



Water and Welfare in Coastal Kenya

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ABSTRACT

Groundwater plays a vital role in human welfare in rural Africa. Despite this commonly held view, the conceptual understanding of the relationship between water and welfare is poorly developed and is not underpinned by longitudinal analyses. Understanding the linkages between water and welfare is critical to unlocking the potential of groundwater for poverty reduction. This thesis explores the associations between water and welfare by applying a framework that considers groundwater as a part of a socio-ecological system linking resource availability and quality with social systems managing and using the resource for domestic and productive uses. The framework provides a flexible diagnostic tool to characterize and explore the interactions and outcomes between water and welfare. The framework is applied in coastal Kenya where high poverty rates and heavy dependence on groundwater interact with unprecedented economic change. A three-panel longitudinal survey of 3,500 households collecting information on socioeconomic factors, household water supply sources and uses, as well as automatically transmitted information on handpump volumetric usage provide data for the analysis. The thesis examines the internal coherency and agreement between multidimensional and subjective welfare indices to detect their capacity to spatially identify dynamic welfare heterogeneity. The thesis explores the links between groundwater and welfare using multidimensional welfare metrics versus drinking water services, productive uses of water, groundwater table depth and dependency. The thesis models welfare transitions to prioritise sustainable development interventions.

Findings suggest that a multidimensional welfare index that uses a small basket of indicators to measure, monitor and map short term welfare changes is robust and converges with subjective welfare measures. Water and welfare associations show that the poor are characterised by greater dependency on shallow groundwater systems, less acceptable drinking water services by reliability, affordability or accessibility but not quantity, with productive use of groundwater for livestock accruing to the non-poor groups. Overall, water services are observed to explain less than a fifth of the variation in welfare with gendered differences emerging by sex of the household's heads. Female-headed households are more vulnerable than male-headed households with welfare transitions suggesting over half of the population is in and out of poverty and a tenth are chronically poor at any point in time. Modelling welfare transitions reveal four priority goals to move people out of poverty: improving water services, maintaining primary education while broadening access to secondary education, increasing access to energy sources and ending open defecation. The findings reflect the complex nature of the interlinkages between water and welfare across different social groups and the potential for cross impacts. The frameworks provide a simple tool to guide interventions which prioritise sustainable development and accelerate attainment of UN Sustainable Development Goals 1 and 6.

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1 INTRODUCTION

1.1 Background of the study

Most people in sub-Saharan African remain disproportionately poor with limited access to water, sanitation and hygiene services (Beegle et al., 2016; WHO & UNICEF, 2014, 2015, 2017a; World Bank, 2000, 2006, 2019). Despite the Millennium Development Goals' report highlighting global success in improving access to improved water services and poverty reduction (United Nations, 2015a), critics have argued that progress on the goals has been regionally and thematically unbalanced (Michael Woodbridge, 2015). Rural Africa lags behind with three in seven Africans (42%) depending on unimproved water supplies in 2015 (WHO & UNICEF, 2017a). While this represented progress from a lower level of access, the net result from demographic growth was that there were over 82 million more rural Africans without improved water access in 2015 than in 1990 (WHO & UNICEF, 2017a). A similar observation is made for poverty where despite a decline in poverty rates and an increase in economic growth rates, the poverty headcount in rural Africa has risen significantly since 1990 (IMF, 2015). It is estimated that there were 50 million more people living below the poverty line in 2012 than there were in 1990 (Beegle et al., 2016). These statistics demonstrate the failure of global measurements of progress to reflect the actual status of livelihoods and access to public services across the world. This has implications on the design of policy and practice aimed at prioritising Sustainable Development Goals under the rapidly changing environmental, economic and political constraints and opportunities pertaining to developing nations.

Lessons from the Millennium Development Goals highlight Africa's potential development pathways to poverty reduction and indicate that improved water services will increasingly be shaped by the identification of effective and equitable policy and practice which balances the competing goals of economic growth and environmental sustainability (AfDB Report, 2014; Africa Progress Report, 2013; Barma et al., 2012; Millennium Ecosystem Assessment, 2005). The Sustainable Development Goals provide some of these development pathways through 17 goals, 169 targets and 230 indicators designed to guide and balance growth and development with the natural resource base. However, the effective transformation of Africa's sustainable development agenda will require additional information to track progress, guide interventions and measure impact while appraising policy and practice (Beegle et al., 2016). The existing information asymmetry on water and welfare in developing countries clouds objective assessments, as baseline conditions for broader social, economic and environmental systems are commonly absent, unavailable or incomplete. Distributional implications and impacts for local populations over time and across varying environmental conditions are poorly documented, providing a weak platform to inform policy and practice to guide development pathways.

Poverty is widely accepted as a condition of multiple deprivations for different individuals or households, varying significantly between countries and over time (Alkire & Foster, 2011; Ravallion, 2011). The nature of poverty in Africa is characterised by lack of access to basic services such as water, health, sanitation, hygiene, transportation, education, energy, amongst others. While common approaches to measuring poverty in the literature include income poverty, consumption poverty, multidimensional welfare and subjective welfare

(Alkire et al., 2015b; Alkire & Foster, 2011; Alkire & Santos, 2011; Belhadj, 2012; Davis, 2003; Ferreira & Lugo, 2012; Sagar & Najam, 1998), the dynamic nature of poverty demands a clear metric and measurement approach to ensure policies are effective and address the needs of the poor.

Poverty and welfare differ in the measurement approach with diverging implications on policy and practice. While poverty metrics are mostly generated from income and expenditure data, welfare measurements recognise health, education, assets and social deprivations. Subjective welfare measurements on the other hand prioritise self-assessment of an individual or household's welfare (Fafchamps & Shilpi, 2009; Sacks et al., 2012). Increasing access to rural public services, inter alia, water, education, health and energy, may contribute significantly to improvements in welfare (Burke & Moench, 2000; Hanjra et al., 2009). However, what is often unclear is the extent of the impact of each of these factors on a household's overall welfare status and how it may vary across the welfare spectrum and across households disaggregated by sex of the household head. This knowledge gap is exacerbated by the lack of monitoring services to produce indicators and welfare metrics at a higher frequency and provide information on transitions. Understanding welfare transitions remains a key element in appraising policy and evaluating the impact of interventions (Kipf et al., 2016) to sustain progress and economic growth.

The focus on water and welfare in this thesis is driven by the importance of water resources to basic livelihoods and economic growth. While water services play a significant role in the livelihoods of people, they directly and indirectly affect other services such as health, energy

and education as these are interlinked socio-ecological systems (Haller et al., 2007; Millennium Ecosystem Assessment, 2005; Moench, 2002, 2003; Ostrom, 2009; Sekhri, 2014; The World Bank, 2009). Understanding how access to improved water resources and services can benefit the poor is therefore central to accelerating and sustaining Africa's development agenda. This includes (1) identifying the role of water in productive uses such as livestock watering and crop irrigation and how these are associated with households across the welfare spectrum and (2) examining the relationship between welfare and changes in water resource availability, and (3) understanding how water dependency and access to sufficient, affordable, reliable, safe, good quality water and physical access are linked to the socio-economic development of households. Beyond this scope of knowledge is the degree of influence between the interlinked factors of health, education and energy on welfare and how this compares to water services' roles in welfare improvement. Such breadth of information is critical to designing effective policies and strategies that aim to reduce poverty and enhance access to basic services at the household level ensuring no one is left behind.

This thesis contributes to improved understanding of Africa's sustainable development challenges through development of multidimensional and subjective welfare metrics to improve data gaps on who the poor are, where they are, and what their needs are. The multidimensional welfare metrics are further used to demonstrate empirical evidence on the relationships between water and welfare. A water-welfare framework is used to understand the links between water and welfare with implications on design of policy and interventions that complement each other in improving water services and poverty reduction simultaneously. The welfare metrics are finally used to navigate competing interests and

goals on prioritising development agendas. This is achieved through modelling welfare and its determinants to inform priority goals for sustainable development.

1.2 Research gaps and contribution to literature

The framing of the thesis builds on three strands of literature. First, Ravallion's insights of two fundamental processes in understanding and responding to poverty – the identification problem and the measurement problem (Ravallion, 1996, 2011). The identification problem refers to the choice of which indicators are appropriate to measure welfare change. An example is 'improved drinking water access' which is commonly used in many multidimensional indexes to reflect global goals to accelerate universal drinking water services (Dhongde & Minoiu, 2013). However, current surveys capture only the household's stated 'main drinking water supply' (e.g. handpump, piped water, surface water) to determine an improved or unimproved status. Whether the water supply is reliable, safe to drink, affordable or near the household is neither known nor captured; this questions the value of knowing the water supply technology alone (Bradley & Bartram, 2013). The measurement problem concerns what weights should be applied to each chosen indicator. A related concern is whether this indicator is a priority for the poor and should be weighted to reflect that safe drinking water is a priority against other competing concerns. Another example is in Alkire's Multidimensional Poverty Index (Alkire & Santos, 2011) where the weights applied to each of the indicators are equal which raises concerns over which indicators are intrinsically important and which ones are instrumentally important (Ravallion, 2011).

A second strand in the literature is the identification and analysis of relationships among multiple levels at different spatial and temporal scales within the socio-ecological systems (Ostrom, 2009). Building on this approach, a water-welfare framework is developed and used to unpack the links between (ground)water and welfare. In practice, poverty reduction and equitable distribution of resources, sustainable services and the environment lies at the heart of the interactions between groundwater and its users. Understanding these interactions in context will help shape policy and practice aimed at accelerating the attainment of the Sustainable Development Goals No.1 and No.6. The third strand is Ravallion's insight on the dynamics of poverty where standard poverty measurement practice is static with the standards relying on infrequent surveys such as the Demographic and Health Surveys and the Kenya Integrated Household Budget Surveys conducted once every four and ten years respectively (KNBS, 2007; Kristjanson et al., 2010; Ravallion, 1996, 2011; World Bank, 2013). Such datasets are useful but unable to estimate the effects of different interventions or political, environmental and economic shocks on welfare due to their coarse temporal scale (Hoogeveen et al., 2014; World Bank, 2013). Further, these datasets are drawn from random samples in different periods rather than tracking the same households across periods. The advantages of the latter include greater confidence in understanding welfare dynamics with panels of households rather than insight into general trends lacking supporting socio-economic and welfare determinants. In sum, disparities and persistence in poverty between different geographical regions are still not well understood. Understanding poverty dynamics is arguably critical to development and improvements of poverty reduction policies and this can be achieved through shifting the focus of analysis

from trends to transitions (Dhamija & Bhide, 2009; Green & Hulme, 2005; Hulme & Shepherd, 2003).

This thesis advances knowledge in spatial and temporal welfare assessment methods (both multidimensional and subjective), empirically demonstrates the links between water and welfare, and evaluates welfare transitions and their determinants in rural coastal Kenya where large-scale mining and irrigated agriculture are in the process of altering the social, economic and environmental landscape. The study site provides social and environmental baseline data to understand and evaluate processes and impacts of distributed change, not well documented in Africa, for the interaction and impacts between development projects and community water supplies.

There are three major contributions to academic scholarship from the thesis:

1. Exploring the conceptual understanding of the relationships between water and welfare.
2. Examining multidimensional and subjective welfare metrics and methods using large panel datasets.
3. Modelling welfare transitions to inform policy and practice.

1.3 Thesis format

The thesis is organised as a set of three papers where the research Chapters are academic papers included as submitted to peer reviewed journals¹. The three papers are represented

¹ There are formal inconsistencies between the submitted papers and the way they are presented in the thesis: The labels for figures and tables have been changed to logically align with the thesis flow and avoid duplicated labels. In some papers, the short form 'Fig.' is used instead of the full word 'Figure'.

in Chapters four through to six detailing substantive and coherent research on water and welfare in Coastal Kenya. Chapter two of the thesis discusses the literature review highlighting the water-welfare framework and its components and describes how this framework is used to unravel the links between water and welfare. Chapter three discusses the study area, data collection and the methods used in the analysis of data to answer the different research questions to produce the three contributions to academic scholarships highlighted above. Chapter four is the paper on multidimensional welfare metrics and methods. Chapter five is the paper on groundwater and welfare, and Chapter six is the third paper on modelling welfare transitions to prioritise sustainable development. The conclusion is presented in Chapter seven with emerging recommendations for policy and practice and opportunities for further research.

2 LITERATURE REVIEW

Water shapes human welfare in multiple and dynamic relationships. Understanding these relationships has created significant bodies of scholarship from climate science, hydrology, law and policy, public health, engineering, development economics and political sciences. No unifying theory of water and welfare is accepted in the literature reflecting the myriad factors and forces which result in welfare outcomes across different spatial and temporal scales from the individual to the community to larger settlements. I discuss a framework for water and welfare to guide and situate the thesis work within a wider canvas. The water-welfare framework, Figure 2-1, has four domains of interactions: a) Water Resources, b) Drinking Water Systems, c) Productive Water Systems and d) Welfare Status. The latter is a particular feature of this thesis which cuts across all the research questions. The dimensions of focus in the water-welfare framework in this thesis are guided by literature and availability of data in the study area which distil to groundwater extracted through handpumps and the drinking water services, and productive water uses for livestock and irrigation with an overarching theme of multidimensional welfare.

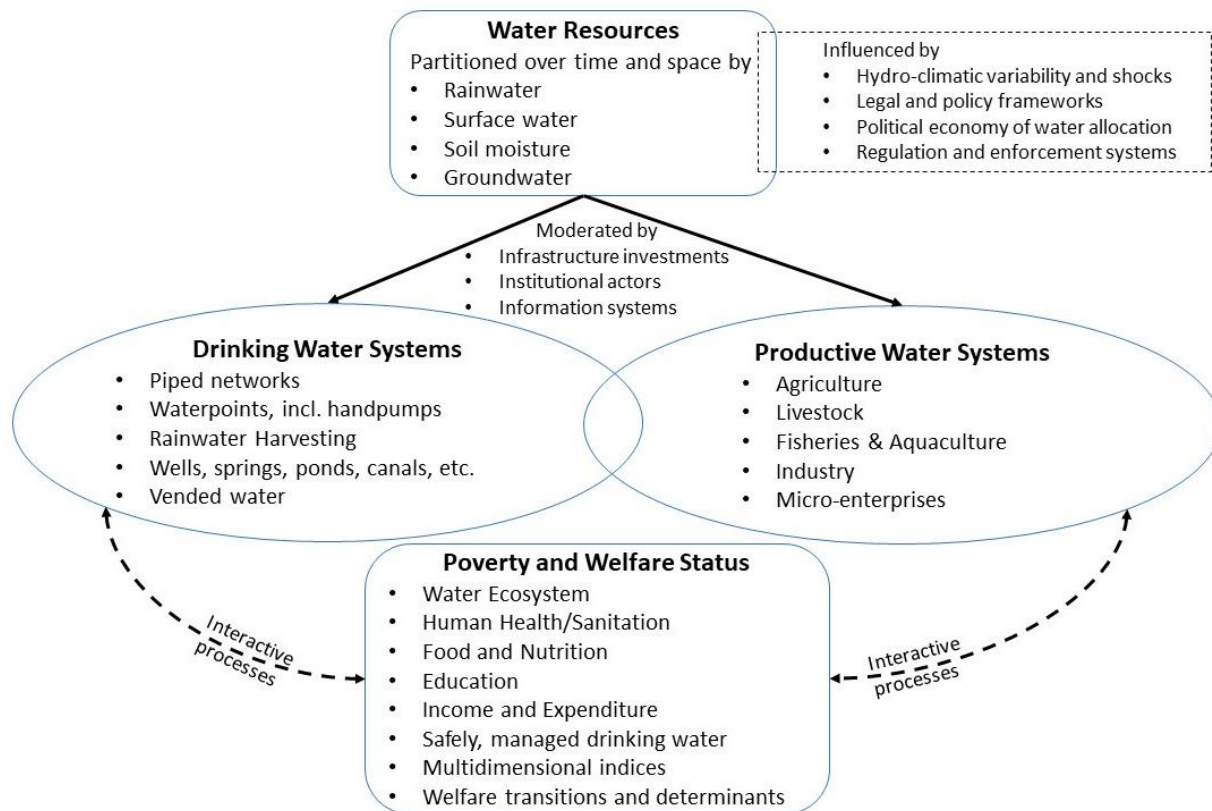


Figure 2-1 Water-Welfare Framework

2.1 Water resources

The first domain is water resources. Water resources may be partitioned over time and space as either rainwater, surface water, soil moisture and groundwater. The latter plays a critical role in sustaining ecosystems, food security, water security and human development (Grey & Sadoff, 2006; Mukherji, 2005) especially in sub-Saharan Africa where over 200 million rural inhabitants depend on groundwater sources through wells and boreholes (Foster & Hope, 2016; Macarthur, 2015). Groundwater is documented to account for at least 36 per cent of domestic demands, 42 per cent of agricultural demands and 27 per cent of industrial demands (Taylor et al., 2013). Groundwater remains a significant water supply option in rural Africa for water security and poverty reduction. MacDonald & Calow, 2009 cite a number of reasons in support of this; groundwater is often available close to where it is required, it can

be developed relatively cheaply to meet demand and it is of better quality depending on the depth and geology. The groundwater resource can be further partitioned into either shallow or deep aquifer (Calow et al., 1997). A vast majority of the rural communities in sub-Saharan Africa depend on the shallow aquifer from wells and boreholes. Shallow aquifers are commonly used by the poor but are exposed to the risks of groundwater depletion and pollution resulting from over-abstraction, climate change and contamination from pit latrines or fertilizers from agricultural fields (Baguma et al., 2017; Macdonald & Davies, 2000; Macdonald et al., 2009). On the other hand, deeper aquifers tend to be more reliable and resilient to short term climatic changes and, quality allowing, may provide a more reliable source that can be exploited to improve water supply services (MacDonald et al., 2012; Taylor et al., 2013). The depth of groundwater largely controls accessibility and cost of access with implications on water security and poverty reduction.

The dependence on groundwater can partly be attributed to the highly variable rainfall patterns across the African continent, for example, rainfall varies from almost zero in parts of Saharan to 10,000 mm per annum in the Gulf of Guinea. This results in variable runoff/rainfall coefficients making surface water unreliable (Foster et al., 2006; MacDonald & Calow, 2009). While the relationship between direct rainfall and groundwater recharge is non-linear, the highly variable rainfall events contributes disproportionately to recharge albeit the projections of these rainfall patterns are not consistent with the observed rainfall data. This is illustrated by East African Paradox where uncertainty from model projections of rainfall patterns remains high, particularly in the long rains (March, April, May) with implications including exposure of millions of people and their livelihood systems to water

insecurity. Understanding these variabilities and extreme events is pertinent to guiding policy and planning on water resources governance under climate uncertainties (Lyon & Vigaud, 2017; Rowell et al., 2015; Taylor et al., 2012, 2013).

Legal and policy frameworks are crucial in water resources governance and management, they are at the heart of growth, sustainable development and poverty reduction. The legal and policy framework in most sub-Saharan Africa countries has, in the past, largely focused on surface water with groundwater governance receiving less attention due to lack of knowledge pertaining to groundwater availability and behaviour. The current trend however takes an integrated water resources management approach with development of legal frameworks for both surface and groundwater while defining institutions and their mandates, rights and obligations. The legal and policy frameworks outline among other issues, protection of water resources including aquifers, conditions for access to water resources, protection of the water resources from pollution and over-abstraction, monitoring and planning tools for resource management, balancing between different water demands including environment, domestic, agricultural and industrial demands and the involvement of both the private and public stakeholders in decision making (Grönwall & Oduro-kwarteng, 2017; Mechlem, 2016). With the growing population and economic development, water demand has exceeded supply in many parts of sub-Saharan Africa making permit-based water allocation systems more prominent. The social, economic and political perturbations confound the existing legal and policy frameworks for water management offsetting the balance between the available resource and the allocated resource (Grey & Sadoff, 2006; Hope & Rouse, 2013; Llamas & Martínez-Santos, 2005). For

legal and policy framework to address water delivery, allocation and enforcement they will need to be strengthened to accelerate sustainable management of water resources (both surface and groundwater) to benefit the poor while balancing growth and development.

2.2 Drinking water systems

The second dimension is drinking water systems. Drinking water systems may take different forms including piped networks, handpumps, rainwater harvesting, wells, springs and vended water. While both piped networks and handpumps have the potential to deliver safe water, piped networks tend to be more complex with high investment costs but with potential to reach more people and offer better services than handpumps in terms of access (Banerjee et al., 2008; Banerjee & Morella, 2011). The development of piped networks is partly controlled by the available yield of water and population densities where sources with low yields and low population densities are more attractive to simple technologies like handpumps (in case of groundwater sources) while high yielding sources and high population densities provide economies of scale necessary to invest in piped networks where pumping and/or gravity technology may be utilised (RWSN, 2010a). The normal approach to ensuring sustainability of rural water supply systems had been community management, however, evidence shows low water supply sustainability levels across sub-Saharan Africa with the recent Joint Monitoring Programme (JMP) report highlighting a big gap in rural water services provision where only a third of the people have access to safely managed drinking water (WHO & UNICEF, 2017a). Empirical evidence shows that over a million handpumps have been constructed in rural sub-Saharan Africa over the last 30 years and less than a third of these are non-functional at any point in time due to operation and maintenance

challenges (Macarthur, 2015; RWSN, 2010b). The human development consequences for this situation remain unquantified with implications for health and welfare likely to be substantial.

The low water supply sustainability levels across sub-Saharan Africa can be attributed to a myriad of factors including the complexities of attaining economies of scale in service provision resulting from sparse and low population densities and high poverty rates as well as environmental constraints such as aquifer yields and water quality. Governments and Non-Governmental Organisations in sub-Saharan Africa are working towards ensuring sustainability of rural water supply systems through advocating for public-private partnership (PPP) models (Harvey & Reed, 2007; World Bank, 2017) and self-supply from rainwater harvesting, wells and handpumps (Carter & Mpalanyi, 2005; Sutton, 2004, 2011). These are aimed at increasing coverage alongside the highly subsidised community water supplies. While all these advancements are geared towards attaining the Sustainable Development Goals of universal and equitable access to safe and affordable drinking water services, there are concerns that investments in drinking water systems is marred by political interference and poor management with evidence showing poor performance of both urban water utilities and community managed water supply systems across rural Africa. In some cases, where water access is provided in both urban and rural areas, cost remains prohibitive. While progress has been made in improving coverage in terms of distance to water sources through development of new infrastructure (WHO & UNICEF, 2017a; World Bank, 2017), more work is needed towards improving and sustaining access to sufficient, affordable, reliable, safe and acceptable water services especially from the existing

infrastructure. This may be achieved through prioritisation of monitoring and maintenance of existing infrastructure to reduce non-functionality rates while improving the water services delivery which may ultimately mitigate the risks of morbidity and mortality from water related diseases (Haller et al., 2007; Hunter et al., 2010; Rizak & Hrudehy, 2008).

2.3 Productive water systems

The third domain is productive water systems. The productive water systems may include agriculture, livestock, industry, fisheries and aquaculture and micro-enterprises. Pathways to poverty reduction are widely acknowledged around the use of water productive systems such as irrigation and livestock farming (Burke et al., 2007; Moench, 2003; Moriarty & Butterworth, 2004; Sekhri, 2014; Smits et al., 2010). Access to groundwater for irrigation is argued to reduces vulnerabilities, stabilizes livelihoods and alleviates poverty (Moench, 2002; Mukherji et al., 2009; The World Bank, 2009). While the economic benefits of productive use of water are widely recognised (Koppen et al., 2006; Smits et al., 2010), *ceteris paribus*, it is not empirically clear how these benefits accrue to different households in different wealth groups (welfare index categories) especially in sub-Saharan Africa. It remains unclear as to whether wealthier households are economically endowed hence more likely to engage in productive uses of water thus remain above the poverty line or whether poor households escape poverty because of engaging in productive use of water or whether poor people lack economic resources hence do not engaging in productive use of water thus remaining trapped in poverty. Unravelling the benefits of productive use of water across the different wealth groups at the household level can shed more light on the underlying process

between the links of water and welfare which can inform development of robust poverty reduction policies.

