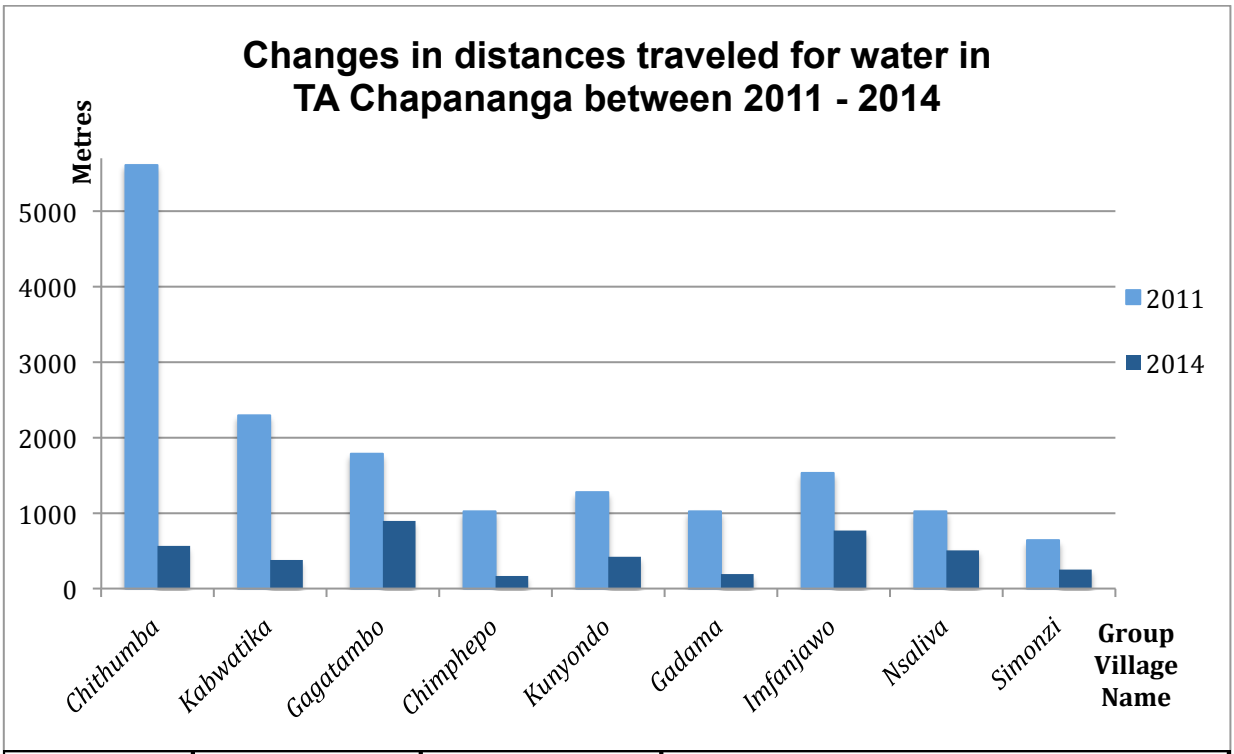
(PRINT NAME)	Hereby agree to take part in the above project
Signature of Participant:	Date

The place of useful learning
The University of Strathclyde is a charitable body, registered in Scotland, number SC01526333

Appendix C: Changes in FLOW Mapping Periods 2011 and 2014

The four graphs in Figure C.1 *(a-c)* outline results that emerged from the model that was developed in Chapter 3.3.3. For each of the 36 Group Villages in Chapananga, the graphs in the top half of the figure visualise the changes in distance that women travelled for water in 2011 compared to 2014. The bottom half of the figures show the corresponding numbers but also indicate time approximates that females invest to travel respective distances. Lastly, the distance and time changes between 2011 and 2014 are outlined with green numbers indicating that less distance is needed to be walked in 2014 compared to 2011, i.e. time is gained, and red numbers outlining that the distances that need to be travelled have increased, i.e. more travel and time investment is required for water collection. The last column in the graphs outlines the cumulative time savings for the entire female population of each Group Villages, these result from multiplying the time savings per female (neighbouring column) with the female population, which is listed for each Group Village in Table C.1