The second and third domains of the water-welfare framework are moderated by infrastructure investments, institutional actors and information systems. Infrastructural investments are an important element in poverty reduction and economic growth. With the growing population in sub-Saharan Africa, there is increased pressure to develop more infrastructure to meet the demand in water, energy, transport and health (Dobbs et al., 2013; Tandi & Earle, 2015). While funding for these infrastructural investments has in the past come from largely public funds, there still exists a major gap in financing of new infrastructure as well as maintenance of the existing water infrastructure. The institutional actors make decisions on which infrastructural investments should be prioritised and how resources are distributed and allocated amidst political, environmental and economic constraints. They are equally responsible for policy development, monitoring and evaluation of progress in water services delivery. The institutional actors are interlinked with the legal and policy framework that addresses the issue of governance of water resources which forms a basis for improved access to water services (Plummer et al., 2007). Information systems remain at the heart of sustainability of infrastructural investments where data on key performance indicators from such systems can be used to track progress, international comparisons, policy development, systems evaluations, planning, assessment of impacts and in rare cases for purposes of enforcement. However, the relevance of these indicators and the monitoring frameworks to the national and international progress in water service delivery needs to be defined (Bradley & Bartram, 2013; Kayser et al., 2013), this speaks to

the apparent compromise between measuring what we value and valuing what we measure (Molle & Mollinga, 2003; Porter, 1995).

2.4 Poverty and welfare status

The fourth domain is poverty and welfare status. Central to unpacking the links between water and welfare is establishing an acceptable estimator for socio-economic status which can be done using either poverty or welfare metrics. It is widely agreed that poverty and welfare have many dimensions yet there is no single index that can capture all the aspects of human well-being (Alkire et al., 2015a; Decancq & Lugo, 2013; Ferreira & Lugo, 2012; Rogers et al., 2006; Sarvimäki, 2006). The dimensions of poverty range from materialistic measures to opportunities and rights to participate in society (Olsson et al., 2014; Ravallion, 1992, 2011). Poverty is also categorised as either absolute or relative. Absolute poverty refers to situation where an individual is unable to satisfy his or her basic needs whereas relative poverty refers to a situation where an individual's income or expenditure is below a defined threshold value below which people are defined as poor (Rogers et al., 2006). While poverty is a condition of multiple deprivations varying over space and time, its dynamic nature has led to a portfolio of metrics and methodologies given its implications on policy and practice. Welfare status on the other hand incorporates both environmental concerns of ecosystem health and status along with multi-dimensional concerns including income and expenditure, health, food and nutrition, as well as the performance of indicators of safely managed drinking water services among others.

Income has long been used as the sole indicator of poverty but has been critiqued for not capturing multidimensional poverty (Alkire & Foster, 2011; Sahn & Stifel, 2000). In response,

many methodologies have been developed to measure poverty levels using multidimensional indicators (Alkire et al., 2015b; Belhadj, 2012; Davis, 2003; Ferreira & Lugo, 2012). While most of these methods have their limitations, they have been improved overtime to better represent well-being at varying spatial and temporal scales. Some of these methods use the marginal distributions of the data (different multidimensional indicators) and ignore the joint distribution while some use the joint distributions and ignore the marginal distributions. Dashboard and composite methods consider the marginal distributions and ignore the joint distributions and hence do not identify the poor (Decancq et al., 2013; Ferreira & Lugo, 2012; Ravallion, 2011). Venn diagrams on the other hand consider the joint distributions of the indicators and ignore the marginal distributions but can only work with a maximum of four indicators beyond which they become difficult to read and offer no summary measure of the poor (Alkire et al., 2015b; Ferreira & Lugo, 2012; Henninger, 1998).

The dominance approach for measuring poverty uses various parameters and functions but is constrained by a maximum of two parameters beyond which it is difficult to implement (Alkire & Santos, 2014; Decancq et al., 2013; Ferreira & Lugo, 2012; J. E. Foster & Shorrocks, 1988; Sahn & Stifel, 2000; Vijaya et al., 2014). Axiomatic approach by Alkire-Foster assigns weights to 10 different indicators grouped into equally weighted three main indicators, this approach assumes that health, education and living standards equally explain poverty rates (Alkire & Santos, 2014; Ferreira & Lugo, 2012; Malik, 2014; Vijaya et al., 2014). This approach is commonly used when analysing poverty at a national scale for comparison with other countries but might be inappropriate to assessments of poverty at local levels because of

high variability driven by many environmental and social factors causing unequal weighting on the indicators. Statistical approaches have been developed and improved over time.

Most approaches to measuring poverty and welfare use a single index which is usually an aggregate of the multidimensional indicators. The aggregated indices, also known as 'composite indicators' or 'mashup indices' are capable of estimating the aggregated socio-economic status of an individual or household over space and time (Decancq & Lugo, 2013; Ravallion, 2011). These poverty indices may include but not limited to; physical quality of life index (Kruijk, 2007), the human development index (Sagar & Najam, 1998) and revised human development index (Hassan & Ibrahim, 2009; Moran et al., 2008), human poverty index and multidimensional poverty index (Alkire & Santos, 2014; Atkinson & Lugo, 2010; Ravallion, 2011). The HDI was introduced by the United Nations Development Program (UNDP) in 1990. This index has since redefined the traditional measure of development from the economic point of view. The HDI has however been critiqued for failing to capture sustainability and is insensitive to changes in any of the three indicators (knowledge, health, living standards) because it uses the arithmetic mean instead of the product of the three indicators (Sagar & Najam, 1998). It also fails to capture the heterogeneity of poverty within a country (Olsson et al., 2014). The MPI was developed by the Oxford Poverty and Human Development Initiative (OPHI) (Alkire & Foster, 2011; Alkire & Santos, 2011), it has 10 indicators that correspond to the HDI's 3 indicators. The MPI and HDI both applies equal weights to the main indicators, this has also been critiqued on the grounds that different dimensions of poverty load differently to livelihoods (Hoque, 2014). This raises the question

of which dimensions are instrumentally important versus which ones are intrinsically important and how do we allocate weights (Ravallion, 2011).

While household expenditure data is preferred to income data in estimating poverty, econometric evidence shows that assets and deprivation indicators are good proxies for expenditure and can be used to assess socio-economic status when aggregated to construct of a welfare index (Filmer & Pritchett, 2001; Montgomery et al., 2000). A copious body of literature has investigated the construction of such welfare indices using assets and deprivation indicators to estimate well-being of households or individuals, making it the basis for estimating socio-economic status in this thesis (Barnett et al., 2008; Barrett et al., 2006; Barrett & Carter, 2013; Berthoud & Bryan, 2011; M. R. Carter & Barrett, 2006a; Filmer & Pritchett, 2001; Kristjanson et al., 2010; Vyas & Kumaranayake, 2006). Welfare indices take a rather different approach that works around the weighting and dimension problem. They address these two problems through the application of different statistical approaches to select weights for a range of multidimensional indicators used to construct the index, the commonly used approaches are factor analysis and principal components analysis methods (Filmer & Pritchett, 2001; Hoque, 2014; Vyas & Kumaranayake, 2006). These methods assign weights based on the variables contribution to the overall poverty component (Zeller et al., 2006).

The commonly used multidimensional indicators in constructing welfare indices include household assets and deprivations in health, education, food, nutrition, consumables, access to public services and other performance indicators of water services (Deaton & Zaidi, 2002; Filmer & Pritchett, 2001; Montgomery et al., 2000; Vyas & Kumaranayake, 2006). However,

the choice of indicators in the construction of the welfare indices remain constrained by the data available (Ravallion, 2011). In this thesis, the data available constrained the construction of a multidimensional welfare index to the use of 29 indicators grouped into household characteristics, dwelling characteristics, assets ownership and consumables, sanitation and health and drinking water services. While these dimensions are important to welfare, some of them may be unrepresentative of the relative speed of welfare change, for example, dimensions of education may take a decade to change. These might not capture well the short-term changes of welfare that may be experienced due to other socio-economic, environmental or political changes. Given the nature of the study area and the expected and observed rate of socio-economic changes, it was important to construct a welfare index that is sensitive to short term changes in welfare but still a robust, coherent and consistent index compared to the multidimensional index. To this end, a short list of indicators was selected based on principal components factor loadings and subjective judgement from the local knowledge of the culture of the people and which dimensions they value most and are likely to change. These indicators developed a welfare index which I referred to as the Dynamic Welfare Index.

There is a growing interest of subjective welfare assessment where people self-evaluate their welfare status (Beegle et al., 2012; Dolan et al., 2011; Ravallion & Lokshin, 2001). While poverty and multidimensional welfare indices continue to inform policy, subjective experiences of people's lives are increasingly proving to be better indicators of well-being (Kahneman & Krueger, 2006; Krueger & Schkade, 2008). Subjective welfare measures may be imperfect and constrained by well-rehearsed limitations of bias and uncertainty, but they

ultimately offer an intuitively appealing strength based on the value judgment on the individual of interest. In theory, one might expect some degree of convergence to alternative poverty measure, and if divergence emerges, it provides an area for further analysis and debate. Subjective welfare measures are considered in the analytical framework of this thesis.

2.4.1 Role of GIS in mapping welfare

Geographic Information Systems (GIS) are used for inputting, storing, managing, manipulating, analysing and displaying data on a spatial framework. A GIS typically is comprised of hardware, software, database, methods and personnel (Bateman et al., 2003). GIS can map data with spatial components to it (Overman, 2010), it can do statistical analyses, calculate time and distance between different point of interests like markets and industrial hubs, distribution of facilities in relation to different geographic areas, road networks and accessibility. GIS has made it possible to map disaggregated welfare indicators spatially and on a temporal scale to enhance and elucidate our understanding of geographic and environmental effect of welfare, therefore, making it possible to apprise the spatial heterogeneity between different indicators of welfare. Furthermore, we can analyse the causalities both spatially and temporally within a statistically enabled GIS framework.

According to Bateman et al. 2003, GIS can be used to answers questions such as; (a) what are the feature of a particular location? (b) where are the poor or non-poor located? (c) which households experienced welfare change over time? (d) is there any spatial association between features such as health centres, water sources, education facilities, roads, markets, etc with welfare variations? (e) how does welfare vary over space and time? Understanding

answers to such questions is central to assessing the impacts of different interventions and appraising policy and practice for poverty reduction and improving public services such as health and rural drinking water access. GIS is however not a universal panacea for improving data analysis but rather the quality of the results is strongly dependent on the accuracy of the input data (Bateman et al., 2003). This strongly relies on the process of data collection from the household surveys for welfare analysis.

Henninger 1998 suggests different approaches to mapping welfare, these include; (1) mapping auxiliary data. (2) Mapping survey data. (3) Mapping modelled results (a combination of both auxiliary and survey data). The most commonly used method is the mapping of survey data, an example here is the small area estimation techniques (Amarasinghe et al., 2005; Davis, 2003; Deichmann, 1999; Hyman et al., 2005; Mistiaen et al., 2002). However, this approach only helps identify broad patterns in human development at country level, it cannot be used to analyse welfare below the first sub-national level (Henninger, 1998; Rogers et al., 2006). Here, the thesis focuses on welfare dynamics and visual representations across space and time to chart and explore heterogeneity by social and environmental features.

Welfare maps remain important for several reasons; (1) They capture the welfare heterogeneity within the study area. Welfare heterogeneity maybe due to differences in resources endowments like health, education, proximity to industrial hubs, different infrastructural investments in the area among other reasons. (2) Maps help identify geographic factors that influence welfare. They make it possible to look for trends, clusters or patterns and correlations between agricultural or agro-ecological resource endowments,

health facilities, and access to water, access to electricity, infrastructure and the welfare conditions of the people in certain areas. (3) Maps improve targeting of resources and interventions. Resources are used more effectively if the needy populace is targeted and the resources reach them. (4) Maps also improve communication about welfare conditions. They communicate information on inequality of certain indicators of welfare. This information is easily understood by non-specialist audience and decision and policy makers if presented in form of maps (Deichmann, 1999).

2.5 The Water-Welfare Framework

The water-welfare framework has outlined the different interrelated dimensions. While these dimensions in the water-welfare framework are independently identified in the Sustainable Development Goals rehearsing poverty eradication, economic growth and environmental sustainability, little is known about how and if individual goals and targets are related. While there exists significant literature to confirm the negative consequences of degraded or failed water systems for health, livestock, agriculture and drinking water security (Grey & Sadoff, 2007; Hunter et al., 2010; Llamas & Martínez-Santos, 2005), the role of water in human welfare is partially understood though widely acknowledged. Sustainable Development Goals identify independent aspects of water for poverty eradication, economic growth and environmental sustainability but do not identify how and if individual goals and targets are related, especially in sub-Saharan Africa. Identifying and measuring water and welfare relationships is a key knowledge gap which this thesis explores in a study site in the South Coast of Kenya. The study site is explicitly chosen as climate, economic, political, poverty and infrastructure dynamics are captured in an interdisciplinary methodology over

space and time. While there are broad aspects of the different dimensions in the water-welfare framework, not all are well documented in the study area and some lack data. Building on literature and guided by data availability, the thesis focuses on only a few aspects of the water-welfare framework, these include; groundwater resource extracted through handpumps and the drinking water services from the handpumps covering quantity, quality, reliability and accessibility and productive use of groundwater for agriculture and livestock watering. The overarching dimension being multidimensional welfare and modelling welfare transitions to prioritise sustainable development pathways.

The thesis takes the following approach in advancing new knowledge on the spatial and temporal dynamics of the interrelationships between water and welfare; First, development of a dynamic multidimensional welfare index that reflects the short-term changes in welfare and test its robustness, consistency and coherency against the standard multidimensional welfare index and subjective welfare measures. Second, demonstrating the empirical evidence of the links between water and welfare using water services including quantity, quality, reliability and accessibility and productive use of groundwater for agriculture and livestock watering and welfare. Third, evaluating the welfare transitions and determinants to prioritise sustainable development interventions under a decentralised governance system in coastal Kenya.

3 METHODS

3.1 My role in the research

In 2013, the DFID funded 'Unlocking the Potential of Groundwater for the Poor' (UPGro)² programme had a catalyst project in Kwale county that sought to understand how groundwater resources can be sustainably managed to benefit both the wider economy and the poor. The catalyst project was titled 'Groundwater risks and institutional response in rural Africa'³ which transitioned to a consortium project titled 'Groundwater risk management for growth and development' (Gro for Good)⁴. I joined the programme as a researcher where I was involved in (1) the design, development and implementation of socio-economic surveys for over 3,500 households. (2) supporting the water audits for all the water infrastructure within the study area. (3) supporting the surface water and groundwater modelling process for the catchments within the study area. (4) design, development and instrumentation of the environmental monitoring network for both surface water, groundwater and climate. (5) coordinating dissemination meetings with the county government and other stakeholders.

The scholarship I received under the Oxford University and Base Titanium Ltd match-funding programme enabled me to start a DPhil research on water and welfare in rural Africa with a particular focus in coastal Kenya. Being a resident of coastal Kenya for over 25 years afforded me a unique position as a researcher with internal understanding of how the environmental,

² <https://upgro.org/>

³ <https://upgro.org/catalyst-projects/gro-for-good1/>

⁴ <https://upgro.org/consortium/gro-for-good/>

economic and political processes interact. For instance; my understanding of the local culture was valuable in structuring the questionnaire in a more acceptable tone and translation to the local language. This amplified the quality of the data collected. In addition, my interaction with the local government officials throughout the research process afforded confidence in the research process and findings. This helped in the dissemination of the research findings through conferences and policy briefs to the county government and other stakeholders.

While my understanding of the history of welfare and access to public services in coastal Kenya was important in the framing and application of the water-welfare framework, it potentially exposed me to some cultural biases such as concepts of welfare or the 'standard' preferred level of access to improved drinking water services by households. However, the findings and recommendations are informed by widely applicable methods backed by analyses of large longitudinal datasets providing pathways towards sustainable growth and development for the people of Kwale county and the wider rural Africa.

3.2 Study area

The study area is located along the southern coast of Kenya, 50 km south of Mombasa (Kenya's principal port facility). The study area experiences a sub-humid climate, with 1,100 mm to 1,380 mm of rainfall (1959 to 2012) split between the long (March-May) and short (October-November) rains respectively (Ferrer et al., 2019; Thomson et al., 2019). Mean annual evaporation is about 2,170 mm/year, giving an aridity index of approximately 0.55. The mean annual minimum and maximum temperature is 22.8°C and 30.0°C respectively. The warmest months are between November and April with mean temperatures of 26.0°C

to 28.0°C while the cooler months have a temperature ranging between 24.0°C and 26.0°C. The mean daily evapotranspiration rate is approximately 4.4 mm/day. The county has a population of over 810,000 (projected from 2009 census) people most of whom live in rural areas (82%) with over 70% living below the poverty line of less than USD \$1.25 a day (KNBS, 2006). The poverty headcount has remained stubbornly high according to the latest Kenya Integrated Household Budget Survey of 2015 (KNBS, 2018). The study area covers 2,156 km² in Lunga Lunga, Msambweni and Matuga sub-Counties with around 300,000 residents (KNBS, 2010). This area includes the international tourism destination of Diani beach. Since 2013, the pace of environmental, economic, social and political change has increased with the establishment of two new and major economic activities in the area. Kwale International Sugarcane Company Limited (KISCOL) has been progressively rehabilitating 5,500 hectares of sub-surface irrigated sugarcane including the commissioning of its own sugar mill in 2015. Adjacent to the plantations is the country's newest and largest mining operation (Kwale Mineral Sands Project). Scattered around the mine site and sugarcane plantation are around 300 handpumps (generally 5m to 30m in depth) providing drinking water to communities, schools and health centres, Figure 3-1.

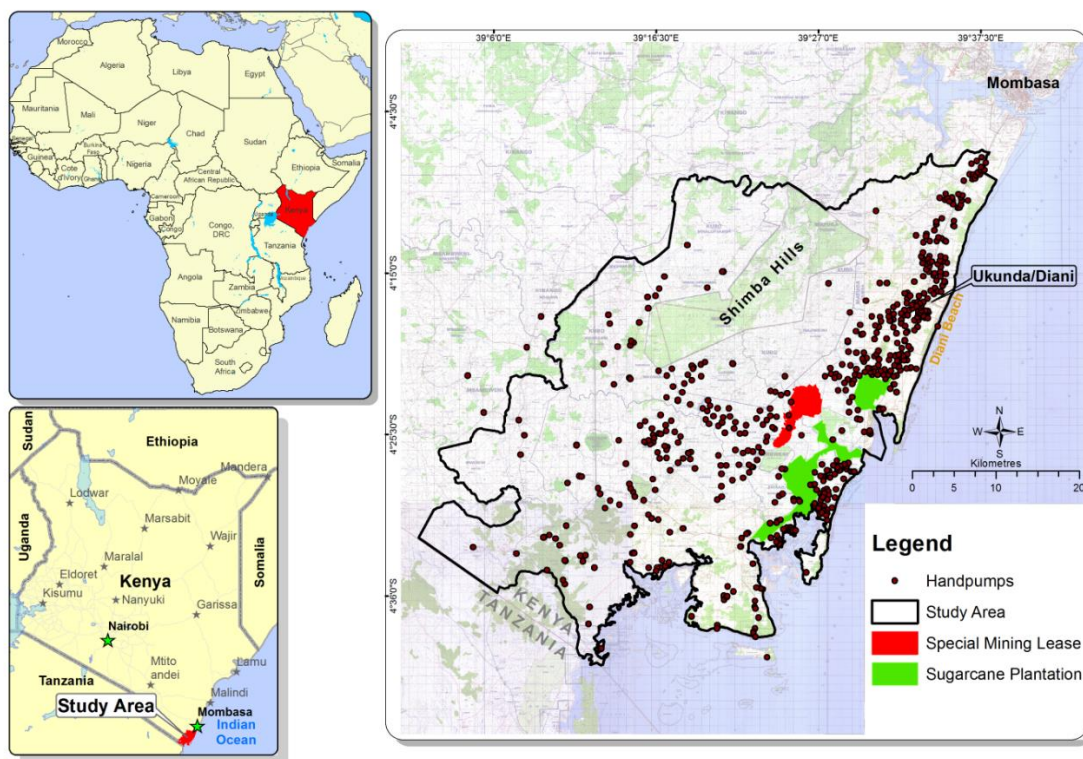


Figure 3-1 Map of Study Area

3.3 Data collection

In August 2013, a water point survey identified 574 handpumps (all Afridevs) of which 45% were non-functioning (Foster & Hope, 2016). A sample of 531 handpump locations was used as a sampling frame for a household survey in 2013/14. A separate water quality assessment was conducted on the functioning handpumps documenting physical water quality parameters such as pH, electrical conductivity and temperature. GSM-enabled transmitters were installed on the 300 operational handpumps to transmit and record daily pumping to estimate water usage and functionality (Thomson et al., 2012a). At each of the 531 handpumps, a stratified random sample of households which currently or previously used the handpump was produced, yielding 3,500 survey participants. A pilot survey was

conducted with 19 enumerators recruited from communities across the study area who administered the survey in local languages (Swahili, 54%; Digo, 43%; Duruma, 2%; other, 1%). All survey questionnaires were digitised and uploaded on android based tablets for ease of data collection and survey management. The main survey entailed a range of themes including demographic, socio-economic status of household (here including livelihood, concerns and subjective welfare), household health status, water sources, water point management, water payments, water resources management, governance and political engagement. All the households surveyed were geo-referenced for mapping purposes. These surveys were repeated in the year 2015 and 2016 yielding three waves of panel data making up a longitudinal dataset; wave 1: n=3,349; wave 2: n=3,567; wave 3: n=3,542. The household survey identified six major water sources used by households, these included; handpumps (n=2,126), protected wells (n=94), boreholes with submersible pumps (n=170), piped sources (n=331), unprotected wells (n=339) and surface water sources (n=231). This thesis largely focuses on the handpumps (groundwater sources) as they were the dominant water supply systems with estimates of volumetric abstraction from the GSM-enabled transmitters, commonly referred to as water data transmitters (WDTs).

Ethical permission to conduct this survey was provided by the University of Oxford's Central University Research Ethics Committee and research permission granted by the Government of Kenya's National Council of Science and Technology, Kenya (NCST/RCD/17/013/132, September 2013). All interviews were voluntary with informed consent procedures observed in the local language. The data have been anonymised and made available here: <http://reshare.ukdataservice.ac.uk/853667/>.



(a)



(b)



(c)



(d)

Figure 3-2 (a) Author interviewing a household, (b) and (c) enumerators interviewing a household, (d) water quality sampling from a handpump with GSM-enabled transmitter (Photo: Author)

3.4 Analytical approaches

The thesis starts by estimating multidimensional welfare indices that would be employed in the water-welfare framework and subsequently in modelling welfare transitions. The

principal components analysis was employed to estimate multidimensional welfare indices (Falkingham & Namazie, 2002; Filmer & Pritchett, 2001; Gwatkin et al., 2007; Vyas & Kumaranayake, 2006). Principal components analysis is a data reduction technique used to reduce large set of possibly correlated variables to a smaller set of linearly uncorrelated variables that still contain most of the information in the large set of variables. Eigenvectors from a covariance matrix are generated during the process of data dimensionality reduction. The eigenvectors are used to determine the weights assigned to each variable. Once the weights to each indicator are assigned, multidimensional welfare indices are then computed for every household for all the three years of data. The first welfare index was a multidimensional welfare index constructed from 29 indicators clustered into five groups i.e., household composition, dwelling characteristics, asset ownership, sanitation and health, and drinking water variables. The second was a dynamic welfare index that comprised of fewer variables, 8 in total, that were likely to change over a short period of time as a result of local environmental, economic and political processes. The multidimensional and dynamic welfare indices were assessed for internal coherency and consistency at both spatial and temporal scales. Results were compared against subjective welfare assessments to assess whether they converged or otherwise. Welfare changes were finally mapped using geographical information systems tools to identify spatial heterogeneity of welfare.

To elucidate the links between water and welfare, the welfare index was cross tabulated with water variables including main drinking water sources, productive uses, drinking water services (affordability, reliability, safe to drink, taste, distance to water source, number of sources), water quality (electrical conductivity), static groundwater depth and volumetric

usage. The analytical challenge of reconciling appropriate temporal and scalar dimensions by broader welfare indicators across individual, household and community limit the utility of a more ambitious but less tractable estimation procedure of welfare. Thus, the multivariable regression approach was employed to estimate the share of groundwater towards welfare, regressing welfare against groundwater variables discussed above. Four models were estimated, model 1 for all households, model II for male respondents, model III for female respondents and model IV for female-headed households. I acknowledge the absence of broader and widely recognised indicators of welfare including education, health, employment and qualitative measures of equality and capabilities. These are however considered in Chapter six which models welfare transitions and determinants.

To model welfare transitions and determinants of welfare, panel data analysis techniques were employed. Panel data allows controlling for variables that are difficult to measure and may change over time but uniformly affecting all individuals (individual heterogeneity); these may include immeasurable political, economic and environmental shocks such as the droughts or floods (Wooldridge, 2010). There are a range of models that can be used in panel data techniques and each model is employed based on a set of conditions that must be met. The commonly used panel data models include the fixed effects model and the random effects model. Some studies advise using certain statistical tests of heterogeneity such as the Hausman-Taylor test (Arellano & Bond, 1991; Hausman & Taylor, 1981) to make inferences on which model to use, a standpoint which is strongly contested with others providing alternative decision making processes (Borenstein et al., 2010). I considered the following

two factors described by Borenstein et al., 2010 to decide on which model fits the distribution of effect sizes and takes account of the relevant error sources.

First, the independent variables I considered did not account for all the possible covariates of poverty, this is the omitted variable problem discussed by Wooldridge, 2010. Some exogenous variables such as employment were omitted, this may introduce bias if a fixed effects model would be considered. A random effects model on the other hand was considered to produce unbiased estimates with the smallest standard errors. Second, the amount of variability among subjects and whether I wished to estimate the effects of time invariant variable or merely control for them (Allison, 2005). All the three household surveys included in this analysis were not strictly 'identical' in the sense that the first survey was, for example, conducted in the dry season, the second one was conducted during the wet season and the third was conducted in a year that the country experienced one of the worst droughts in history. Furthermore, not all the enumerators went back to the same households they visited the year before thus introducing randomness in the survey administration. The amount of variability within subjects is also found to be too small for a fixed effects model to be consistent and efficient.

Some of the endogenous variables were time-invariant (did not change over time) and others were time-variant variables (those that change over time), the latter did not exhibit dramatic changes every year. The key insight here being if the unobserved variable does not significantly change over time, then any changes in the dependent variable must be due to influences other than these fixed effects (Stock and Watson 2003). This made a case for a random effects model. Based on the above factors, the random effects model was applied

with the multidimensional welfare index as the dependent variable against independent variables categorised into water services, water infrastructure, education, energy, agriculture, sanitation and the sex of the household head.

In the case of the binary dependent variables, the commonly used models are probit and logit models. The fundamental differences between probit and logit models is that probit models use the cumulative distribution function of the standard normal distribution while the logit (logistic) model uses the cumulative distribution function of the logistic distribution (Arellano, 2003; Wooldridge, 2010). However, both models were based on probability distributions and yielded similar results (Conaway, 1990). The logit model coefficients can be interpreted as odds ratios which made it more desirable in this analysis. Given that the subjective welfare measures are binary (in this case well-off and not well-off categories) and longitudinal, the random effects logit model was used. This was necessary to compare the outcomes of both the welfare index and the subjective welfare assessment in estimating the effects of the different independent variables on welfare.

3.5 Limitations of the research

This section discusses the overarching limitations to the whole thesis of water and welfare in coastal Kenya. I present a note on the survey administration to highlight the logistical challenges and various engagements that I experienced during the field work phase, I then discuss the limitations of the scope of the thesis and the analytical approach. The detailed limitations affecting the specific research questions are discussed within the research papers presented in Chapters four, five and six.

3.5.1 A note on survey administration

The data collection process during the field work phase was conducted in multiple stages, three rounds over three years. This comprised of training of over 19 local enumerators, where each and every question in the 1-hour long questionnaire, Appendix 9.2, was read and translated into the local language while ensuring that the intended interpretation did not change. The training included pilot days where households were interviewed by two or more enumerators at the same time but with only one enumerator asking the questions while the rest filled the questionnaire. This enabled assessment of inter-rater reliability to ensure that all enumerators understood and asked the questions properly and recorded similar responses. During the survey, the data was collected from the tablets with protocols for quality control on a daily basis to ensure all questions were answered and that the skip logic within the questionnaire was unambiguous. Every enumerator was given a target of five questionnaires per day and the households interviewed were mapped to track progress, ensure no duplication of households and support logistics. While the survey administration was a closely monitored process, there were still some limitations to what we could achieve on the ground. Some of the limitations pertained to follow up respondents not willing to participate anymore or having moved away after a year or so. In some cases, the household heads were not available, and this meant the next eldest member of the household above 18 years-old was to be interviewed and in the worst-case scenario, the household was replaced with a nearby household. This introduced an analytical challenge in the panel data analysis as the reflections and responses from the same household, but different respondents might vary. Dropping these households from the analysis also meant reducing sample sizes, which explains the variations in the sample sizes across Chapters four, five and

six. Other limitations were logistical where environmental factors such as rainfall interfered with enumerator transport with implications on budgets as this meant longer time in the field. Overall, the field work exercise took at least 100 days to collect data from over 3,500 households in every round. I had a supporting role in the first survey and then became a research co-lead in the second and third rounds responsible for the design, training, quality control, data management and cleaning, and eventual analysis.



(a)



(b)

Figure 3-3 (a) Household survey training, (b) the team of enumerators (Photo: Author)

3.5.2 Limitations on scope and analytical approaches

I identify five limitations to this research relating to the scope, and analytical approaches. First, the research did not include assessment of the standard income and expenditure poverty metrics and measurements for any of the surveyed households. While evaluating the multidimensional welfare indices for coherency against this metric would have yielded insights into the representativeness of the two metrics, it was not possible to do so due to lack of credible income and expenditure data. However, it is generally agreed that multidimensional welfare metrics and measurements afford a much clearer and pragmatic

representation of the socio-economic statuses of individuals or households as respondents may give inaccurate information, which is difficult to interpret or validate.

Second, the thesis conducted limited qualitative work on processes and practices of welfare change. While the data collected during the field work surveys were closely monitored to ensure quality, they were incomplete in the sense that there were no focused group discussions or key informant interviews to query, explore or discuss wider cultural, social or political processes. This limited triangulation of the findings with what the policy makers and other important groups in the society think about water and welfare. Third, the water-welfare framework looked at only a fraction of the complex interactions between water services from groundwater resources and multidimensional welfare metrics. It is not yet clear whether the framework would be feasible to assess wider associations such as water and health. Fourth, while the communities studied in the research were characterized by varying economic activities such as fishing, farming and tourism, the research did not collate data on traditional practices of these economic activities. This would otherwise have added a dimension to the analysis to understand the role of seasonal variations in these activities on welfare and water services. Finally, the research did not directly examine the influence of the mining and irrigated agriculture industries in the study area. While the spatial analysis allows insights to zones of welfare change there were insufficient data to fully determine any causal links given wider developmental interventions, such as electrification, road improvements, sanitation and others, to attribute change without bias.

3.6 Research collaboration and co-authored publications

As mentioned earlier, this research thesis built on the wider programme of work funded by DFID under the UPGro programme. Through the research process I have participated in conferences and co-authored publications that have greatly shaped the three papers that I present here as Chapters four, five and six. The roles and responsibilities of each co-author are detailed in the Declaration of Authorship form attached in Appendix 9.1. The rest of the thesis is organised as follows; Chapters four, five and six present the three papers as submitted to peer-reviewed journals while Chapter seven succinctly discusses the general findings from the research, it specifically highlights the broader significance and implications of water and welfare, and suggests the recommendations and opportunities for further research.

4 DO THE POOR THINK THEY'RE POOR? WELFARE METRICS, MONITORING AND MAPPING IN COASTAL KENYA

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Notes:

This Chapter is presented as submitted to Journal of Development Policy Review. The paper was under consideration by the time the thesis was submitted.

Abstract

Motivation

The multidimensional nature of poverty is widely accepted in policy and practice despite uncertainty over which type and combination of indicators best reflect welfare transitions due to economic, environmental or political change.

Purpose

Empirical evidence is examined to determine (a) the internal coherency and agreement between the two welfare indices, (b) the agreement of welfare indices and households' subjective welfare assessment, and (c) the spatial and dynamic heterogeneity of welfare change over the two panel sets.

Approach and Methods

Using two rounds of panel data from over 3,000 households in coastal Kenya, we examine theory-driven choices of short-term welfare indicators (based on dynamic indicators such as daily consumption and access to basic services) and multidimensional welfare index using both 'short term' and 'long term' indicators (e.g. education, health) against subjective welfare measures to evaluate internal coherency and agreement.

Findings

Results indicate that both 'short term' and multidimensional welfare indices are able to capture welfare transitions. People's subjective evaluation of welfare change is found to agree with both welfare indices tested, though the spatial distribution of this agreement is more varied.

Conclusions

We conclude that higher frequency, lower volume data collection is required to understand welfare transitions in the context of turbulent and rapid economic, environmental and political change such as is occurring in the south coast of Kenya.

Keywords: Subjective Welfare, Panel Data, Multidimensional Poverty, Kenya

4.1 Introduction

Whilst there is broad consensus on the multidimensional nature of poverty, the identification of appropriate welfare indicators is on-going work in progress (Kakwani & Silber, 2008; Ravallion, 2011). Theory identifies consumption, health, education, assets and access to services (e.g. water, energy, communications) as important to welfare (Bigsten et al., 2003; Castro et al., 1981; Giesbert & Schindler, 2012; Liverpool-Tasie & Winter-Nelson, 2011; Reardon & Vosti, 1995) though which indicators, combination and relative weighting provide the best measure of poverty is disputed (Ferreira & Lugo, 2012; Ravallion, 2011). Often absent from much of the debate is the relative speed of welfare change, which we stylize here as ‘short term’ and ‘long term’. ‘Long term’ welfare indicators may include education, perhaps taking a decade or more, or health indicators, such as life expectancy. ‘Short term’ welfare indicators would include consumption, if reliable income or expenditure data are available, or proxies such as common and observables staples in the house, such as cooking oil, flour, tea or sugar, or the type of dwelling floor or roof. Though artificial in separation, the notion of ‘long term’ and ‘short term’ welfare matters where the frequency of survey data are meant to relate to wider economic, environmental or political change. To be relevant to policy and practice, welfare measurements should be based on metrics that are likely to change within the timeframe relevant to the the event or intervention being assessed. We explore the notion of ‘short term’ and ‘long term’ welfare indicators in the context of coastal Kenya where significant economic and political change has recently led to major private investments in commercial mining and irrigated agriculture at a time of political

instability related to terrorism threats along the coast of Kenya (Atta-asamoah, 2015; County Government of Kwale, 2013).

The choice of indicators for welfare measurement can be a source of confirmation bias. Whether theory-driven or opportunity-driven, selection of a sample of welfare indicators will generate a welfare score, whilst unobservable but significant welfare dimensions may be outside the reach or comprehension of the analyst. Implicit is the imperceptible compromise of shifting from measuring value to valuing metrics (Molle & Mollinga, 2003; Porter, 1995). This is more than wordplay, particularly if there is no opportunity to validate welfare measures with alternative but valid approaches. Here, we examine the growing interest in subjective welfare measures where people self-evaluate their own welfare status (Beegle et al., 2012; Dhongde & Minoiu, 2013). Inevitably, subjective assessments are imperfect and constrained by well-rehearsed limitations but offer an intuitively appealing strength based on the value judgement of the individual of interest. Hypothetically, one might expect some degree of convergence between subjective and indicator-based measurements of welfare and where divergence exists it provides a concrete area for further analysis and debate.

The study context of coastal Kenya is chosen for three reasons: (1) the historically high rates of poverty in a generally quiet corner of Kenya insulated until recently from economic and political change at the national level; (2) the recent and major commercial investments by a mining company and an irrigated agriculture venture to create employment, build new infrastructure and invest in local enterprises; and (3) the increasing political instability in the area due to terrorism threats affecting international tourism, particularly in the area of Ukunda/Diani. Analyzing longitudinal household data

from two survey rounds, we develop two welfare indices; (1) a multidimensional welfare index based on combined 'short term' and 'long term' indicators (we refer to this as the 'multidimensional welfare index') and (2) a multidimensional welfare index based only on 'short term' welfare indicators (we refer to this as the 'dynamic welfare index'). We test the robustness of these indices across temporal and spatial dimensions checking for internal coherence, spatio-temporal coherence, consistency, and assess how they compare with subjective welfare assessments. We also test their suitability for spatial mapping of welfare.

This paper contributes to the literature through exploration of the following questions:

1. Is there internal coherency and agreement between a multidimensional welfare index and a dynamic welfare index?
2. Do the welfare indices agree with subjective welfare assessments?
3. How can welfare indices be used to represent temporal and spatial welfare change?

4.2 Who decides who is poor?

Income and expenditure measures of poverty are a long-established tool in policy and practice for measuring the nature, depth and transitions of poverty (Deaton, 1997). As described in the seminal work of Sen (1976, 1993), welfare analysts identified numerous failings of income poverty measures which led to the development of multidimensional measures of poverty such as the UNDP's Human Development Index (Sagar & Najam, 1998) and the Multidimensional Poverty Index (Alkire et al., 2017; Alkire & Santos, 2011, 2014). Both measures employ widely and nationally representative datasets from demographic health surveys (DHS) and multiple indicator cluster surveys (MICS) to develop poverty indices. Despite advances in theory and methods, core methodological challenges remain: (1) identification and (2) weighting (see Ravallion, 2011). The former

refers to the choice of which indicators are appropriate to measure welfare change, the second concerns what weights should be applied to each chosen indicator. An example is 'improved drinking water access' which is commonly used in many multidimensional indexes to reflect global goals to accelerate universal drinking water services (Dhongde & Minoiu, 2013). However, current surveys capture only the household's stated 'main drinking water supply' (e.g. handpump, piped water, surface water) to determine an improved or unimproved status. Whether the water supply is reliable, safe to drink, affordable or near the household is neither known nor captured; this questions the value of knowing the water supply technology alone (Bradley & Bartram, 2013). A related concern is whether this indicator is a priority for the poor and should be weighted to reflect that safe drinking water is a priority against other competing concerns. Another example is in Alkire's Multidimensional Poverty Index where the weights applied to each of the indicators are equal which raises concerns over which indicators are intrinsically important and which ones are instrumentally important (Ravallion, 2011).

Multidimensional welfare indicators focus on observed or revealed data about, for example, the health status, drinking water supply or expenditure of a household. A parallel and extensive literature also documents the 'voices of the poor' (Narayan, Chambers, et al., 2000; Narayan, Patel, et al., 2000; Narayan & Petesch, 2002) and acknowledges qualitatively richer understanding of the ways in which an individual, household or cohort may be affected by the complex process of change in their welfare. Economists are increasingly interested in subjective welfare and seek to understand whether formal welfare indicators correspond with people's own preferences. A growing literature is exploring correlations between subjective and objective measures

(multidimensional and dynamic welfare indices) of well-being (Fafchamps & Shilpi, 2009; Sacks et al., 2012) with some reporting weak agreements between subjective assessments and objective welfare metrics constructed from expenditure data (Beegle et al., 2012). The relationship between the subjective and objective welfare indexes has significant policy implications in that it determines whether poverty intervention strategies based on these indexes reflect the priorities of the poor.

Limitations to subjective welfare measurements relate to bias from cognition, representation and stability (OECD, 2013). Cognition bias refers to the uncertainty as to whether everyone interprets a single question on welfare status in an equivalent and consistent manner. The literature suggest this would be a bold and probably unsubstantiated claim (Helliwell et al., 2013) but the alternative of externally deciding what matters to people most is equally fraught. Second, representation refers to whom the respondent is qualified to answer for. Clearly, at the individual level, the respondent is qualified to speak for her or himself, but commonly owned assets and other welfare measures accrue at the household level and some understanding of welfare of the whole household is desirable for comparison. This opens up the question of welfare stability and the extent to which respondents may change their understanding of the question over time. Short term test-re-test measures of subjective well-being indicate that measures of this kind can meet criteria for internal consistency (Diener, 1984; OECD, 2013), and can thus indicate real changes over time (e.g. the effects of life events on subjective well-being as described by Kahneman & Krueger, 2006).

Rapid economic, environmental and political change has led to calls for more frequent surveys of welfare surveys perhaps through the use of mobile phones (Dabalen et al.,

2016; Hoogeveen et al., 2014; KIPPRA, 2013; World Bank, 2014). The situation in Kenya reflects some of the wider trends in Africa where increasingly unpredictable hydro-climatic variation and extremes interact with political decentralisation and instability with uneven but strong economic growth. A survey once a decade provides little information for policy makers to take any credible action given dynamic socio-economic and environmental interactions and impacts between and within years. This study aims to contribute to the existing research on welfare measurement with a panel study (Kristjanson et al., 2010, 2005; Radeny et al., 2012) that allows insights into which households are improving or declining in terms of welfare metrics, whether different composite measures using 'short term' and 'long term' welfare indicators produce the same results, and to what extent subjective welfare assessments agree with objective welfare metrics. Geo-spatial referencing allows mapping of economic activity and welfare change to illustrate whether major economic activities (e.g. mining, agriculture, tourism) are related to welfare change over space and time.

4.3 Methodology and data

4.3.1 Study area

The study area is located in Kwale county, Kenya, south of Mombasa and adjacent to northern Tanzania (Figure 4-1). The coastal climate has a bi-modal rainfall pattern with an average annual precipitation of 1,200mm belying significant inter-annual and spatial variability. The county has a population of 730,000 people most of whom live in rural areas (82%) with over 70% living below the poverty line of less than USD1.25 a day (KNBS, 2006). Our study area covers 2,156 km² in Msambweni and Matuga sub-Counties with around 300,000 residents (KNBS, 2010). This area includes the long-established coastal tourism industry at Ukunda/Diani and the more recent investments in mining and

commercial irrigated agriculture. Since 2013, there has been an increasing pace of environmental, economic, social and political change with the establishment of two new and major economic activities. Kwale International Sugarcane Company Limited (KISCOL) has been progressively rehabilitating 5,500 hectares of sub-surface irrigated sugarcane including the commissioning of its own sugar mill in 2015. Adjacent to the plantations is the country's newest and largest mining operation (Kwale Mineral Sands Project). The mine, operated by Base Titanium Limited, is currently projected to have exported 6.5m tonnes of titanium ore by 2028 from Likoni port some 30km north of the mine site. Scattered around the mine site and sugarcane plantation are around 300 handpumps (5-30m deep) providing drinking water to communities, schools and health centres.

In August 2013, a waterpoint survey identified 571 handpumps (all Afridev model) in the study area of which 45% were non-functioning. A sample of 531 handpump locations were used as a sampling frame for two rounds of household survey in 2013/14 (Nov-Jan) and 2015 (March-May). The majority of the households in the study area were sampled near functioning and failed water points; the latter reduced spatial bias in the absence of a geo-referenced record of all households, see Figure 4-1. GSM-enabled transmitters (Thomson et al., 2012a) were installed on 300 operational handpumps to provide daily usage data. At each of the 531 handpumps, an average of six households were randomly selected generating a sample of 3,500 households. The household survey captured the following types of information: a) demographic, b) socio-economic, c) health, d) drinking water supplies, e) waterpoint management, and, f) welfare and assets.

All the households surveyed were geo-referenced. A pilot survey was conducted with 19 experienced enumerators recruited from communities spanning the study area, who administered the survey in local languages (Swahili, 54%; Digo, 43%; Duruma, 2%; other,

1%). The sample for 2013/2014 was 3,500 households and 3,300 in 2015. Attrition was due to households moving away and non-responses or refusal to participate a second time, though the majority (97%) of the households were successfully re-sampled. After data quality checks and cleaning a core sample of 3,229 surveys were analysed. Given the variation in livelihood systems from inland, remote communities to the more densely-populated coastal strip we report both on aggregate results and on a simplified typology of three economic geographies in the area: (1) the southern, coastal belt with people living within a 5 km strip of the sea (52% of the sample size), whose main economic activity is fishing; (2) inland and more remote areas below the Shimba Hills and away from the coastal margin (37% of the sample size) where the main economic activity is farming; and (3) the small town of Ukunda/Diani which largely serves the tourism industry along Diani beach (10% of the sample size).

Ethical permission to conduct this survey was provided by the University of Oxford's Central University Research Ethics Committee and research permission granted by the Government of Kenya's National Council of Science and Technology, Kenya (NCST/RCD/17/013/132, September 2013). All interviews were voluntary with informed consent procedures observed in the local language. Data have been anonymised and stored in encrypted files.

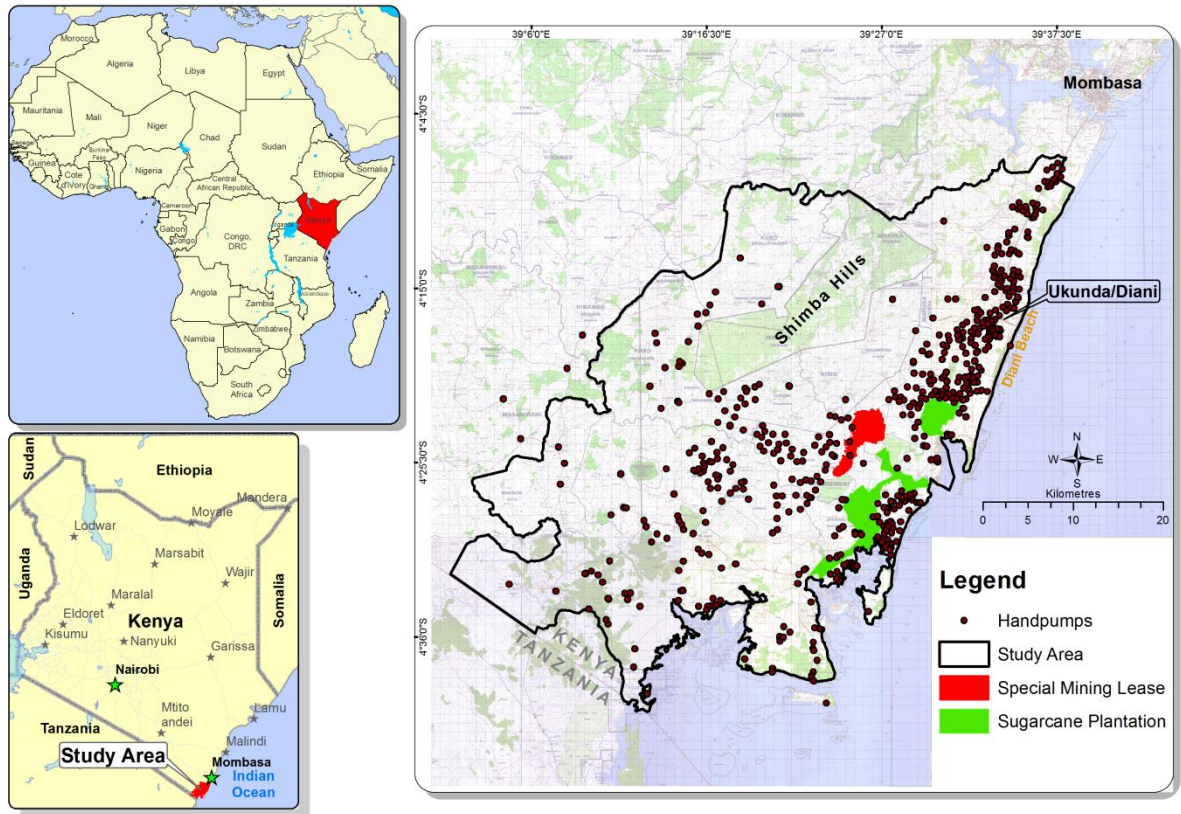


Figure 4-1 Study area with handpumps indicating sampling activities

4.3.2 Constructing a welfare index

We applied the Principal Component Analysis (PCA) technique in constructing a welfare index (Falkingham & Namazie, 2002; Filmer & Pritchett, 2001; Gwatkin et al., 2007; Vyas & Kumaranayake, 2006). PCA is mainly used for dimensionality reduction of continuous variables but in this paper, we apply it on binary variables not for dimensionality reduction but to use the eigenvectors from the co-variance matrix to decide on weighting the variables. The indicators identified here are similar in principal to what has been used in literature to measure welfare. Asset based indicators as well as indicators closely aligned to the Millennium Development Goals have been proved to be valid predictors of welfare (Alkire & Santos, 2011; Montgomery et al., 2000; Sahn & Stifel, 2003). We used a total of 29 indicators clustered into 5 groups: household composition, dwelling characteristics, asset ownership, sanitation and health, and drinking water (Table 4-1).