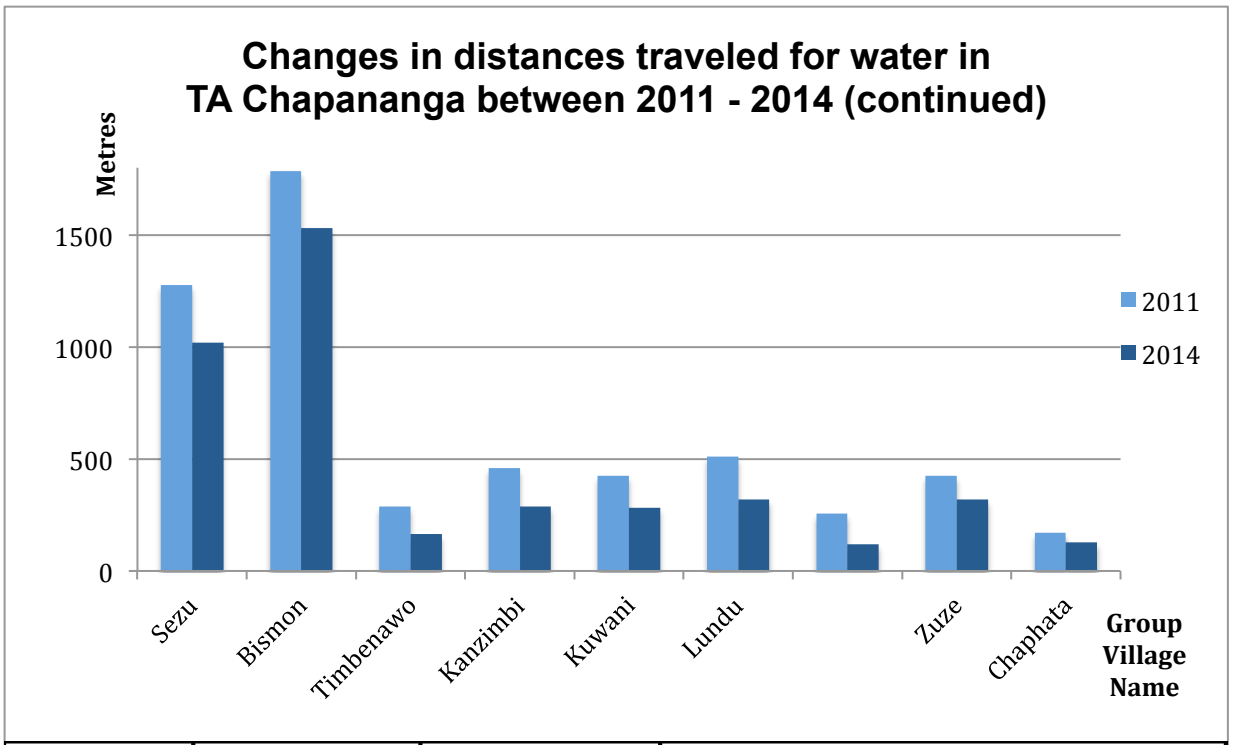
Figure C.1 *a-c* show that distances to travel between households and boreholes have decreased for 18 Group Villages (GVs) but also show that females in five GVs travel longer distances in 2014 than they did in 2011. Changes for the missing 13 GVs could not be captured due to a lack of data in at least one of the two mapping periods. These 13 GVs are for the aforementioned reasons not plotted within the graphs below; the changes in travel distances for the other 23 GVs are illustrated in graphs and are arranged by changed variables, i.e. from the highest resulting savings descending accordingly, which allows to immediately spot where the greatest distance and time savings have occurred.



Group Village Name	Distances 2011 (metres/ time)	Distances 2014 (metres/ time)	Changes		
			Distance (metres)	**Time gained or lost per female (minutes per day)**	**Time gained or lost per female population (hours per day)***
Chithumba	5,610 m/ 67.3 min	561 m/ 6.7 min	-5,049	+ 60.6	+ 3,997.6
Kabwatika	2,295 m/ 27.5 min	383 m/ 4.6 min	-1,912	+ 22.9	+ 497.9
Gagatambo	1,785 m/ 21.4 min	892 m/ 10.5 min	-893	+ 10.9	+ 296.6
Chimphepo	1,020 m/ 12.2 min	170 m/ 2 min	-850	+ 10.2	+ 233.3
Kunyondo	1,275 m/ 15.3 min	425 m/ 5.1 min	-850	+ 10.2	+ 160.1
Gadama	1,020 m/ 12.2 min	191 m/ 2.3 min	-829	+ 9.9	+ 81.4
Imfanjawo	1530 m/ 18.4 min	765 m/ 9.2 min	-765	+ 9.2	+ 162.8
Nsaliva I	1020 m/ 12.2 min	510 m/ 6.1 min	-510	+ 6.1	+ 46.4
Simonzi	638 m/ 7.7 min	255 m/ 3.1 min	-383	+ 4.6	+ 84.7