Households were assigned a score of '1' if they met the criteria for an indicator, otherwise '0'. Households with missing data on at least one of the indicators were removed from the analysis. We then developed a multidimensional welfare index for the year 2014 based on all indicators; we label this welfare index the 'multidimensional welfare index'. This was done for years 2014 and 2015 using the same weights generated by the PCA with 2014 as the reference year. (Applying different weights for the year 2015 would have made the two years incomparable). Finally, we selected a subset of indicators likely to change over the short term as a result of local processes or events, eight 'short term' indicators were identified. Here we included inter alia dwelling characteristics such as the flooring, roofing and walling materials. While these dwelling characteristics indicators may be ostensibly slow to change, the study area offers a unique context where the mining and irrigation project are investing in the local communities with the mining project employing over 900 people directly with 2,800 jobs indirectly and the irrigation project targeting over 4,500 ha of out-grower farmers. These investments have seen the local population invest their income on improving their living conditions especially changing from mud walled housing units to use of bricks or stone walls and flooring the house with cement. We thus expected to see a quick change in dwelling characteristics within the first few years. From these eight indicators we developed a welfare index for the years 2014 and 2015 using the same approach as above. We label this welfare index the 'dynamic welfare index'.

The welfare index developed for both the 29 indicators and the 8 indicators ranged between 0 and 1. To compare the fraction of households across different welfare groups,

we split the welfare index range into five wealth groups⁵ with equal range defined by the lowest welfare group with a welfare index ranging between 0 and 0.2 while the highest wealth group had a welfare index more than 0.8. We refer to these as welfare quintiles and compute the fraction of households in each welfare quintile.

4.3.3 Assessment of reliability

Filmer & Pritchett (2001) and Houweling et al. (2003) assessed the reliability of asset-based welfare indices based on internal coherence of the indices, the ability of the indices to stratify households into wealth groups and the mobility of households between welfare quintiles. We applied these tests to evaluate the robustness of the multidimensional welfare index and the dynamic welfare index, assessing their ability to stratify households into different wealth groups in different locations with heterogeneous economic activities and their ability to map welfare changes over time and space. The three distinct locations, with heterogeneous economic activities were used to group the households into zones, i.e., coastal, inland and Ukunda/Diani.

We investigated the consistency with which subjective welfare assessment and objective welfare indices identified households with either positive or negative welfare changes. Households that scored a lower welfare index in year 2015 compared to year 2014 were categorized as having a negative change and were coded as '0' while those that had a positive change were coded as '1'. For the subjective welfare assessments, we used three categories, i.e., 'not-well-off', 'average' and 'well-off'. These categories elicit a global evaluation of one's life, in contrast, the spacing between a likert scale is not often

⁵ Wealth group is used to refer to group of households that have a welfare index that falls between a predefined range, for example 0.2 to 0.4 will be the second wealth group or used synonymously with the second welfare quintile.

equidistant and subject to problems of measuring the true attitudes where people tend to avoid the extreme ends (Hartley, 2014).

The majority of households fell in the 'average' (39%) and 'not-well-off' (61%) categories. The 'well-off' category had few households, 0.24%, and was removed from the analysis as the sample was too small to generate any significant inferences. For welfare transition between 2014 and 2015, we coded the households as follows; households moving from 'average' to 'not-well-off' (negative change) were coded as '0' while those moving from 'not-well-off' to 'average' (positive change) were coded as '1'. We further analyzed for agreement between the subjective assessment of welfare and the objective welfare indices across the three locations.

4.3.4 Mapping welfare

The ability of a welfare index to generate welfare maps is pertinent to identifying poor areas to facilitate decisions on resource allocation and inform poverty reduction programmes and policy formulation (Collier & Dollar, 2002; Rutstein & Johnson, 2004; World Bank, 2013). Welfare maps have historically been developed on a country by country basis for the purposes of comparing and ranking countries (Henninger, 1998). Recently, there is increasing interest in locally based welfare maps for resource allocation and also as a tool to leverage development funds in devolved countries like Kenya. The limitation to locally based maps has been the temporal and spatial resolution of household data with surveys capturing only a small proportion of the population every 10 years and thus not being spatially representative (KNBS, 2006, 2007). Existing data do not capture welfare transitions over short temporal and spatial intervals thus making identification of where the poor area and the impacts of environmental, economic and political shocks on the poor difficult (Collier & Dollar, 2002; Deichmann, 1999).

We assessed the ability of the multidimensional welfare index and the dynamic welfare index to generate spatial maps at fine temporal (c.15 months) and spatial (c.250 m) resolution, using the spatially distributed household data. We applied the Kolmogorov Wiener prediction method (kriging) commonly used in geo-statistics to provide spatial predictions (Webster & Oliver, 2007). This method was selected over other local interpolation methods because it provides estimates of the error of estimation and the variability of the predicted surfaces (Oliver & Webster, 1990; Webster & Oliver, 2007). Kriging also assumes that some of the spatial variation observed in natural phenomena can be modelled by random processes with spatial autocorrelation (Johnston et al., 2003) thus making it a good candidate for spatial welfare prediction.

4.4 Results

4.4.1 Summary statistics for welfare indexes

We begin by presenting the results of the principal component analysis on the 29 multidimensional welfare variables; their mean, standard deviation and factor scores. As expected, welfare variables associated with low welfare status had negative factor scores values. Unimproved sanitation (bush/field) was the most closely associated with a low household welfare index (-0.64), followed by limited educational attainment (primary school, -0.41), using wood to cook (-0.25), and households with more children than adults (outnumbered, -0.17). As with other studies (Booyesen et al., 2008; Filmer & Pritchett, 2001), positive welfare is strongly associated with the household's dwelling characteristics (floor, wall or roof). Weights generated from the principal component analysis were used to construct the multidimensional welfare index and the dynamic welfare index as per the indicators marked 'X' (Table 4-1).

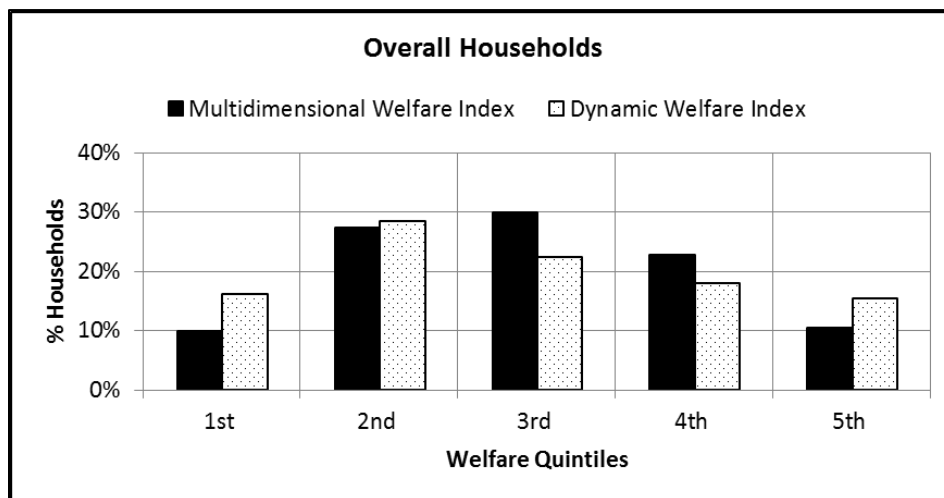
Table 4-1 Overall household PCA factor scores and summary statistics for variables, year 2014;
n=3,229

	Variables	Multidimensional Welfare Index	Dynamic Welfare Index	Mean	Factor Score
Household composition	Highest level of education (Primary school)	X		0.55	-0.41
	Highest level of education (Secondary school)	X		0.33	0.39
	Outnumbered - more children under 15 to adults	X		0.28	-0.17
	At least one wage earner	X		0.10	0.17
Dwelling	Floor of main dwelling is improved (cement)	X	X	0.29	0.62
	Roof of main dwelling is improved (corrugated)	X	X	0.32	0.59
	Walls of main dwelling are improved (brick, blocks, cement)	X	X	0.41	0.56
	Walls of main dwelling are rendered	X		0.21	0.40
Asset ownership and consumables	Owens radio	X		0.71	0.44
	Owens bicycle	X		0.46	0.39
	Owens motorbike	X		0.11	0.33
	Owens mobile phone	X		0.84	0.40
	Owens cooking oil	X	X	0.45	0.52
	Owens sugar	X		0.60	0.51
	Owens flour	X	X	0.66	0.46
	Owens tea leaves	X	X	0.65	0.50
	Owens greater than 2 acres of land	X		0.42	0.16
	Owens large livestock (cattle or oxen)	X		0.20	0.13
	Uses wood to cook	X		0.95	-0.25
Sanitation and Health	Sanitation (pit with slab)	X	X	0.45	0.57
	Sanitation (bush/field)	X		0.45	-0.64
	Per cent of children under 5 years with diarrhoea in last week	X		0.05	-0.09
	Per cent of children 5-15 years with diarrhoea in last week	X		0.08	-0.08
	Owens soap	X	X	0.65	0.47
Drinking Water	Access to improved drinking water source in dry season	X		0.82	0.20
	Dry drinking water source is affordable, close, reliable or safe (3 or more)	X		0.14	0.20
	Access to improved drinking water source in wet season	X		0.83	0.21
	Wet drinking water source is affordable, close, reliable or safe (3 or more)	X		0.14	0.18
	Treat Water with Chlorine	X		0.14	0.12

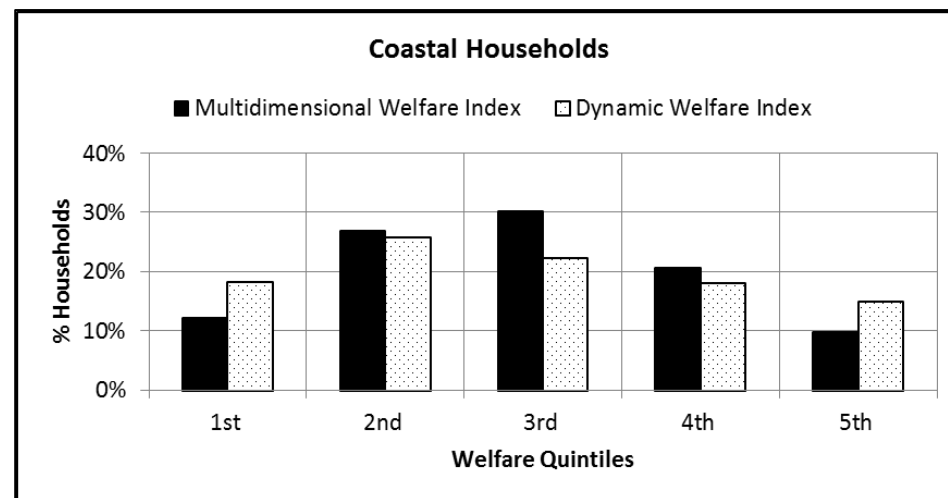
Note: X marks the variables used in constructing the welfare indices

We categorized households into welfare quintiles using the multidimensional and dynamic welfare indices (Figure 4-2a). The two welfare indices had similar percentages of households across the quintiles with the largest deviations observed in the third quintile (8%). The Spearman rank correlation coefficient was significant and high with

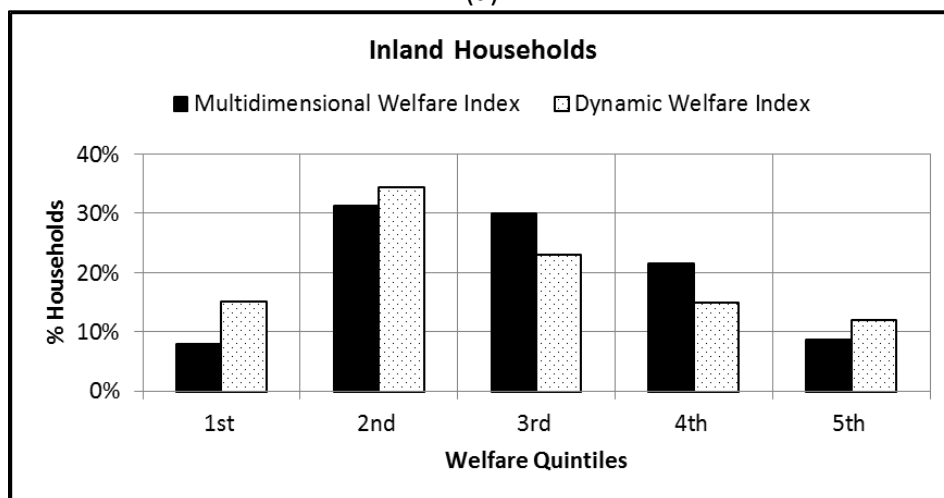
results revealing a convergence between the multidimensional and the dynamic welfare indices ($r_s=0.908$ at $p<0.01$, $n=3,229$). However, the dynamic welfare index consistently identified a higher share of the lowest welfare quintile with a corresponding lower share in the third quintile. The dynamic welfare index incorrectly classified less than 1 out of every 12 households with consistency in the pattern of welfare groups across the zones (Figure 4-2).



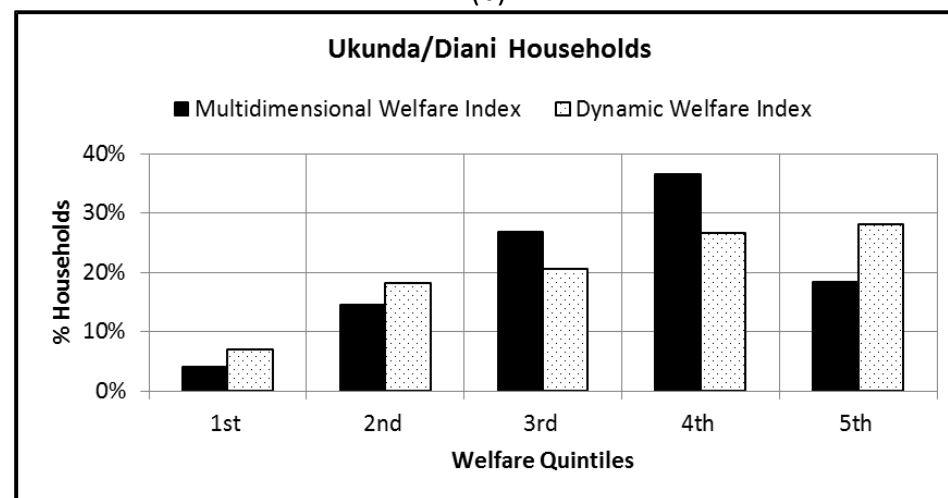
(a)



(b)



(c)



(d)

Note: (a) All Households, $r_s=0.908$ at $p<0.01$, $n=3,229$ (b) Coastal zone, $n=1,690$ (c) Inland zone, $n=1,207$ (d) Ukunda/Diani zone, $n=332$

Figure 4-2 Percentage of households in welfare quintiles by zones

4.4.2 Are welfare indices internally coherent and consistent?

Here we explore internal coherency in the multidimensional and the dynamic welfare indices (Table 4-2). The mean scores represent the relative, not absolute, share in each quintile, which sum to 100 per cent. For example, in the multidimensional welfare index, mobile phone ownership is four times higher in the second quintile (24%) compared to the bottom quintile (6%) which is half that in the top quintile (12%). As widely rehearsed, this reflects that mobile phone ownership is broad (84% ownership here) though there is much lower relative access among lowest welfare households. The mean scores are computed for all variables, irrespective of whether they were used in the construction of the index, by both multidimensional and dynamic welfare index to enable assessment of internal coherence between the two indices across all variables. These data reveal in almost all cases the bottom quintile has higher deprivation by household composition, dwelling type, assets or water and sanitation services.

In theory, one would expect a transition in increasing relative ownership from lower to higher quintiles. The data do not conform consistently to this pattern; in many variables, the top quintile has a lower relative share compared to the third or fourth quintiles. For example, one might expect lower quintile households to have a higher share of low education attainment than upper quintiles. However, while upper quintile households are much less likely to have primary school as the highest attainment level this does not hold consistently with the second and third quintiles which are more likely to have achieved primary school as the highest education level than the bottom quintile. A similar pattern is found with the outnumbered variable with the bottom quintile less likely to have more children than adults compared to the second and third quintiles.

Table 4-2 Summary statistics for variables by welfare quintiles, n=3,299

Variables		Mean Scores									
		Multidimensional Welfare Index					Dynamic Welfare Index				
		1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th
Household composition	1. Highest level of education (Primary school)	14%	37%	32%	15%	2%	19%	34%	23%	15%	9%
	2. Highest level of education (Secondary school)	2%	13%	30%	33%	22%	11%	21%	23%	22%	24%
	3. Outnumbered - more children under 15 to adults	15%	30%	33%	16%	6%	19%	29%	26%	14%	12%
	4. At least one wage earner	7%	16%	23%	31%	23%	14%	16%	21%	21%	28%
Dwelling	5. Floor of main dwelling is improved (cement)*	0%	6%	19%	40%	35%	1%	8%	11%	30%	50%
	6. Roof of main dwelling is improved (corrugated) *	0%	8%	20%	41%	30%	1%	10%	15%	31%	43%
	7. Walls of main dwelling are improved (brick, blocks, cement) *	1%	11%	26%	37%	24%	4%	12%	15%	34%	36%
	8. Walls of main dwelling are rendered	1%	12%	22%	35%	30%	5%	17%	19%	24%	36%
Asset ownership	9. Owns radio	3%	22%	32%	28%	14%	10%	27%	23%	20%	19%
	10. Owns bicycle	2%	18%	31%	32%	17%	8%	24%	25%	22%	21%
	11. Owns motorbike	1%	8%	22%	35%	34%	4%	13%	22%	22%	38%
	12. Owns mobile phone	6%	24%	32%	26%	12%	12%	26%	24%	20%	18%
	13. Owns cooking oil*	0%	12%	32%	35%	20%	1%	13%	30%	25%	31%
	14. Owns sugar	1%	18%	33%	31%	16%	4%	23%	26%	23%	23%
	15. Owns flour*	2%	21%	32%	29%	15%	4%	24%	27%	22%	23%
	16. Owns tea leaves*	2%	20%	32%	30%	15%	2%	24%	28%	23%	23%
	17. Owns greater than 2 acres of land	6%	23%	31%	27%	13%	11%	28%	25%	19%	16%
	18. Owns large livestock (cattle or oxen)	6%	22%	29%	29%	14%	11%	27%	24%	20%	18%
	19. Uses wood to cook	10%	28%	31%	22%	9%	17%	30%	23%	17%	13%
Sanitation and Health	20. Sanitation (pit with slab)*	0%	11%	30%	39%	20%	4%	17%	26%	24%	29%
	21. Sanitation (no access: bush/field)	21%	46%	28%	5%	0%	29%	39%	19%	10%	2%
	22. Per cent of children under 5 years with diarrhoea in last week	15%	32%	28%	20%	5%	19%	31%	20%	19%	10%
	23. Per cent of children 5-15 years with diarrhoea in last week	13%	30%	31%	19%	7%	16%	31%	24%	18%	10%
	24. Owns soap*	2%	20%	33%	30%	15%	3%	23%	29%	23%	23%
Drinking Water	25. Access to improved drinking water source in dry season	8%	26%	30%	24%	12%	15%	28%	22%	18%	17%
	26. Dry season: drinking water source is affordable, close, reliable or safe (3 or more)	1%	18%	33%	29%	19%	5%	27%	24%	22%	22%
	27. Access to improved drinking water source in wet season	8%	26%	30%	24%	12%	15%	28%	22%	18%	17%
	28. Wet season: drinking water source is affordable, close, reliable or safe (3 or more)	2%	20%	31%	30%	17%	6%	28%	22%	22%	20%
	29. Treat Water with Chlorine	6%	22%	27%	28%	17%	15%	21%	23%	19%	21%

*indicators/variables used in the dynamic welfare index

The dynamic welfare index is more internally coherent than the multidimensional welfare index in a number of domains – education (primary, secondary), wage earner, dwelling condition (floor, wall, roof), assets (oil, sugar, flour, tea) and sanitation (pit, bush). Where the data do not neatly align to theory this may reflect sampling or non-sampling errors related to the diversity and complexity of measuring welfare by land, livestock, energy, water supply or other factors. The results suggest some caution in over-interpreting the findings, particularly for the multidimensional welfare index, though longer-term measurement for both between and within years may provide more insights particularly supported by qualitative assessment of the processes and practices of welfare accumulation and loss across households.

Overall, dwelling characteristics provide the most compelling and consistent illustration of welfare transitions with the top four quintiles seven times or more likely to have improved floor, walls or roof than the bottom quintile. While the second quintile fare considerably better than the bottom quintile there is marked difference between the lower two and upper three quintiles suggesting dwelling characteristics are a stable and good predictor of deprivation, which is in agreement with national data (KNBS, 2006).

For assets, there is consistency in the second quintile always having a higher share than the bottom quintile, but the pattern becomes less stable with the top quintile falling below the third or fourth quintile in the multidimensional welfare index. A consistent predictor of being in the lowest quintile is limited consumable goods in the house (e.g. oil, sugar, flour, tea or soap). In all cases, the lowest quintile is at least seven times less likely to have one of the consumables in the household than the top quintile. However, the third or fourth quintile has a higher share of ownership than the fifth quintile. For

sanitation, the lowest quintile is seven times less likely to have improved facilities and fifteen times more likely to have no access (bush/field) than the top quintile. However, the quintile transition is not always consistent with the highest deprivation by the no access (bush/field) criterion with the second rather than lowest quintile. Of note is the transition in drinking water access when one compares the standard measure (improved technology) with the alternative measure (improved services - quality, reliable, affordable, close). The lowest quintile faces two to three times more deprivation as measured by the more exacting 'improved services' criteria (as indicated by the dynamic index mean scores).

Similar trends were observed with the dynamic welfare index especially across the variables used in constructing the index. To illustrate the trend in differences by quintiles for each variable we plot the difference between the dynamic index scores and the multidimensional index scores to see the extent to which variables were being under or over-estimated (Figure 4-3). The multidimensional welfare index scores for the first quintile were consistently lower than those for the dynamic index - on average, around five percent more households met the criteria for each of the variables. A similar trend was observed in the second quintile distribution; however, five variables in this quintile had fewer households when categorized by the dynamic welfare index as opposed to the multidimensional index (these were: limited education attainment-primary school, more children under 15 to adults-outnumbered, no access to improved sanitation facilities-bush/field, children under 5 years with diarrhoea in last week). The plot reveals that the third and fourth quintiles consistently record higher values for the multidimensional welfare index compared to the dynamic index (a difference of 0 – 10 per cent).

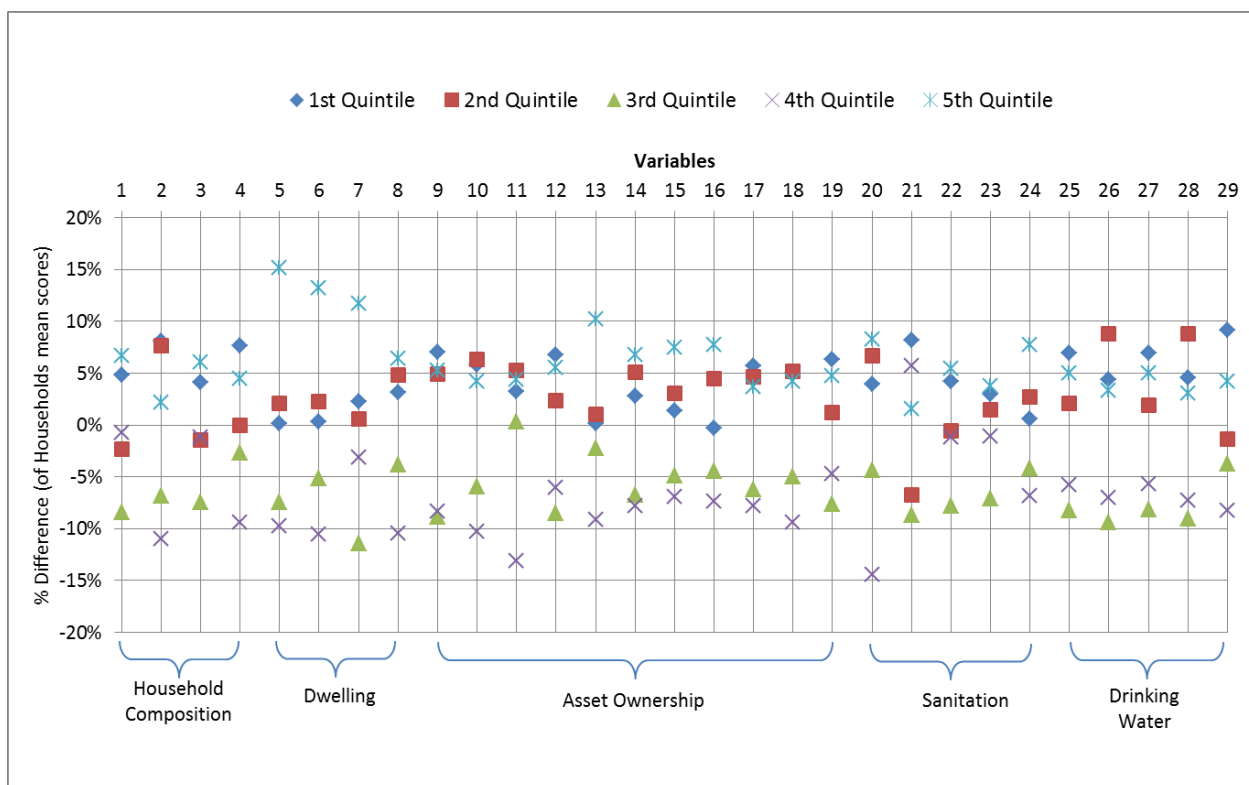


Figure 4-3 Difference in mean scores of variables by subtracting the multidimensional welfare index from the dynamic welfare index

4.4.3 Do households move rapidly between welfare classes?

To monitor household mobility between welfare quintiles we take the dynamic welfare index from the baseline year (2014) and calculate what share of households remain in the same quintile (status quo), Table 4-3. The findings indicate most households (61%) remain in the same welfare class with slightly more being re-classified to lower welfare categories (23%) compared to those being re-classified to higher welfare categories (16%). Using absolute welfare changes between 2014 and 2015, we analyzed for agreement between the multidimensional and dynamic welfare index in tracking welfare changes. The results revealed that both indices were able to track welfare changes and had a statistically significant agreement on 85% of the households ($r_s = 0.857, p < 0.01, n = 3,229$).

Table 4-3 Change of households to other welfare quintiles when using dynamic welfare index

Description	Stability	Dynamic Welfare Index
Overall	Households with falling welfare	23%
	Status Quo	61%
	Households with rising welfare	15%
Zones	Stability	Dynamic Welfare Index
Coastal	Households with falling welfare	21%
	Status Quo	62%
	Households with rising welfare	17%
Inland	Households with falling welfare	29%
	Status Quo	59%
	Households with rising welfare	11%
Ukunda/Diani	Households with falling welfare	18%
	Status Quo	64%
	Households with rising welfare	18%

Note: percentages may not add up to 100% due to rounding

4.4.4 Do people self-identify in the 'right' welfare index quintile?

We now report on how individuals classify their household compared to the quintile distribution for the multidimensional and dynamic welfare indices. Excluding the 'well-off' category, we tabulate by the two dominant criteria 'average' and 'not well-off' (Table 4-4). Overall there appears reasonable agreement with the 'average' subjective assessment skewing to the upper two quintiles for the multidimensional welfare index (55%) and dynamic welfare index (53%). However, the fit was better for the dynamic welfare index as the third quintile for the multidimensional index is higher (28%) than the top quintile (21%). Equally, the classification is less clear for the 'not well-off' classification as the second and third quintiles (67%) best represent this group. Again, the dynamic welfare index seems a more consistent fit with the bottom two quintiles representing the majority (59%).

Similar results were observed across two of the three zones, i.e., coastal and inland (Figure 4-4). A reasonable agreement was observed in the coastal zone, the 'average' classification skewed to the upper two quintiles for the multidimensional welfare index (52%) and dynamic welfare index (55%). There was however a better fit for the dynamic

welfare index as the third quintile for the multidimensional index was higher (30%) than the top quintile (21%). The dynamic welfare index was more consistent than the multidimensional welfare index in the 'not-well-off' classification with the bottom two quintiles representing the majority (56%). In the inland zone, the 'average' classification skewed to the upper two quintiles with the multidimensional welfare index being more representative (52%) than the dynamic welfare index (45%). Neither the dynamic nor the multidimensional welfare index had a very good fit as the third quintile was higher than the top quintile in both cases. However, the dynamic welfare index was more consistent than the multidimensional welfare index in the 'not-well-off' classification with the bottom two quintiles representing the majority (66%).

In the Ukunda/Diani zone (Figure 4-4), a reasonably good agreement was observed with the 'average' classification skewing to the upper two quintiles of the dynamic welfare index (75%) and the multidimensional welfare index (78%). In this classification, the first, second and the third quintiles had the lowest representation for both dynamic welfare index (<14%) and multidimensional welfare index (<15%) compared to the other two zones above. The dynamic welfare index had a better fit than the multidimensional welfare index as there was an increasing trend represented from the third quintile towards the top quintile. The classification for the 'not-well-off' category was less clear as there was no distinctive skew trend towards either the top or bottom quintiles.

The evidence presented here suggests some cautious optimism for people being reasonably likely to classify their households in the "right" domain (as compared to an objective measure) with the strong caveat that few people choose to self-classify as 'well-

off', which may be considered an expected 'decoy effect' from both a design and analytical perspective.

Table 4-4 Overall cross tabulation of subjective welfare versus objective welfare indices

Subjective Welfare	Welfare Quintile, n=3,229									
	Multidimensional Welfare Index					Dynamic Welfare Index				
	1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th
Average	2%	15%	28%	34%	21%	5%	19%	22%	25%	28%
Not-well-off	15%	36%	31%	15%	3%	24%	35%	23%	13%	6%

Between 2014 and 2015, the multidimensional and dynamic welfare indices classified 41 per cent of households as having a negative change. In comparison, the subjective welfare measure categorized 53 per cent of the households as having moved from 'average' to 'not well off' (Table 4-5). Similar results were observed when the households were disaggregated by zones, i.e., coastal, inland and Ukunda/Diani. We tested for the level of association (range 0 to 1) between the subjective and objective welfare measures with the results indicating a significant, but not high, level of association for the dynamic welfare index (0.42) and the multidimensional welfare index (0.37). Similar degrees of agreement were observed across all the zones ranging from 34 per cent in the coastal zone to 48 per cent in Ukunda/Diani for the multidimensional welfare index and 41 per cent in the coastal zone to 44 per cent in Ukunda/Diani for the dynamic welfare index.

Table 4-5 Percentage of Households by Welfare Changes

Index	Welfare Change Between 2014 and 2015		Agreement between Subjective and Objective Welfare Indices (Cramer's V)			
	Negative	Positive	Overall	Coastal	Inland	Ukunda/Diani
Multidimensional Welfare Index <i>n=1,357</i>	41%	59%	0.368**	0.343**	0.344**	0.481**
Dynamic Welfare Index <i>n=1,233</i>	41%	59%	0.420**	0.406**	0.412**	0.443**
Subjective Welfare <i>n=670</i>	53%	47%				

** Statistically significant at $p < 0.001$; $\phi = V$ since it's a 2 by 2 matrix

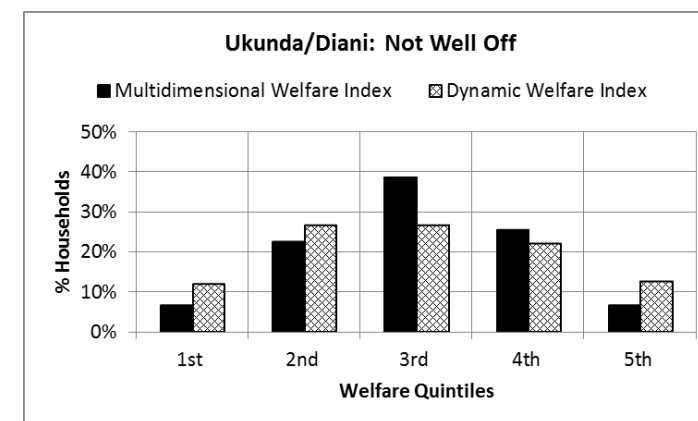
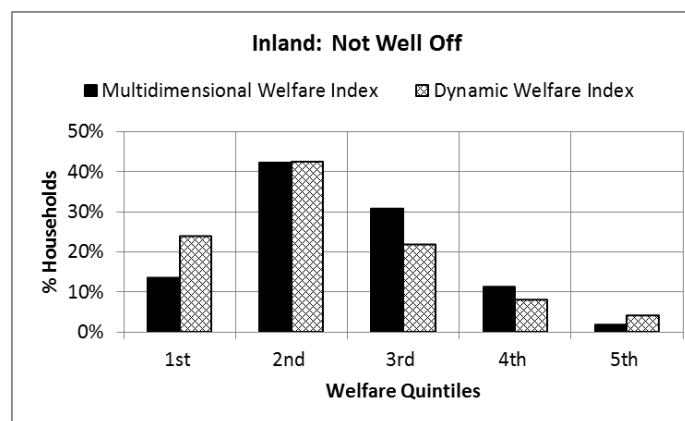
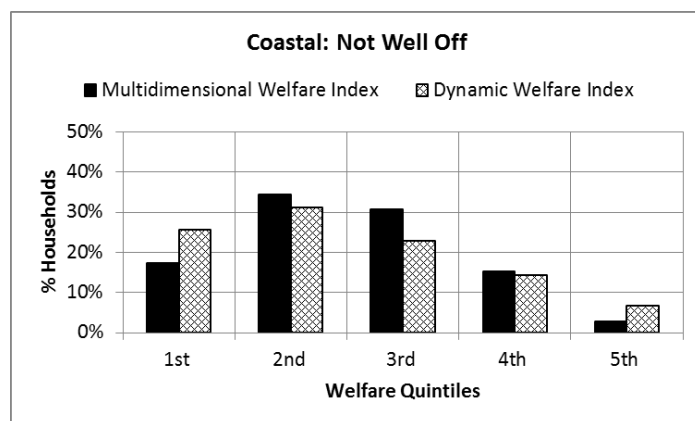
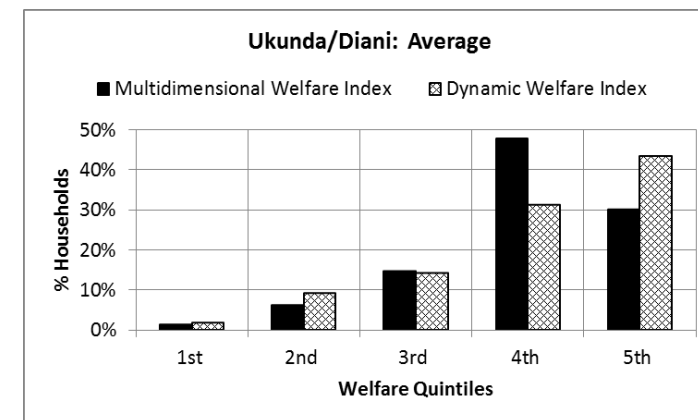
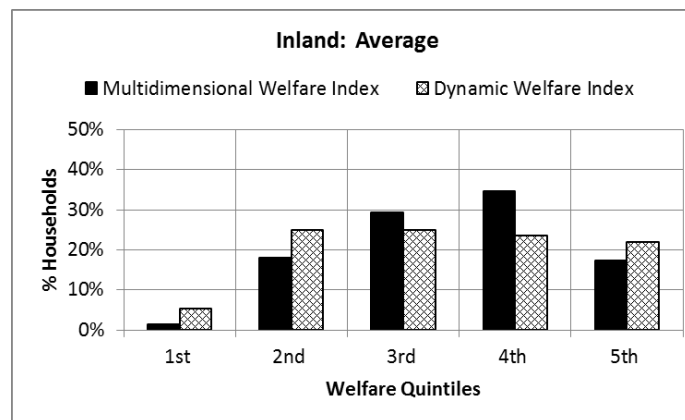
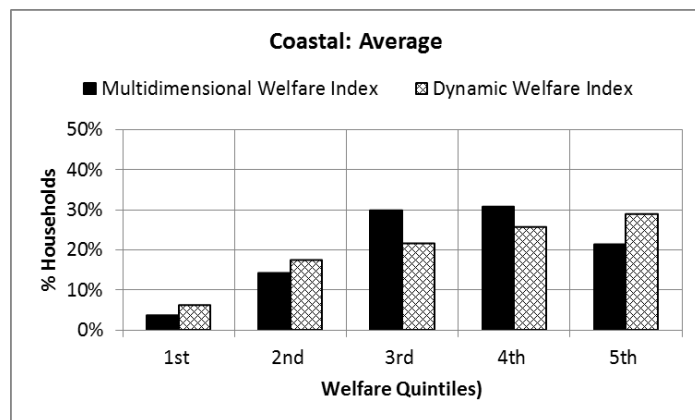


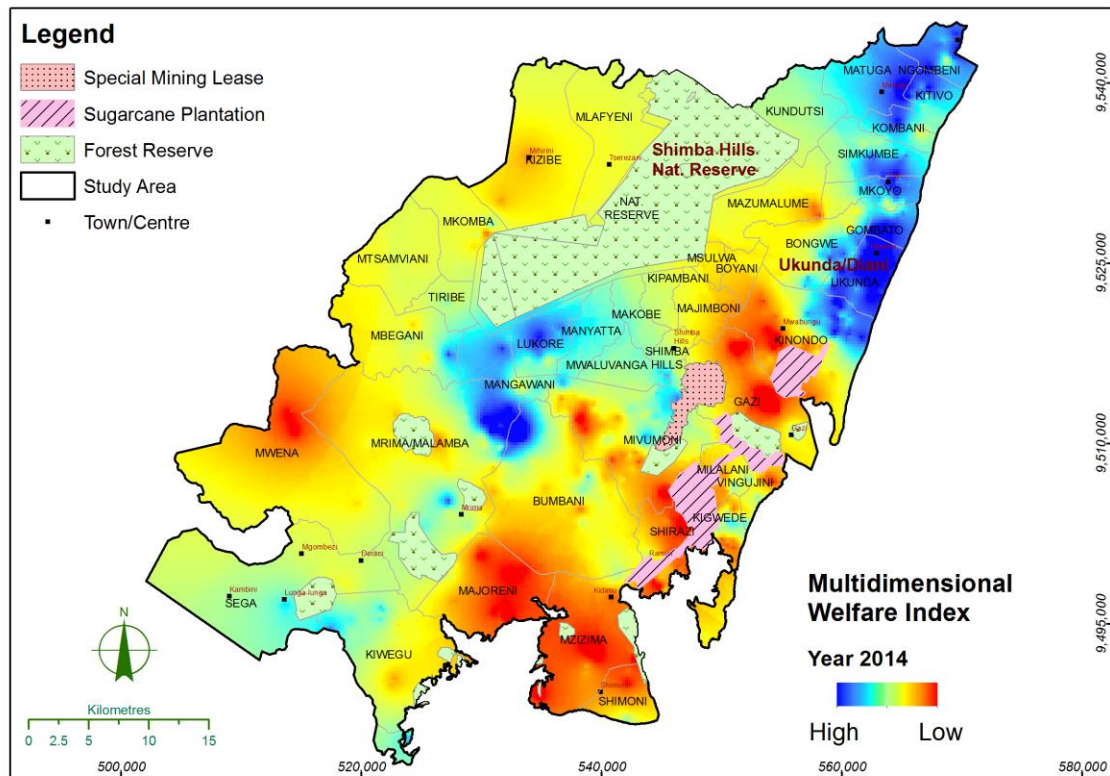
Figure 4-4 Agreement between subjective welfare and objective welfare indices

4.4.5 Spatial and temporal welfare

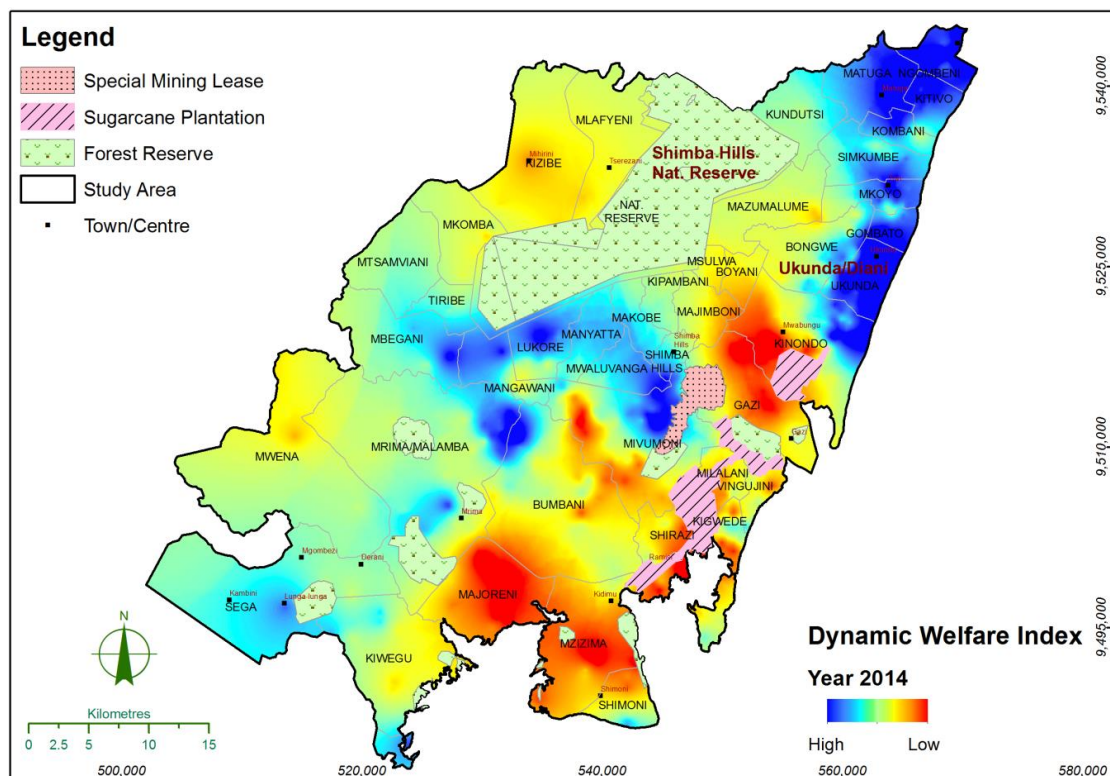
We finally develop spatial and temporal welfare maps in a GIS environment using the geo-location and multidimensional and dynamic welfare indices data of each household for 2014 and 2015 using Kriging to compute the spatial welfare variations. The maps from the two welfare indices compared well, revealing existing spatial welfare heterogeneity, distribution and transitions of welfare. Figure 4-5 and 4-6 shows welfare maps for 2014 and 2015 produced by the multidimensional and dynamic welfare indices. Both welfare indices similarly identified the regions with high welfare in 2014 to be around Ukunda/Diani, Tiwi, Matuga and the western parts of the mine site, i.e., Mangawani, Lukore and Shimba Hills centres. Low welfare indexes were observed in Shimoni, Majoreni, Mwena, Ramisi and Kinondo area. The 2015 welfare maps compared generally well. There were slight mismatches of predicted welfare on households around the sugarcane plantations and Mazimalume region.

Uncertainty in the predicted welfare values (standard errors of prediction) was minimal for both multidimensional and dynamic predicted welfare indices (Figure 4-7). The multidimensional welfare index had standard errors of prediction ranging between 2% to 5% while the dynamic welfare index had errors of prediction ranging between 5% and 9%. The standard errors of prediction increased away from the densely populated areas; (the distribution of water points which coincides with the distribution of households and therefore population concentration is shown in Figure 4-1). The increasing standard error of prediction can be attributed to there being fewer households which are more sparsely distributed and are thus not spatially autocorrelated.

To illustrate the welfare change over time, we subtract the welfare maps of 2014 from 2015. The welfare change map depicted by the dynamic welfare index, Figure 4-8 (b) was slightly different from the multidimensional welfare change map, Figure 4-8 (a). The dynamic welfare index map showed a welfare change ranging between -17% to +35% while the multidimensional welfare index map showed a welfare change ranging between -16% to +28%. While these differences are not substantial, spatial variations were noticeable. Both the multidimensional and the dynamic welfare indices maps identified Ukunda/Diani as having falling welfare and the regions around the special mining lease and the sugarcane plantation as having rising welfare.