*= Female population data provided in Table C.1

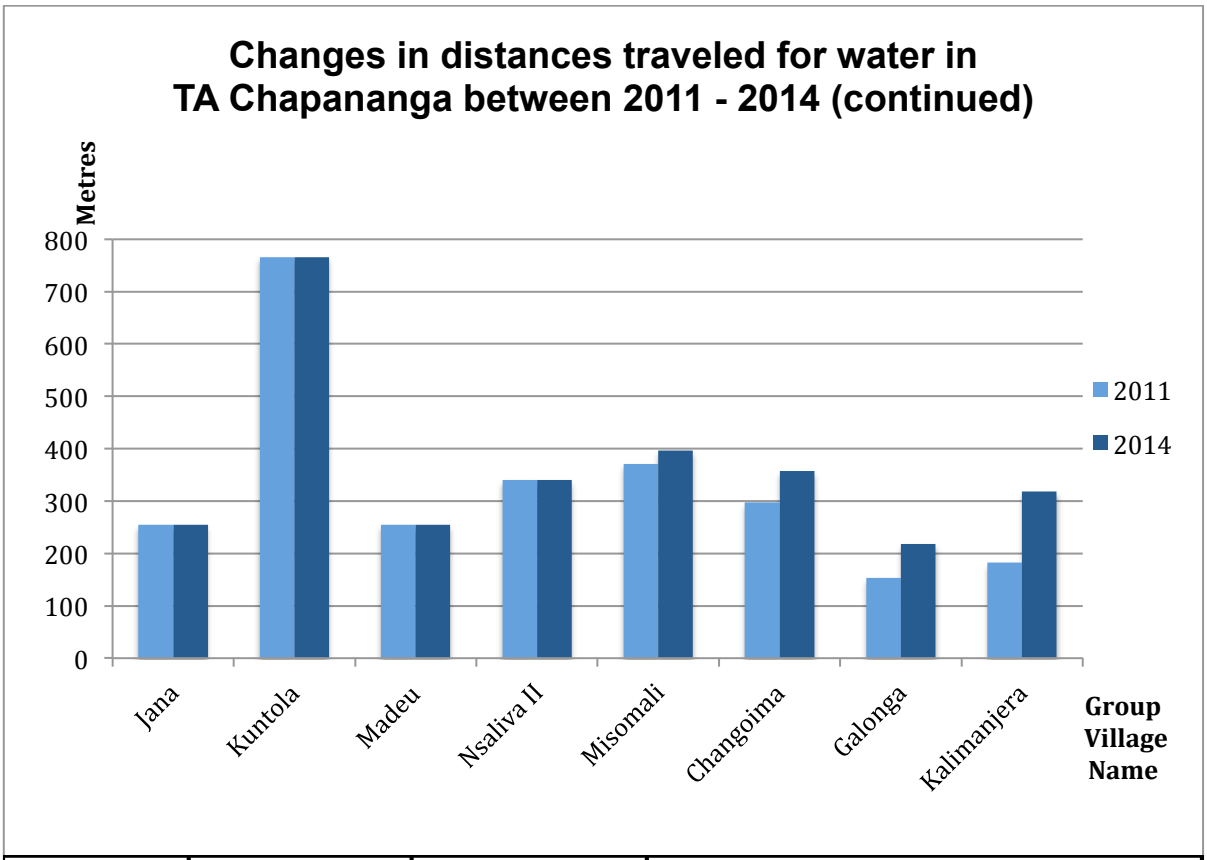
Figure C.1 (a): Changes in female's travel patterns for water collection (2011-2014)