(a)



(b)

Figure 4-5 Spatial Welfare Maps for year 2014; (a) multidimensional welfare Index; (b) dynamic welfare index

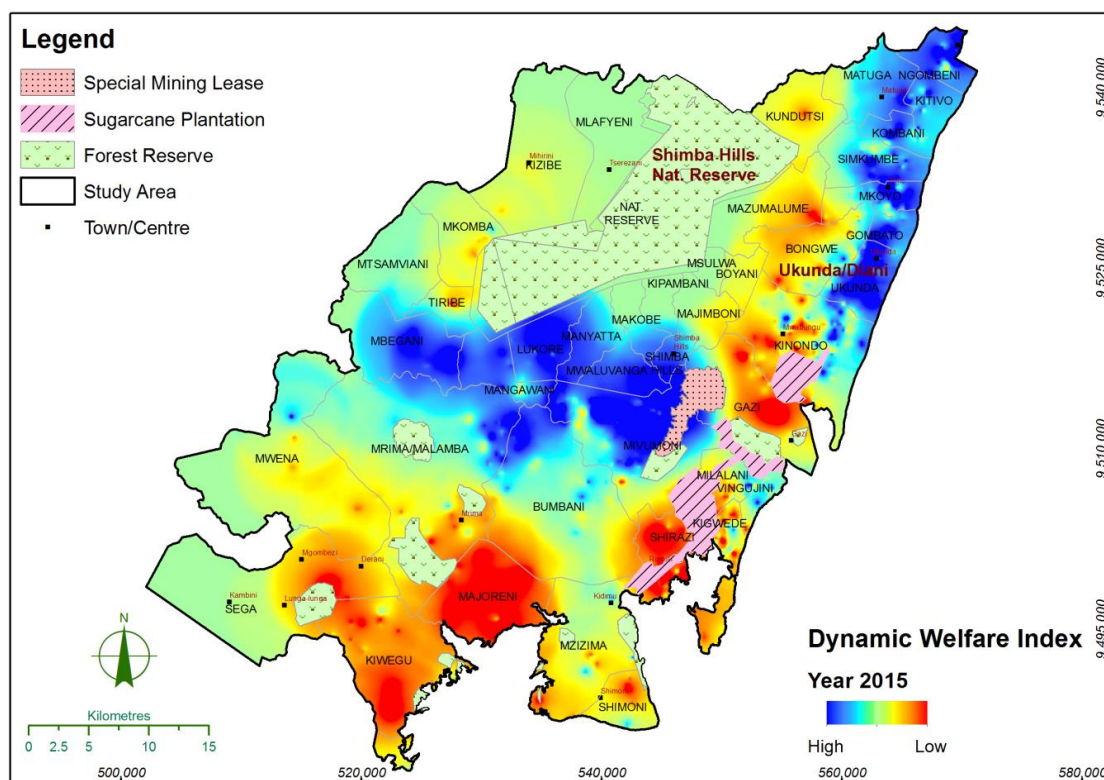
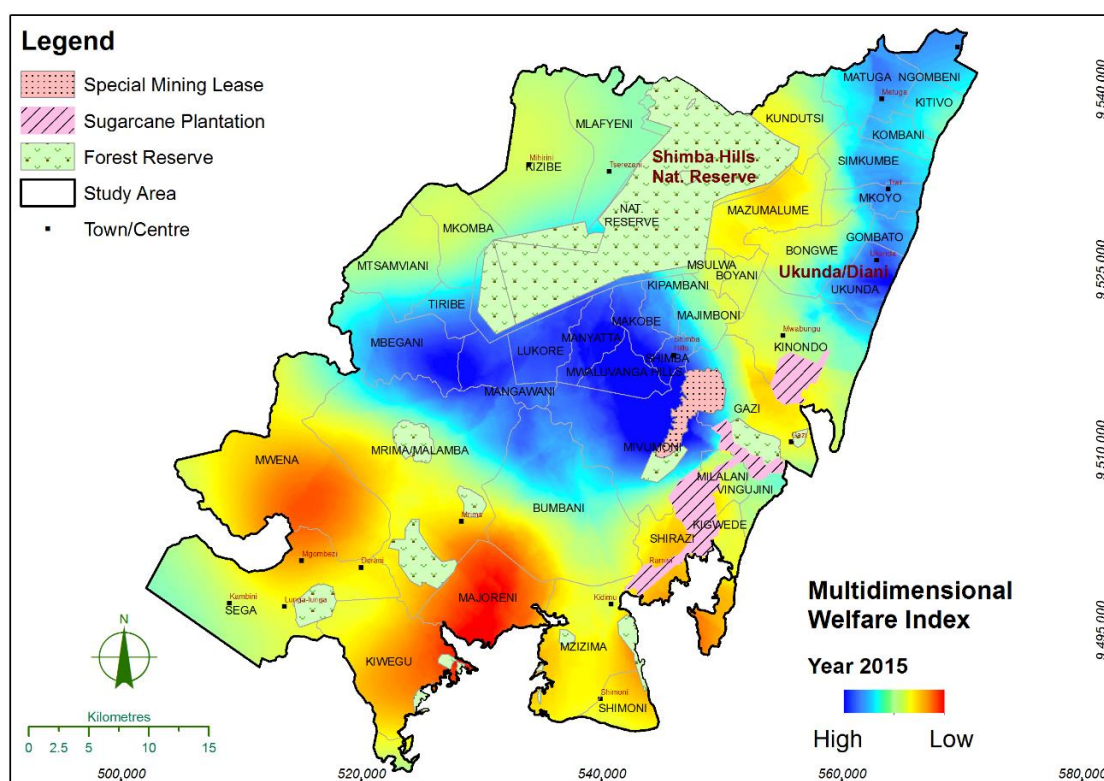


Figure 4-6 Spatial Welfare Maps for year 2015; (a) multidimensional welfare Index; (b) dynamic welfare index

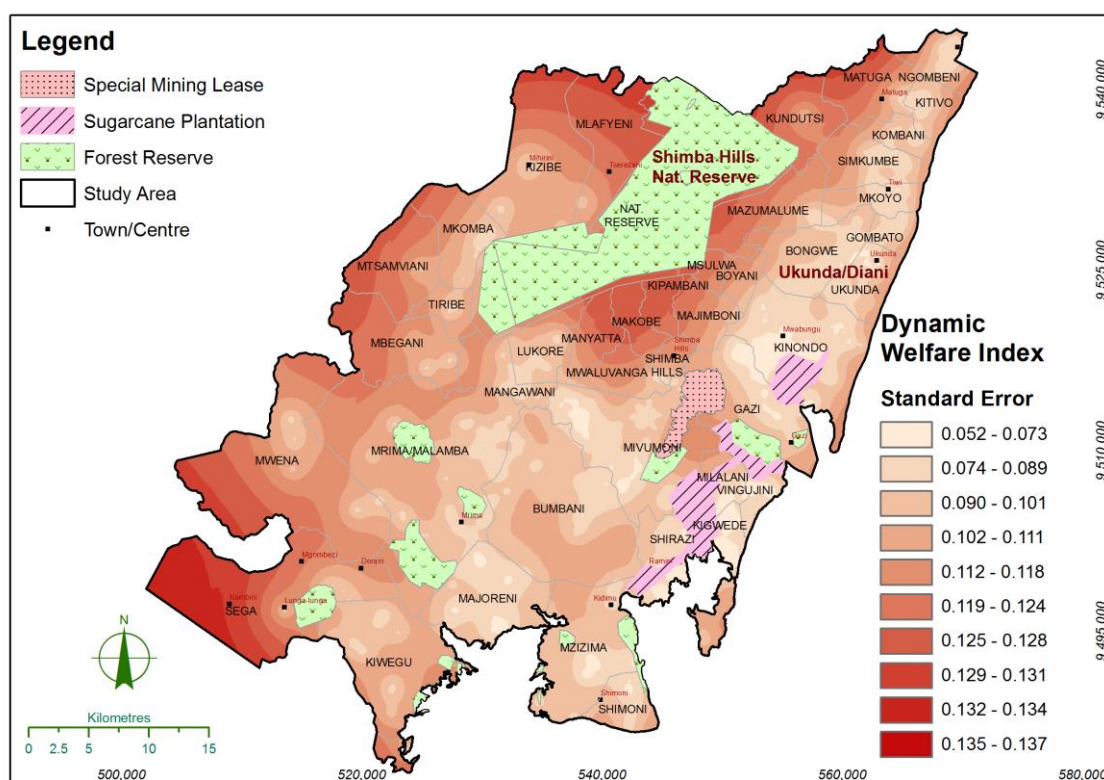
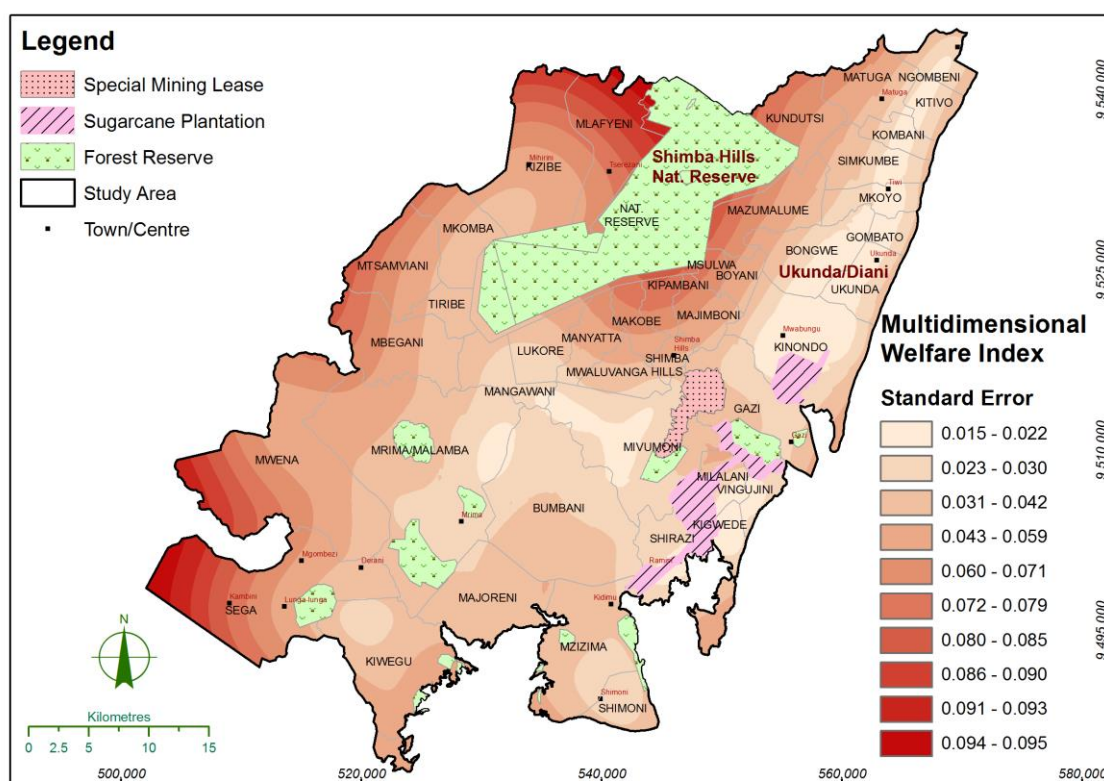


Figure 4-7 Standard Error of Prediction for (a) multidimensional welfare index; (b) dynamic welfare index

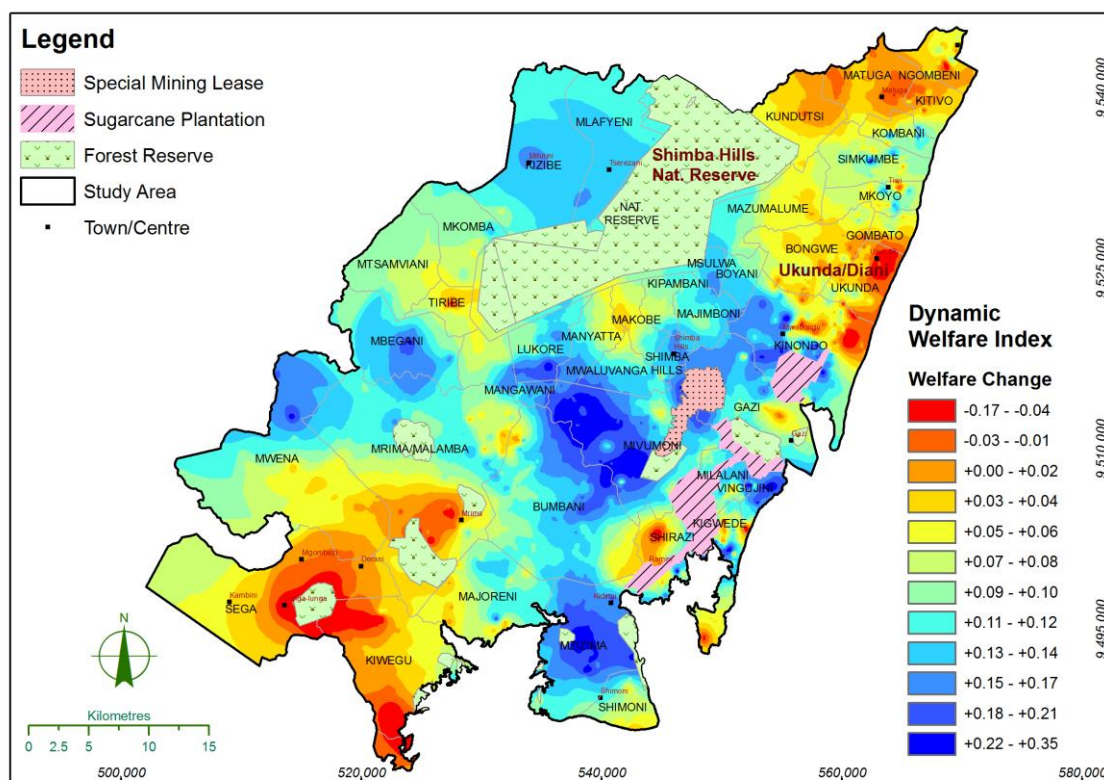
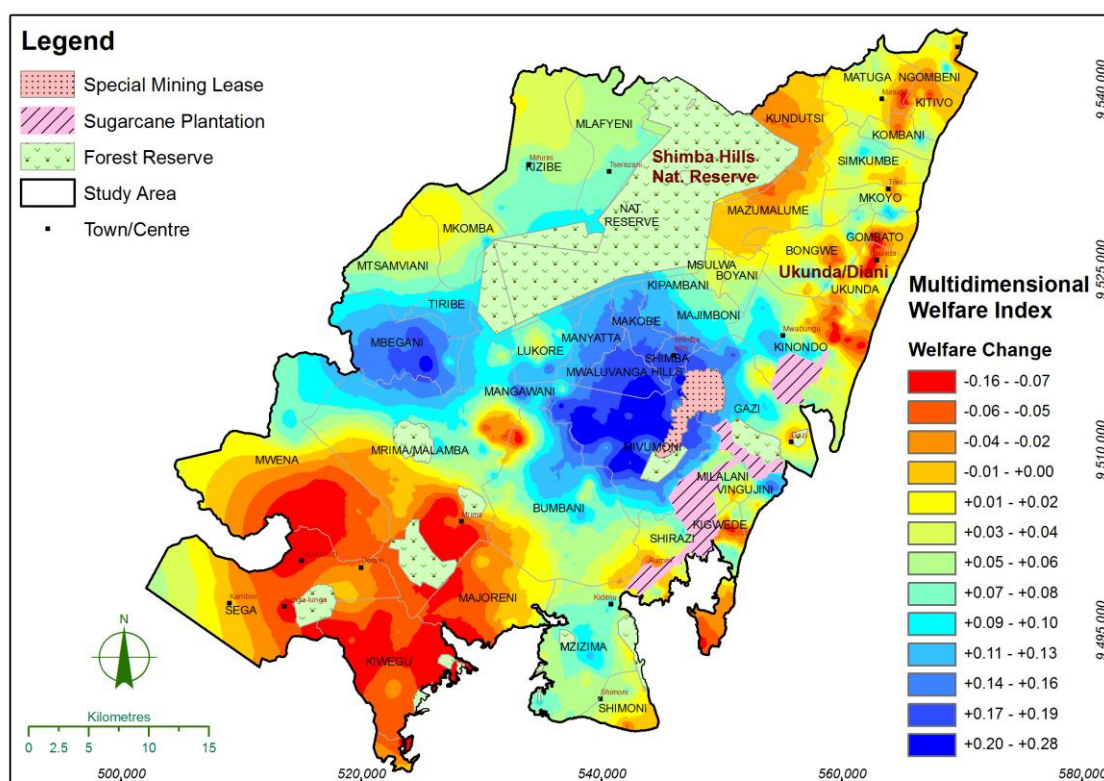


Figure 4-8 Spatial Welfare Changes between 2014 and 2015 (a) multidimensional welfare index; (b) dynamic welfare index

4.5 Discussion

The findings enable exploration of the three related questions on: (a) the coherency and level of agreement between a multidimensional welfare index and a dynamic welfare index, (b) the level of agreement between these indices and a subjective welfare assessment, and (c) the spatial distribution of welfare change in the study area. The dynamic welfare index is by design based on fewer indicators, a subset of those used to construct the more inclusive multidimensional welfare index, and specifically those which are likely to change in response to political, climatic or economic shocks. From a pragmatic perspective, a dynamic welfare index with fewer and simpler variables may be within the capacity and budget of sub-national government to monitor without waiting for census data or infrequent and unpredictable national welfare assessments. In Kenya and many African countries decentralization has increased the need for more nimble and accountable monitoring systems where dynamic welfare indices could complement more comprehensive but less regular national monitoring.

The internal coherency of both indices is called into question by the non-linearity of mean scores across the quintiles on several variables. The re-classification between quintiles in both indices is bumpier than expected with the top quintile often failing to behave as would be expected in an internally coherent index. The dynamic welfare index appears more stable meeting the expected direction of re-classification in key indicators of education, wage-earning, basic consumables, dwelling type and sanitation. Both welfare indices are constructed independently, and it is an open question as to whether the problems with internal coherency are an artefact of the index construction method or the theoretical

assumption of linear and consistent changes across quintiles for each variable. Sensitivity checks applying quartile thresholds improved the internal coherency, suggesting that sample sizes may partly explain the deviation. In all cases, the lowest quintile is more deprived than all other quintiles, generally by a wide margin.

Between the indices the distribution of indicator values across quintiles reveals higher average scores for the bottom and top quintiles in the dynamic index in contrast with higher scores for the third and fourth quintiles in the multidimensional index. While the spread of values falls in the +/-10% range, the distribution indicates greater spread in the dynamic index compared to congestion in the middle for the multidimensional index. From a policy perspective the greater spread for the dynamic index could allow a clearer understanding of the degree and extent of deprivation to guide interventions. Both indices appear to robustly identify classes of households rising or falling in welfare between 2014 and 2015 with the overall results indicating roughly three out of five households with no change (status quo) and of the remainder a stronger pulse in declining welfare, which had a greater relative impact in the inland zone (29%) compared to coastal (21%) or Ukunda/Diani (18%).

Turning to the second question of how well the indices correspond to the subjective measure reveals a promising degree of convergence. By the simple measure of how well upper or lower quintiles agree with subjective measures, overall, there is a good fit supported by a slightly higher fit for the dynamic welfare index (0.42) compared to the multidimensional welfare index (0.37). However, both dynamic and multidimensional indices suggested that most households experienced improved welfare over the period (59%) in contrast to a small

decline in welfare suggested by the subjective assessment (47%). This 12 per cent swing suggests that theory-driven improvements in standard indicators do not fully capture what is going on in people's own subjective assessments. Why subjective assessments are lower is open to debate; it may be explained by sampling errors or bias (e.g. protest votes, strategic bias, cognitive complexity) or a combination of these, but it is worthy of reflection. The coastal zone had the least convincing match between the indices and the subjective assessments, compared to match for the inland and Ukunda/Diani zones. It is plausible that local circumstances in this transitional zone at the interface of tourism in the north, mining and agricultural in the centre, and the border area in the south may partly account for the variation.

From a policy perspective use of a subjective measure may offer a simple and low-cost proxy to collecting multiple indicators, if they are consistent over time. A methodological challenge is potential attrition of the household respondent which is illustrated by our second sample which drew only 1,960 of same person, same household cases indicating a replacement rate of 41 per cent. The degree to which another household member can replace existing respondents is questionable though applicable to all longitudinal data collection where attrition (in terms of changes in the respondent) is common though often weakly reported. Testing multiple household members to independently determine convergence or difference in welfare assessments may reveal important intra-household variation in future work contributing to the 'cooperative conflict' ideas proposed by Sen, 1987.

Third, the spatial distribution of welfare illustrates pockets of improvement and decline. The decline in Ukunda/Diani where international tourism drives the local economy will partly be attributable to the threat of terrorism in the coastal regions of Kenya (Atta-asamoah, 2015). While tourism decline is well-documented, the rate and extent of welfare decline across near and distant communities are of policy importance to inform appropriate policy responses. Equally, areas of uplift emerge near to the mine and sugarcane zones but do not reach the historically poorer and more remote southern zone bordering Tanzania. It is important to disentangle wider development interventions to attribute where and why investments in institutions or infrastructure are taking place, and to verify that they are indeed supporting the most marginal whether through improved energy access and roads, more reliable services or mobile finance. Mapping of the type demonstrated here can help ensure that future interventions are focused where needs are objectively greatest rather than politically loudest.

4.6 Limitations

We identify four limitations to this study. Firstly, this is a case study with no claim to wider representation of the broader development challenges in Kenya. However, the launch of major new economic activities in the study area is an increasing phenomenon across Africa and one where there is limited systematic research to track environmental and social change and impacts over time or extended spatial zones. Secondly, the two rounds of panel data were collected in different rainfall seasons, one towards the end of the short rains and the other during the long rains; this could influence the responses to some of the indicators such as access to water. Thirdly, the panel data captured only a 16-month period which constrains

the ability to conclusively determine the causes or process of welfare change. Fourthly, environmental change and shocks related to flooding, dry spells or saline intrusion in groundwater systems are not addressed here but form part of wider work to explicitly link the interactions between economic growth, environmental sustainability and poverty reduction.

4.7 Conclusions

Measuring, monitoring and mapping welfare is a policy challenge and investment imperative in Africa. Our findings have explored the dynamic and spatial nature of welfare change through both 'short term' and 'long term' multidimensional poverty. Results support the notion that welfare is a construct shaped by theory, norms and values differing between exogenous ideas and local perspectives. The 'identification' problem remains elusive though findings here suggest that a smaller basket of indicators can reasonably capture the diversity in dynamic welfare by household condition, education, wage-earning, basic consumables and sanitation facilities. Applying the dynamic welfare index provides insights into the turbulent and rapid change on the south coast of Kenya, related to economic, political or environmental change, whether negative, positive, gradual or sudden. Decentralisation has recently sharpened the political compass in Kenya with regular elections theoretically increasing the lens of accountability between public promises and grounded delivery (Cheeseman et al., 2016). In this context the demand for understanding who is poor, why they are poor, and how to respond to poverty has a new local and powerful constituency in county governments. The results here suggest cautious optimism in the agreement between subjective welfare and dynamic welfare measures which may allow higher frequency, lower

cost monitoring systems to emerge. Kenya's leadership in using mobile technologies to translate time-consuming and costly household surveys into more nimble mobile variants could advance this foundational work, though robust results are not guaranteed (Dabalen et al., 2016; Wesolowski et al., 2012). Future work needs to explore the 'cooperative conflict' of intra-household perspectives on subjective welfare measures and to explicitly link welfare monitoring to a relevant set of environmental, economic and political shocks so that policy and practice has stronger empirical and theoretical grounds for interventions to benefit the poor.

Notes

1. We caution that the welfare indexes generated in this paper provide a reasonable and satisfactory proxy of welfare but do not serve as an economic indicator on their own right (Gwatkin et al., 2007).
2. We ran the welfare computation using 16 indicators and the results were equally robust. Data to this analysis can be provided upon request.
3. Anonymised data will be uploaded on public data bases after final reporting of the project in February 2019.

5 GROUNDWATER AND WELFARE: A CONCEPTUAL FRAMEWORK APPLIED TO COASTAL KENYA

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Notes:

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Abstract

The links between groundwater and welfare are highly contested, unclear and confounded by political, environmental and economic factors. The lack of understanding of these links has wider implication on policies and strategies aimed at accelerating the Sustainable Development Goals of safely managed drinking water services and eradicating poverty. This study provides empirical evidence of the existing links between groundwater and poverty using welfare metrics versus productive uses of water, groundwater table depth, drinking water services and groundwater dependency with data obtained from a household socio-economic survey (n=3,349), a water audit of water infrastructure (n=570) and volumetric usage from water data transmitters (n=300). Results show that the bottom welfare households are characterized by greater dependency on shallow groundwater, less acceptable drinking water services by taste, reliability, affordability or accessibility but not quantity. Productive use of groundwater for livestock accrues to the middle welfare quintiles with the bottom and top welfare quintiles by choice or exclusion having little engagement. Groundwater productive uses, services and characteristics explain at least 17% of the variation in a households' welfare with productive uses particularly benefiting female headed households. We conclude that understanding the links between welfare and groundwater will support the formulation of policies and strategies aimed at poverty reduction, inclusive growth and access to safe water for all.

Keywords: groundwater, water services, welfare, Kenya

5.1 Introduction

Groundwater by virtue of its extensive distribution, often good quality and natural buffering to dry periods is increasingly argued to play an important role in human welfare, particularly for vulnerable and marginalized populations in rural Africa and Asia (Calow et al., 2010; Moench, 2002; Mukherji, 2005). However, the relationship between groundwater and human welfare lacks conceptual clarity due to identification and measurement problems. Identification issues concern how people use different water resources (surface water, rainwater or vended water) at different times for domestic (bathing, cooking, drinking, laundry or washing) and productive (livestock, agriculture, enterprise) purposes. Measurement issues revolve around availability of acceptable data on the timing, type and volume of water usage and the associated linkages to welfare. Welfare as a broader conceptualization of the well-being, capabilities and functioning of individuals, households or communities goes beyond income or expenditure analysis, which provide one aspect of multi-dimensional poverty (Alkire & Foster, 2011; Dasgupta, 2001; Ravallion, 2011; Sen, 1976). Understanding groundwater and welfare is of increasing importance for progress towards the Sustainable Development Goals targets, including poverty, gender inequality, water, climate, hunger, health, work and growth, and sustainable cities and communities. Africa is a region of concern and priority as unsatisfactory progress from the Millennium Development Goal era leaves the continent lagging behind the rest of the world.

In Africa, groundwater resources are estimated to be two orders of magnitude greater in terms of storage compared to annual, renewable surface water resources (Lapworth et al., 2017; MacDonald et al., 2012; Taylor et al., 2012). However, high-yielding aquifers (> 20 l/s)

often do not coincide with human demand, shallow and limited aquifer systems (<80 m; < 5 l/s) are the primary resource for some 200 million rural Africans (Foster & Garduño, 2013; Macdonald et al., 2009). Despite examples of geogenic contamination from arsenic, fluoride and iron in particular environments (Edmunds et al., 2015; Smedley & Kinniburgh, 2013), groundwater quality is generally considered of good quality (Giordano, 2009), particularly in relation to organic contamination in shallow wells or surface exposed to human or animal pollution (Hunter et al., 2010; Prüss-Ustün et al., 2014). Widespread gaps in scientific understanding on the extent, nature and variability in groundwater across Africa is underlined by less than 0.001% of global, shallow aquifer records (Fan et al., 2013). Africa's systematic data deficit reflects the uncertainty in understanding groundwater and welfare interactions and impacts.

Since the 1980s access groundwater in rural Africa has increased with the installation of manually dug wells or drilled boreholes; the latter installed with handpumps or submersible pumps powered by diesel, electricity or increasingly solar panels. Donors (and increasingly governments) tend to fund the drilling of boreholes with a community of users then responsible for the management, operation and allocation of groundwater for domestic and productive uses (Carter & Bevan, 2008; Cronk et al., 2015; Harvey & Reed, 2007; Smits et al., 2010). Cross-country analysis of the functionality of community handpumps in African (Bartram et al., 2014; Fisher et al., 2015; Foster, 2013; Thomas, 2017) have revealed significant challenges in relation to satisfactory operational performance with associated implications for the availability and benefits of groundwater over time. This includes the seasonal use and access to groundwater with multi-decadal evidence from coastal Kenya

finding that handpumps are largely used in dry periods with revenue collection systems, poor groundwater taste and increased distance from household to handpump influencing people to choose alternative and unimproved water sources (Foster & Hope, 2017).

In this context, the broad assumptions that access to groundwater may improve health, reduce collection time for women and girls, promote small-scale agriculture, such as food gardens or livestock, or other micro-enterprises (Haller et al., 2007; Hunter et al., 2010; Namara et al., 2010; Prüss-Ustün et al., 2014) may not align well with the evidence on the functionality, availability or allocation of handpumps in rural African communities. This paper aims to contribute to advancing the conceptual understanding of groundwater and welfare in three dimensions. First, a conceptual framework identifies the salient components and interactions between water resources, including groundwater, and their association with domestic and productive water uses, which in turn influences different welfare outcomes and impacts. Second, we test this framework in coastal Kenya drawing upon interdisciplinary data from over 3,349 households and measured handpump usage using ‘smart handpump’ technology (Thomson et al., 2012a). Third, we map and model these relationships to estimate the share of household welfare associated with groundwater and its spatial distribution in a study area of some 2,000 km². The following section introduces the conceptual framework followed by the methodology and study site. Section four presents the results followed by a discussion of the three major findings followed by a conclusion.

5.2 Groundwater and Welfare

In this section, we outline a conceptual framework of groundwater and welfare. The framework has four dimensions in a schematic of the dynamic and multiple feedback loops between: (1) water resources, (2) drinking water systems, (3) productive water systems, and (4) welfare status. The framing is devised in the context of the systems which are found in large parts of rural Africa and Asia (Fig. 5-1).

The water resources' dimension recognizes the major flows or stocks available to people in terms of rainwater, surface water (rivers, streams, springs), soil moisture and groundwater. The partitioning of these resources over space and time will naturally vary and be influenced by hydro-climatic variability and shocks, legal and policy frameworks, the political economy of allocation, and regulation and enforcement systems. Hydro-climatic variability across Africa is illustrated by the East African Paradox where modelling projections of rainfall patterns are not consistent with observed data, particularly in the long rains season (March, April, May), which has implications for the vulnerability and exposure of millions of people and their livelihood systems in the future. Equally, the disproportionate influence of El Niño events on groundwater recharge in the short rains season (October, November, December) illustrate the spatial and temporal importance of extremes to guide policy and planning on groundwater management (Lyon & Vigaud, 2017; Rowell et al., 2015; Taylor et al., 2012, 2013). Existing legal and policy frameworks for groundwater management are constrained by the significant gaps in Africa's hydro-meteorological and groundwater monitoring systems (Comte et al., 2016; Mumma et al., 2011a). In turn, the political economy of allocating groundwater for competing users is challenged by scientific uncertainty and

water-based interest groups claiming historical rights or new claims with short-term demands potentially not consistent with long-term resource sustainability (Burke & Moench, 2000; Hope & Rouse, 2013; Llamas & Martínez-Santos, 2005). Regulatory and enforcement systems are another critical but often constrained institutional response to dealing with scientific uncertainty and significant monitoring gaps to provide the checks and balances to manage groundwater sustainably. While recognizing the importance and relevance of all these dimensions, here we will focus only on the groundwater resource in a rural Kenyan context.

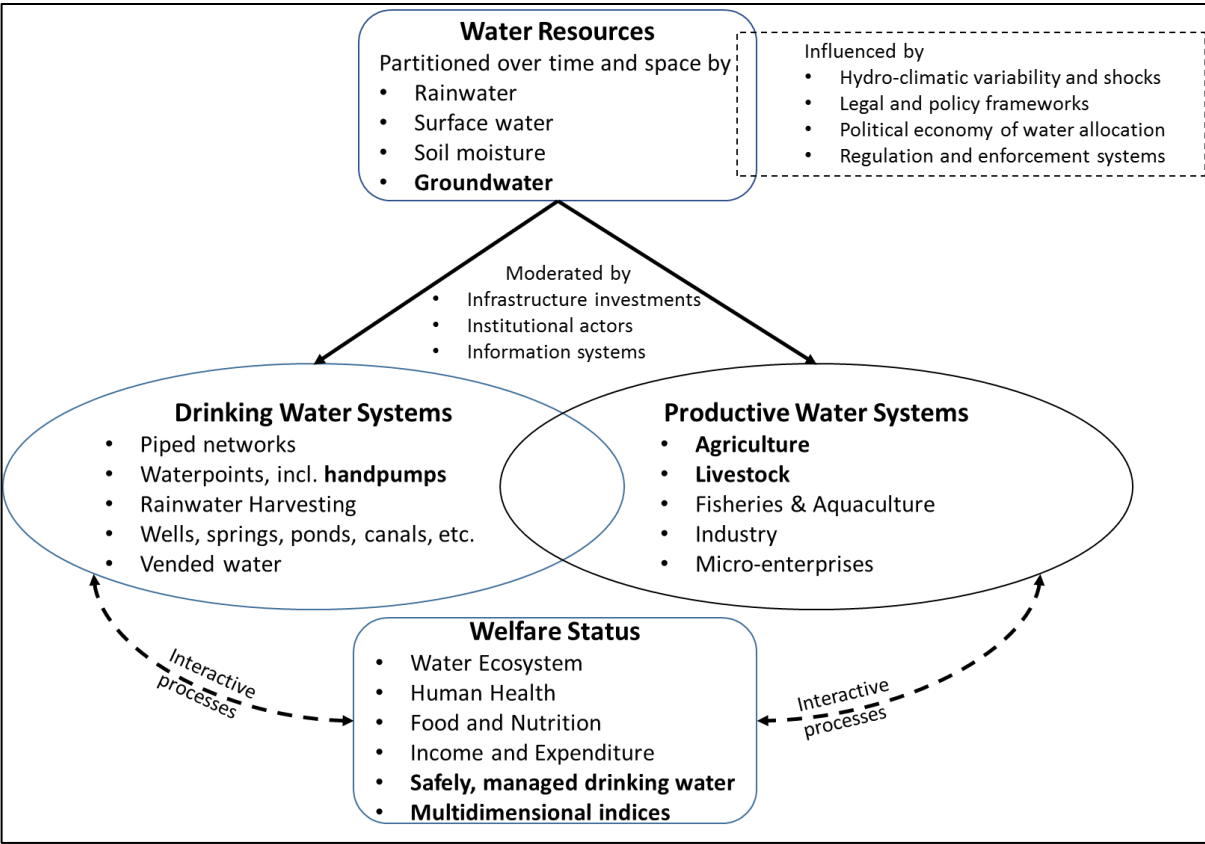


Figure 5-1 Groundwater and Welfare Conceptual Framework

Water resources provide stock or flows of water for drinking water systems and productive water systems moderated by infrastructure investments, institutional actors and

information systems. Drinking water systems include a portfolio of technologies with our focus explicitly interested in handpumps, which we discuss further below. This does not exclude the wider array of piped networks, kiosks, vended water or self-supply sources but proposes a parsimonious approach for testing the framework below. Productive water systems may share the same infrastructure for small-scale agriculture, livestock or micro-enterprises as domestic water though in bulk water demands for fisheries, industry or commercial agriculture rely on separate infrastructure investments. Infrastructure investments may be financed in multiple ways with differing risks and returns partitioning the level and mix of public or private finance. At one level, self-supply of domestic water may be a function of private investment in labour and some materials. Alternatively, large industrial water demands may require hundreds of thousands of dollars of investment capital geared to the expected returns of the productive activity over years or possibly decades. New financing instruments consider social and private investment returns with impact investing or green bonds providing favourable forms of finance which blend both capital returns as well as social returns, such as benefits to women, children or protecting environmental flows or groundwater quality (Trémolet, 2011; Trémolet et al., 2010) Explicit in this new water financial architecture is that performance-based metrics and monitoring systems are required to document and validate the societal or private returns. This reflects the progress in water information systems from remote sensing, mobile-based technology or digital monitoring surveillance (Hutchings et al., 2012; Thomson et al., 2012b). Here, we consider 'smart handpumps' (Thomson et al., 2012a) which use mobile-enabled data transmitter to send data automatically on hourly usage. The institutional actors for these

wider water systems is extensive across irrigation, utility, industrial or community typologies (Johanna Koehler et al., 2015; Molle & Mollinga, 2003; Ostrom, 2009). Here, we consider community water management as one sub-component of this wider institutional system.

Finally, welfare status incorporates both environmental concerns of ecosystem health and status along with multi-dimensional welfare concerns including income and expenditure, health, food and nutrition, as well as the performance of indicators of safely managed drinking water services. The latter provide the focus in our analysis covering the quantity, quality, reliability and accessibility of handpumps for different social groups.

5.3 Methodology

5.3.1 Study site

The study site is located in Kwale county, Kenya, south of Mombasa and adjacent to northern Tanzania (Fig. 5-2). The coastal climate has a bi-modal rainfall pattern with an average annual precipitation of 1,200 mm with inter-annual and spatial variability. The coastal lowland is the wettest with the climate getting drier to the west (inland) and north. The average annual temperatures are above 28°C (GOK, 1985). The county has a population of over 730,000 people most of whom live in rural areas (82%) with over 70% living below the poverty line of less than USD \$1.25 a day (KNBS, 2006). The study area covers 2,156 km² in Lunga Lunga, Msambweni and Matuga sub-Counties with around 300,000 residents (KNBS, 2010). This area includes the international tourism destination of Diani beach. Since 2013, the pace of environmental, economic, social and political change has increased with the establishment of two new and major economic activities in the area. Kwale International Sugarcane Company Limited (KISCOL) has been progressively rehabilitating 5,500 hectares of sub-

surface irrigated sugarcane including the commissioning of its own sugar mill in 2015. Adjacent to the plantations is the country's newest and largest mining operation (Kwale Mineral Sands Project). The mine, operated by Base Titanium Ltd., is currently projected to export 6.5m tonnes of titanium ore by 2028 from Likoni port, some 30km north of the mine site. Scattered around the mine site and sugarcane plantation are around 300 handpumps (generally 5m to 30m in depth) providing drinking water to communities, schools and health centres.

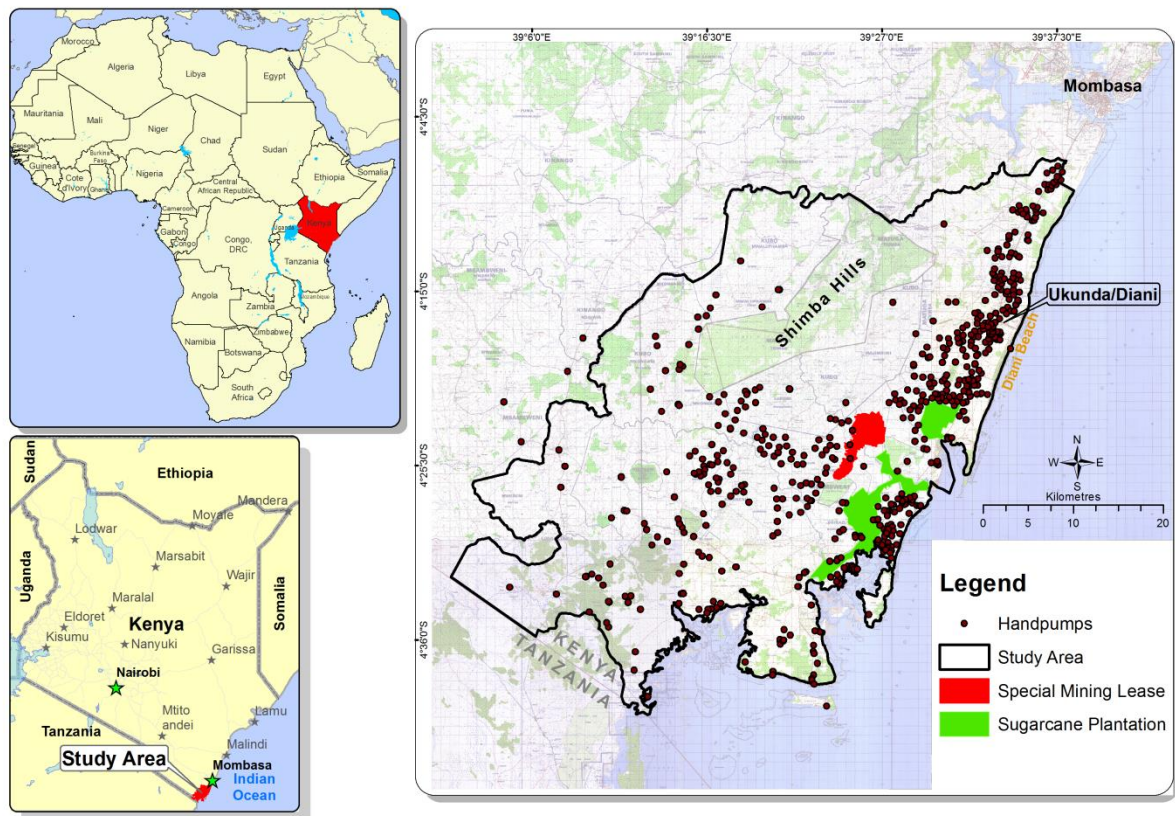


Figure 5-2 Map of study area

5.3.2 Sampling frame

In August 2013, a waterpoint survey identified 574 handpumps (all Afridevs) of which 45% were non-functioning (T. Foster & Hope, 2016). A sample of 531 handpump locations was

used as a sampling frame for a household survey in 2013/14. A separate water quality assessment was conducted on the functioning handpumps documenting physical water quality parameters such as pH, electrical conductivity and temperature. GSM-enabled transmitters were installed on the 300 operational handpumps to transmit and record daily pumping to estimate water usage and functionality (Thomson et al., 2012a). At each of the 531 handpumps, a stratified random sample of households which currently or previously used the handpump was produced, yielding 3,500 survey participants that reduced to 3,349 after data cleaning. A pilot survey was conducted with 19 enumerators recruited from communities across the study area who administered the survey in local languages (Swahili, 53.8%; Digo, 42.6%; Duruma, 2.1%; other, 1.5%). The main survey entailed a range of themes including demographic, socio-economic status of household (here including livelihood, concerns and subjective welfare), household health status, water sources, waterpoint management, water payments, water resources management, governance and political engagement. All the households surveyed were geo-referenced for mapping purposes.

Ethical permission to conduct this survey was provided by the University of Oxford's Central University Research Ethics Committee and research permission granted by the Government of Kenya's National Council of Science and Technology, Kenya (NCST/RCD/17/013/132, September 2013). All interviews were voluntary with informed consent procedures observed in the local language. Data have been anonymised and stored in encrypted files.

5.3.3 Data analysis

The household survey identified six major water sources used by households, these included; handpumps (n=2,126), protected wells (n=94), boreholes with submersible pumps (n=170),

piped sources (n=331), unprotected wells (n=339) and surface water sources (n=231). This analysis largely focused on the handpumps (groundwater sources) as they were the dominant water supply and we had estimates of volumetric abstraction from the GSM-enabled transmitters. A multidimensional welfare index was constructed using 29 indicators drawn from household composition, dwelling characteristics, asset ownership, sanitation and health, and drinking water variables. The weights used to compute the welfare index were generated from principal component analysis (Falkingham & Namazie, 2002; Filmer & Pritchett, 2001; Gwatkin et al., 2007; Vyas & Kumaranayake, 2006). The welfare index ranged between 0 and 1 where households scoring higher values were relatively well off compared to those scoring values close to zero. We divided the welfare index into five levels with equal range, i.e., welfare index ranging from 0 to 0.2 (Q1), 0.2 to 0.4 (Q2), 0.4 to 0.6 (Q3), 0.6 to 0.8 (Q4) and 0.8 to 1.0 (Q5). Each level comprised of a wealth group which we refer to as 'welfare quintile 1' to 'welfare quintile 5'. Households were then categorized into the five wealth groups depending on their welfare index scores to identify household distribution across 'welfare space'. This classification was used to reflect the dimensions of welfare space and associated share of households falling into each welfare quintile.

We further categorized the households into three groups by a simplified typology of three economic geographies in the area: (1) the southern, coastal belt with people living within a 5km strip of the sea (52% of the sample), whose main economic activity is fishing; (2) inland and more remote areas below the Shimba Hills and away from the coastal margin (38% of the sample), where the main economic activity is farming; and (3) the small town of Ukunda/Diani which largely serves the tourism industry along Diani beach (10% of the

sample). A spatial welfare map was developed using Kolmogorov Wiener prediction method (also known as kriging) to provide spatial welfare predictions (Webster & Oliver, 2007). This map was later used to evaluate spatial welfare patterns around waterpoints and estimate the generalised welfare indexes of households associated with each handpump through resampling the spatial welfare patterns to 1km grid cells using the bilinear interpolation technique in geo-statistics. The result from this process was the associated mean welfare index for every handpump based on a 1km spatial resolution. The spatial resolution of 1 km was chosen taking into consideration the computed distance at which spatial autocorrelation becomes more pronounced, this was determined to be 7.6 km from the Moran's I statistic (Getis, 2007; Legendre & Legendre, 1998; Overmars et al., 2003). Given that the spatial resolution ought to be smaller than 7.6km while at the same time large enough to ensure that majority of the cells had at least one household represented, a 1km spatial resolution was selected.

Monthly data on volumetric usage of groundwater from each handpump was obtained from the waterpoint data transmitters which were installed on 300 handpumps while electrical conductivity data was collected using handheld EC/pH/temperature testers. The electrical conductivity variable was re-defined as binary with cut off threshold value set at 1,500 $\mu\text{S}/\text{cm}$. This threshold value was based on the Drinking Water Standards that recommend a threshold value of 1,500 $\mu\text{S}/\text{cm}$ (WHO, 2011). Data on static groundwater depth level (referred to as water rest level not influenced by abstraction or recharge) was obtained from the drilling records kept at the county government's offices. The records were part of a major Swedish Development Agency (Sida) and the World Bank drilling programme in the mid and

late 1980s which was one of the first installations of Afridev handpumps in Africa. Records included data on location (name), borehole depth, casing diameter, static (rest) water level, temperature, EC and yield (litres per hour). We then had to match these handpumps records to our own records using a number of parameters like name of borehole, location on map, administrative unit, and borehole completion record numbers. We matched about 333 handpumps which had static groundwater depth level data to our database. Data on groundwater productive uses such as livestock watering and crop irrigation as well as information on whether the households had access to sufficient, affordable, reliable, safe, good quality water (in terms of perceived taste) and distance to the groundwater source was obtained from the 2014 household socio-economic survey data.

5.4 Results

5.4.1 Descriptive statistics

Table 5-1 below shows the fraction of households associated with different variables and disaggregated by sex of respondent and household head. Examining household drinking water profiles reveals handpumps are used for drinking water by two in three households with one in five households also using handpumps for livestock watering. Household perceptions of the satisfaction with drinking water services declines from physical proximity (58%) to water quality (taste at 40%, safety at 39%), and from reliability (31%) to affordability (12%). Groundwater from handpumps was six times more likely to provide households with drinking water compared to piped water networks though one in four households stated that groundwater was the only water supply. About one in ten households depended on piped water sources which reflected the limited infrastructure found in Ukunda/Diani and

Tiwi (North of Ukunda) areas (Fig. 5-2). We found no difference in comparing scores of the female-headed households with the wider sample (t-test, all values > 0.10, not reported) despite the descriptive data indicating higher surface water use, greater dependency on groundwater and a lower affordability score.

Table 5-1 Profile of groundwater use and drinking water services by disaggregated household data (n=3,349)

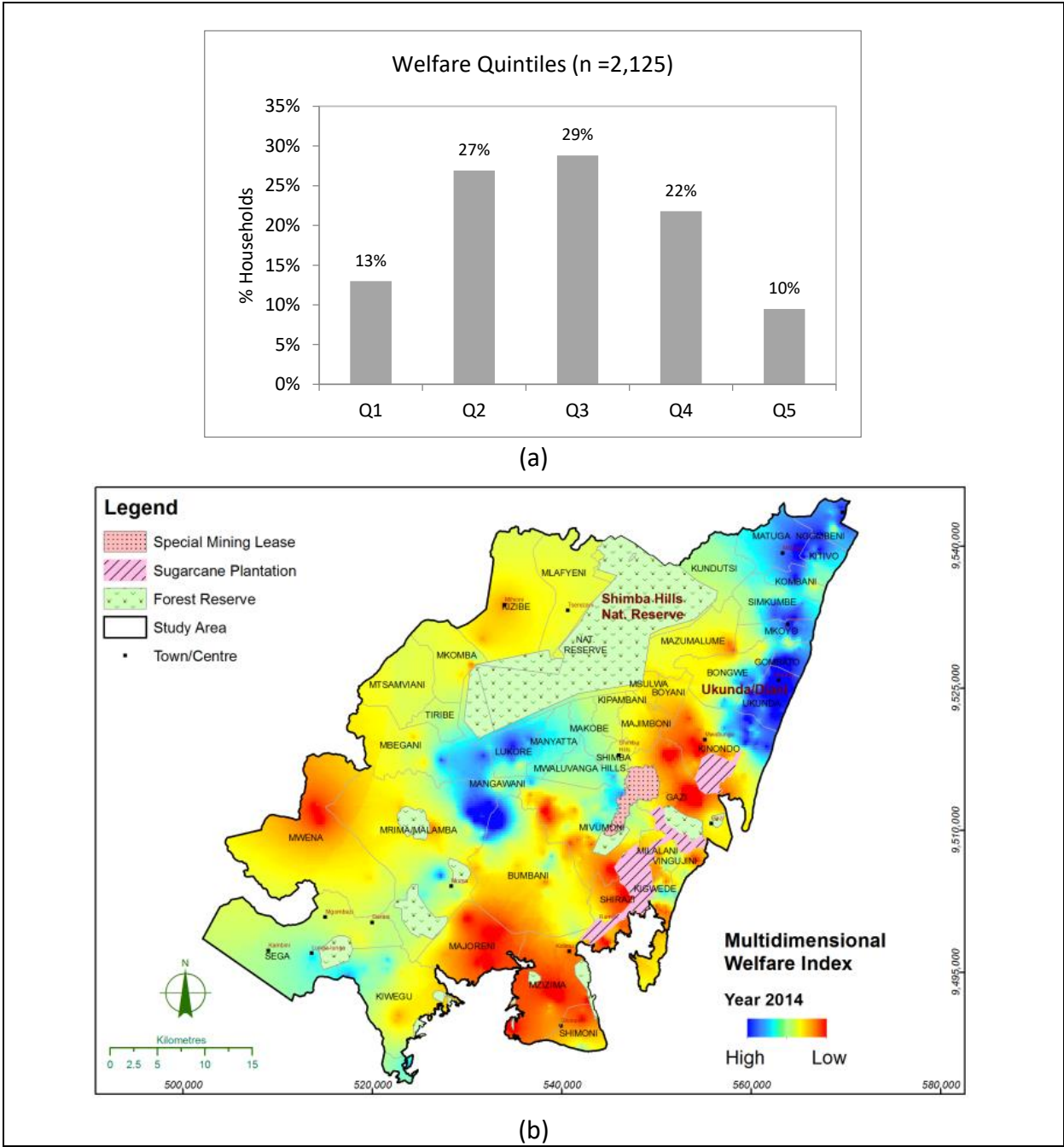
		All Households Mean (n=3,291)	By sex of respondent Male Mean (n=2,190)	Female Mean (n=1,101)	By female-headed household Mean (n=516)
Explanatory Variables					
Main drinking water source	Handpump	0.65	0.63	0.65	0.67
	Piped	0.10	0.10	0.10	0.08
	Protected well	0.03	0.03	0.03	0.03
	Submersible pump	0.05	0.05	0.05	0.03
	Surface water	0.07	0.09	0.06	0.09
	Unprotected well	0.10	0.11	0.10	0.10
	Use handpump for Irrigation	0.05	0.06	0.05	0.07
	Use handpump for Livestock	0.17	0.14	0.18	0.18
	Own Livestock	0.21	0.22	0.20	0.22
	Electrical Conductivity (< 1,500 µS/cm)	0.83	0.84	0.83	0.79
% of households stating drinking water is...	Affordable	0.12	0.10	0.13	0.10
	Reliable	0.31	0.31	0.31	0.30
	Safe to drink	0.39	0.36	0.40	0.36
	Taste (good)	0.40	0.35	0.42	0.38
	Close (distance to water source)	0.58	0.52	0.61	0.60
	Groundwater is the only source	0.26	0.28	0.24	0.28

This table only shows the binary variables. Rounding means all totals may not sum to 100%. Female-headed households are defined by 'no male adult living in the household'.