Group Village Name	Distances 2011 (metres/ time)	Distances 2014 (metres/ time)	Changes		
			Distance (metres)	**Time gained or lost per female (minutes per day)**	**Time gained or lost per female population (hours per day)***
Sezu	1,275 m/ 15.3 min	1,020 m/ 12.2 min	-255	+ 3.1	+ 35.9
Bismon	1,785 m / 21.4 min	1,530 m/ 18.4 min	-255	+ 3.1	+ 28.6
Timbenawo	287 m/ 3.4 min	85 m/ 1.0 min	-202	+ 2.4	+ 49.2
Kanzimbi	459 m/ 5.5 min	287 m/ 3.4 min	-172	+ 2.1	+ 108.5
Kuwani	425 m/ 5.1 min	283 m/ 3.4 min	-142	+ 1.7	+ 68.3
Lundu	510 m/ 6.1 min	379 m/ 3.8 min	-131	+ 1.6	+ 49.3
Tombondera	255 m/ 3.1 min	120 m/ 1.4 min	-135	+ 1.6	+ 47.7
Zuze	425 m/ 5.1 min	319 m/ 3.8 min	-106	+ 1.3	+ 19.1
Chapatha	170 m/ 3.5 min	127 m/ 1.5 min	-43	+ 0.5	+ 2.1

*= Female population data provided in Table C.1

Figure C.1 (b): Changes in female's travel patterns for water collection (2011-2014)



Group Village Name	Distances 2011 (metres/ time)	Distances 2014 (metres/ time)	Changes		
			Distance (metres)	Time gained or lost per female (minutes per day)	Time gained or lost per female population (hours per day)*
Jana	255 m/ 3.1 min	255 m/ 3.1 min	0	0	0
Kuntola	765 m/ 9.2 min	765 m/ 9.2 min	0	0	0
Madeu	255 m/ 3.1 min	255 m/ 3.1 min	0	0	0
Nsaliva II	340 m/ 4.1 min	340 m/ 4.1 min	0	0	0
Misomali	371 m/ 4.5 min	397 m/ 4.8 min	26	- 0.3	- 16.4
Changoima	297 m/ 3.5 min	357 m/ 4.3 min	60	- 0.8	- 19.7
Galonga	153 m/ 1.8 min	218 m/ 2.6 min	65	- 0.8	- 54.8
Kalimanjera	182 m/ 2.2 min	319 m/ 3.8 min	137	- 1.6	- 22.4

*= Female population data provided in Table C.1

Figure C.1 (c): Changes in female's travel patterns for water collection (2011-2014)

Group Village Name	Distances 2011 (metres/ time)	Distances 2014 (metres/ time)	Changes		
			Distance (metres)	**Time gained or lost per female (minutes per day)**	**Time gained or lost per female population (hours per day)***
Chitungwani	-	191 m/ 2.3 min	Not detectable		
Kachibade	-	-	Not detectable		
Kalima	-	1020 m/ 12.2 min	Not detectable		
Liston	-	-	Not detectable		
Mkhutche	-	510 m/ 6.1 min	Not detectable		
Mtombosola	170 m/ 2.0 min	-	Not detectable		
Muonda	-	255 m/ 3.1 min	Not detectable		
Nasambi	-	-	Not detectable		
Sila	-	1,785 m/ 21.4 min	Not detectable		
Chikuse	-	2,040 m / 21.4 min	Not detectable		

*= Female population data provided in Table C.1

Figure C.1 (d): Changes in female's travel patterns for water collection (2011-2014

Table C.1: Chapananga's assumed female population at Group Village level

Group Village Name	Female population
Bismon	571
Changoima	1477
Chaphata	252
Chikuse	1564
Chimphepo	1372.5
Chithumba	3958
Chitungwani	590
Gadama	493.5
Gagatambo	1632.5
Galonga	4112
Imfanjawo	1061.5
Jana	184
Kabwatika	1304.5
Kachibade	607
Kalima	680
Kalimanjera	839
Kanzimbi	3098.5
Kuntola	571.5
Kunyondo	942
Kuwani	2409
Liston	841
Lundu	1847.5
Madeu	1014.5
Misomali	3270
Mkhutche	274
Mtombosola	67
Muonda	631.5
Nasambi	262.5
Nsaliva	456.5
Nsaliva II	597
Sezu	695
Sila	1687
Simonzi	1105
Timbenawo	2035.5
Tombondera	1787.5
Zuze	883.5
Total:	**45174,5**