5.4.2 Welfare distribution

The distribution of households, that depended on groundwater sources through handpumps, by the redefined welfare quintiles in the data analysis section approximated a normal distribution with a third of households in the fourth and fifth welfare quintiles while two in every five households were observed in the first and second welfare quintiles (Fig. 5-3a). The spatial welfare map identified the majority of higher welfare households located in the Ukunda/Diani area while another cluster was observed to reside inland and south of the

Shimba Hills National Reserve in Lukore and Mangawani locations (Fig. 5-3b). Along the coastline but south of the Ukunda/Diani area were found households with lower welfare indexes.



5.4.3 Groundwater and productive uses

Here, and following, we assess the intensity of welfare in each welfare quintile by counting the sub-sample of households that reported using, for example, groundwater for livestock watering in each welfare quintile as the numerator divided by the total number of households using groundwater sources which are handpumps ($n=2,125$) in each welfare quintile. The results show that the use of groundwater for livestock watering varied distinctively across the welfare quintiles. The top two welfare quintiles had almost a third of the households using groundwater for livestock watering (Fig. 5-4a). In contrast, the bottom two welfare quintiles were half as likely as the top two quintiles to water their livestock using groundwater albeit about a third of the households in these welfare quintiles owned livestock. While fewer households in Kwale county chose to irrigate from groundwater (5%), we observed variability in irrigation practices across the welfare quintiles with the top welfare quintiles being almost twice as likely to irrigate compared to the bottom two welfare quintiles (Fig. 5-4b). As such, groundwater for livestock watering appeared a potential strategy to benefit lower welfare groups though it will benefit few, about one in ten households in the bottom quintile.

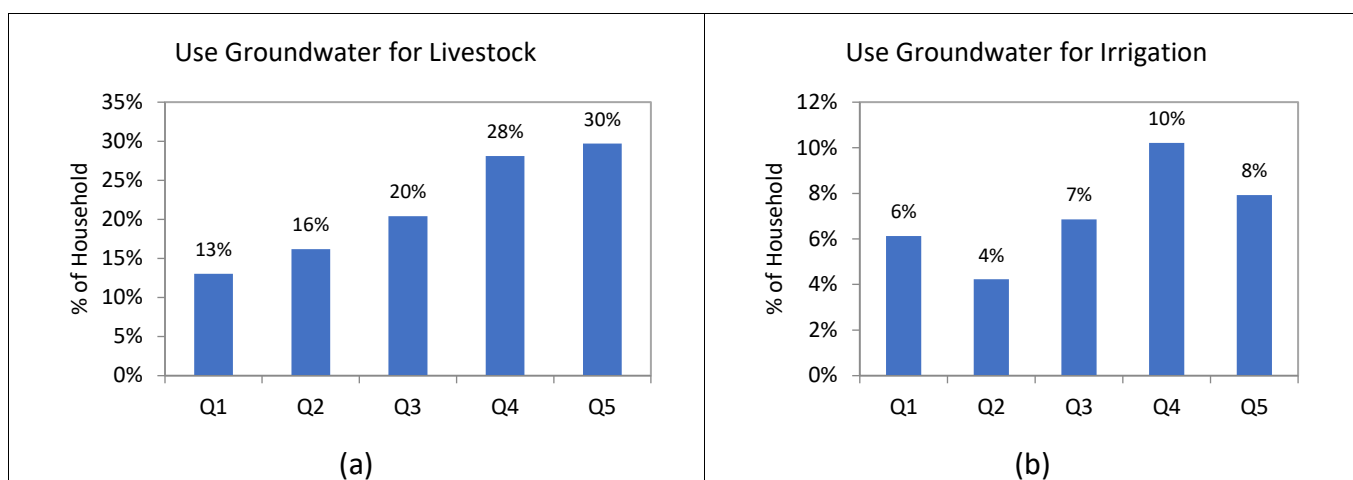


Figure 5-4 Share of households in welfare quintiles using groundwater for (a) livestock watering and (b) irrigation

5.4.4 Groundwater depth and welfare

Results indicate increasing welfare is associated with increasing depth to groundwater (Fig. 5-5). The data do not provide a means to determine causality and it is plausible that higher welfare households have been able to invest in deeper and more secure groundwater sources. Other confound factors maybe geography related in that households living further inland practice farming and tend to be wealthier but the groundwater sources are deeper, deeper boreholes have a higher failure rate which may impose a higher financial burden on the less wealthier households depending on the deeper boreholes and vice versa. The median depth provided a linear profile of greater welfare with deeper boreholes. A bivariate and ahistorical correlation test suggests there is a significant relationship ($r=0.542$, $n=332$, $p<0.001$). Despite the uncertainty over the historical or political processes, the data showed higher welfare households gained access to deeper boreholes though how this process occurred is not known. What is more certain is that lowest welfare group rely on shallower groundwater (6m to 14m deep) which may be more vulnerable to natural or human-related contamination.

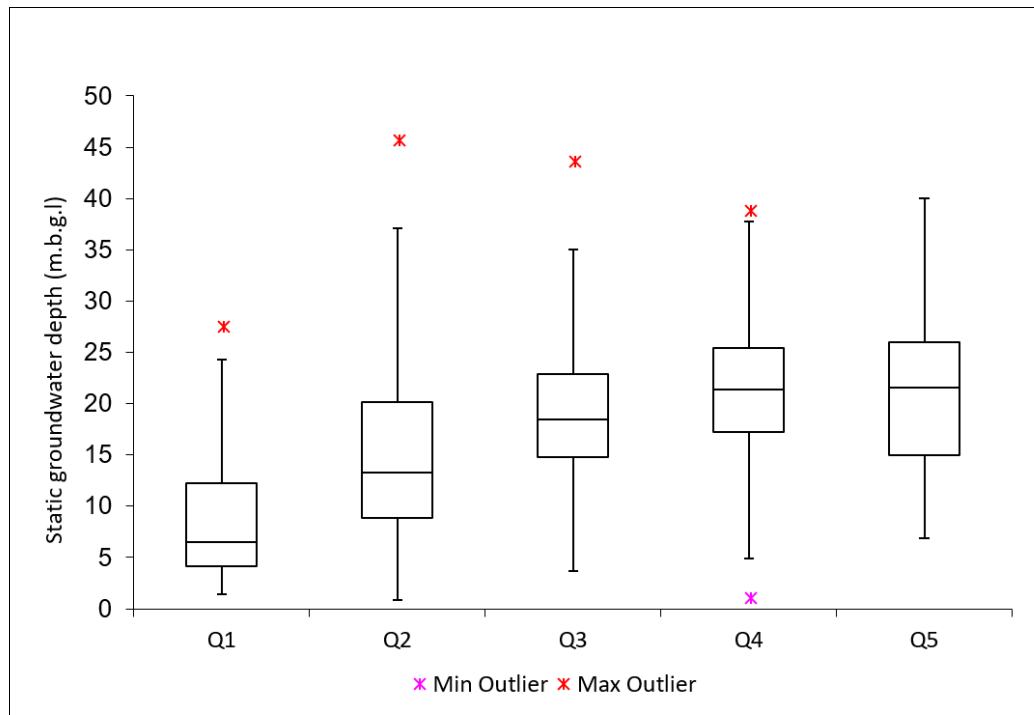


Figure 5-5 Box plot of groundwater table depth vs welfare quintiles ($r=0.542$, $n=332$, $p<0.001$)

5.4.5 Groundwater and drinking water services

Access to affordable, safe and reliable drinking water roughly doubled if a household was in the top rather than lowest welfare quintile; this relationship did not apply to proximity (Fig. 5-6). We observed a gradual increase of the fraction of households who found groundwater sources affordable in each welfare quintile. Households in the top welfare quintiles were twice as likely to have access to affordable groundwater sources. A similar pattern held for reliability, safety but not proximity where the difference between low and high welfare access was relatively minimal, and overall higher in terms of access across the five categories evaluated.

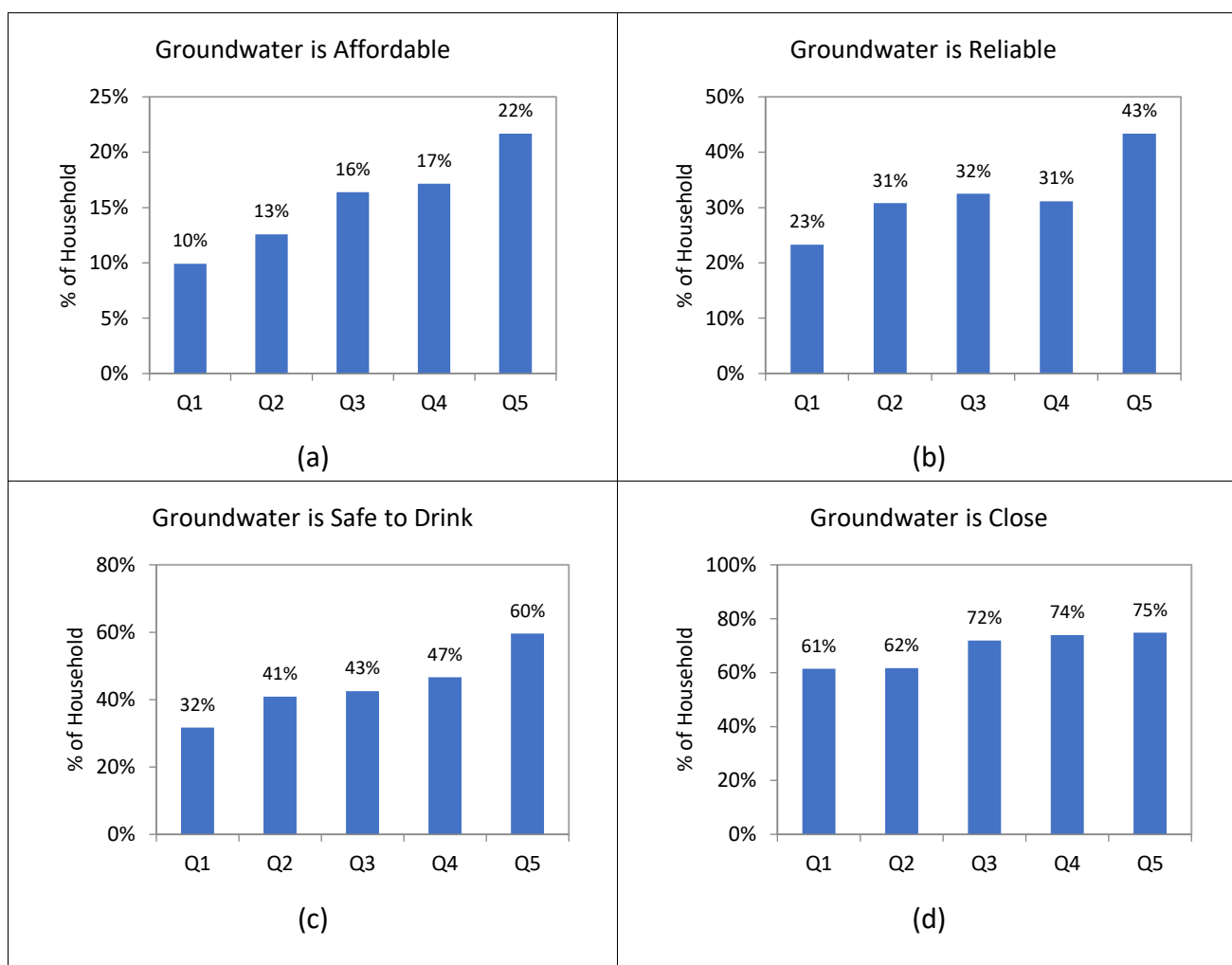


Figure 5-6 Drinking Water Services vs Welfare Quintiles

Electrical conductivity (EC) was lower than the recommended threshold for the majority of households across all the welfare quintiles (Fig. 5-7a). However, the perception of taste suggested about three in every five households had access to drinking water sources with unsatisfactory taste (Fig. 5-7b). About one in every five households in the first to fourth welfare quintile depended on groundwater sources as the only source for drinking water while the top welfare group had about nine in ten households depending on other sources of water (Fig. 5-7c). Given that the denominator was the number of households using groundwater sources extracted via a handpump, the intensity of handpump usage was

expected to mimic the welfare profile across all the quintiles. Handpump usage was therefore observed to be higher among households in the third welfare quintile, 29%, while one in ten households used handpumps as the main drinking water sources in the bottom and top welfare quintile (Fig.5-7d).

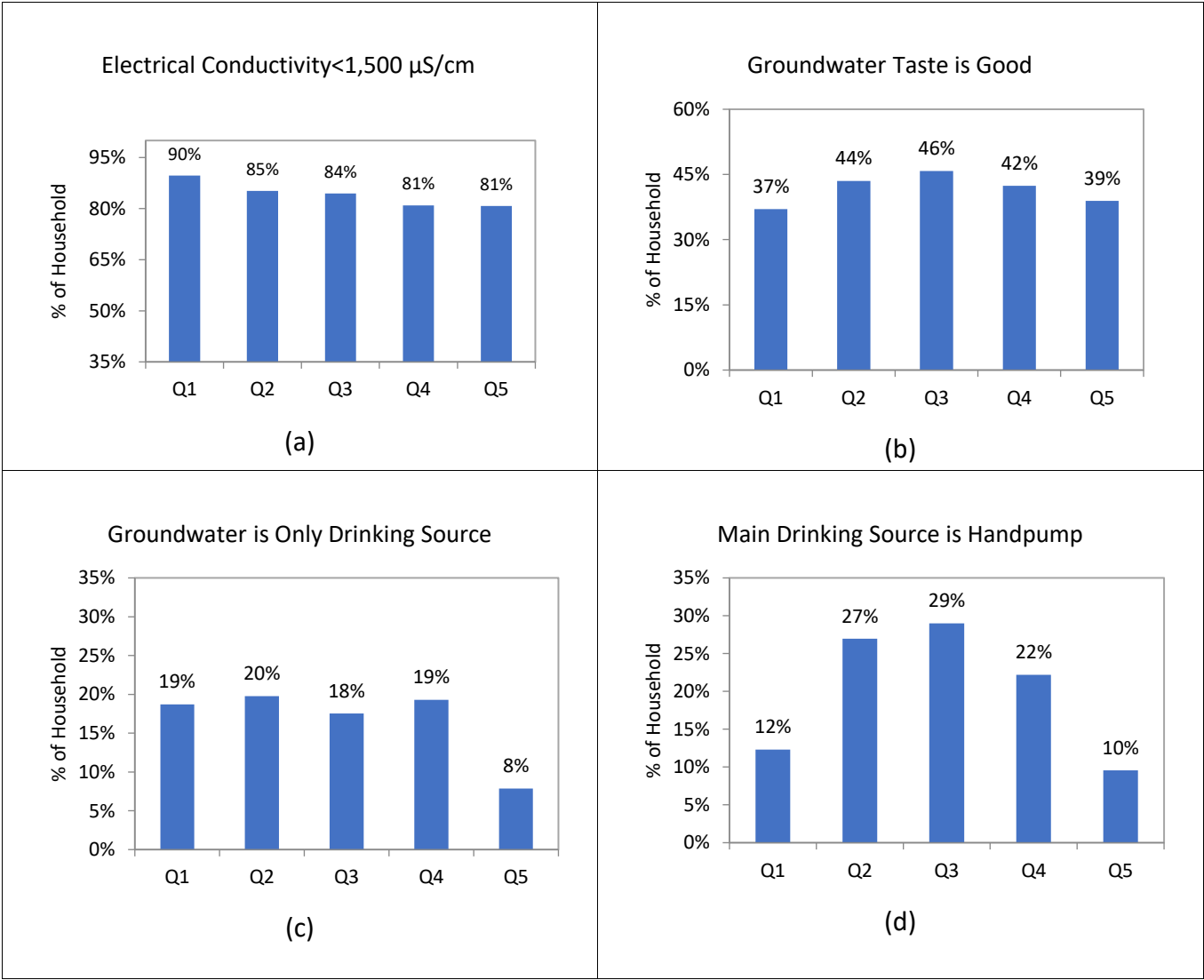


Figure 5-7 Groundwater quality and dependency by welfare quintiles

5.4.6 Groundwater usage and welfare

Groundwater usage was assessed using estimated volumetric data from the water data transmitters. We plotted usage against welfare quintiles which were estimated from the re-

sampled spatial welfare maps at 1km spatial resolution. Figure 5-8 shows a box plot of monthly total volume of groundwater abstracted from the handpumps and welfare quintiles for 2014. There was variation on monthly volume abstracted across all the welfare quintiles with a median value of around 50,000 litres per month with the upper quartile range for the second and third welfare quintiles around three times the median.

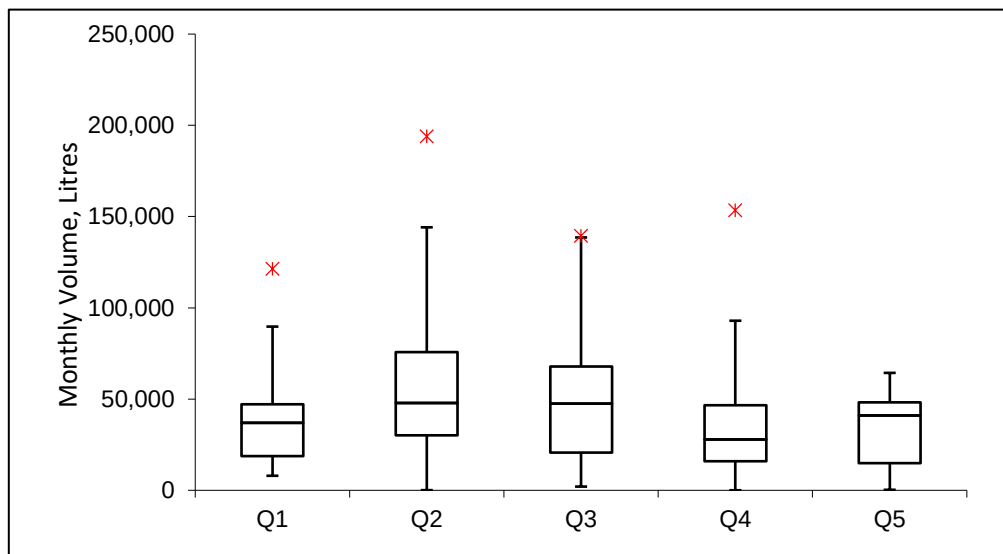


Figure 5-8 Groundwater dependency and Welfare

Mapping abstraction rates from the handpumps revealed no clear pattern (Fig. 5-9). Further analysis may later consider seasonal patterns to understand peak demand and also the issue of attribution between drinking water and livestock water demands over space and time.

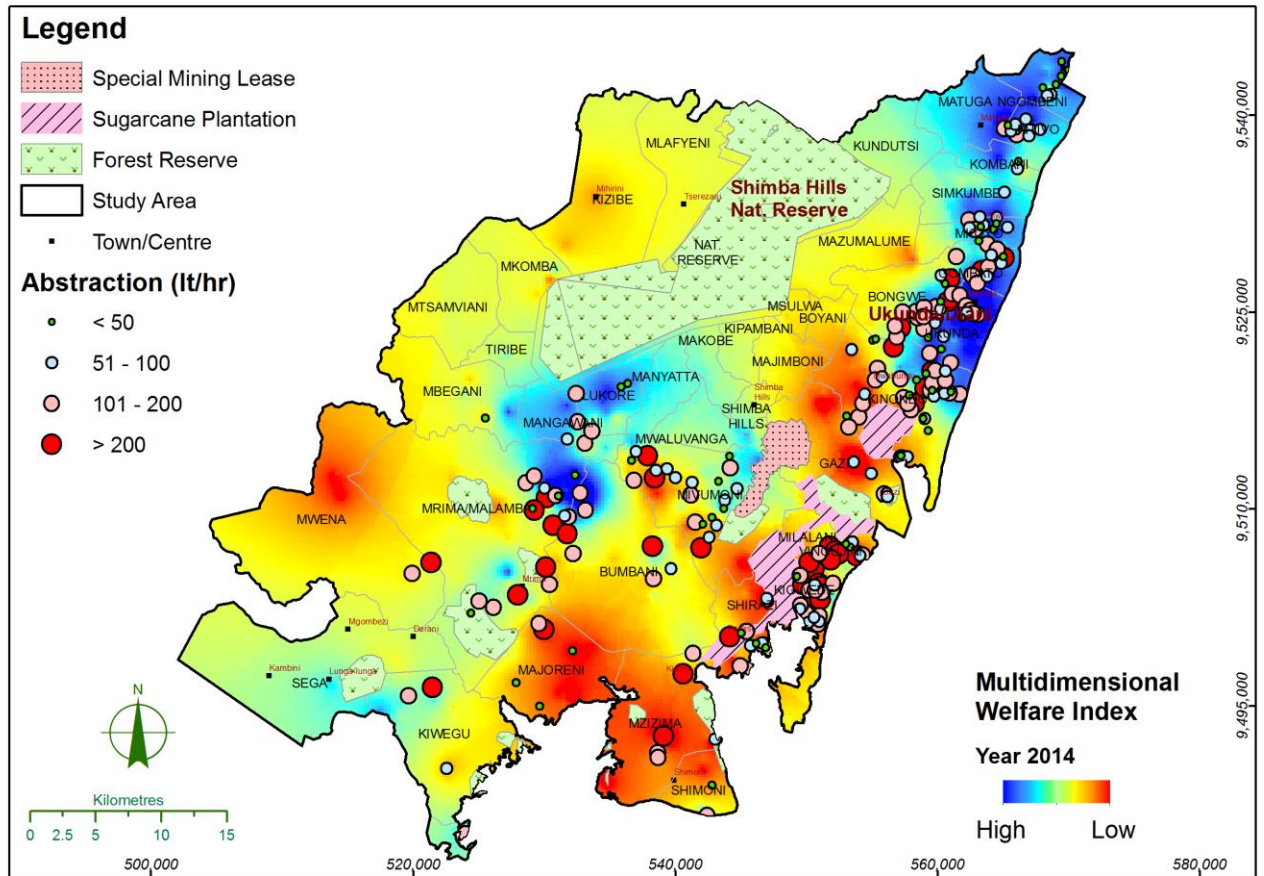


Figure 5-9 Groundwater abstraction by handpumps and welfare in 2014

5.4.7 Estimating the share of groundwater towards household welfare

In theory, the share of a household's welfare to groundwater may be modelled by regressing a range of groundwater-related variables independent to the welfare index comprising here of common consumables such as tea, flour, cooking oil, soap and dwelling condition by floor, wall and roof. Available data focus on the unique availability of handpump usage, groundwater quality and groundwater usage. We acknowledge the absence of broader and widely recognized indicators of welfare, including education, health, employment and qualitative measures of equality and capabilities. The analytical challenge of reconciling appropriate temporal and scalar dimensions by broader welfare indicators across individual, household and community limit the utility of a more ambitious but less tractable estimation

procedure of welfare. Here, we tackle a more constrained and simple relationship with data sources of suitable temporal and spatial coherence. The estimation is multidimensional by design and a multivariable regression (an extension of simple linear regression) procedure is chosen. The model reported in Table 5-2 provides a general estimation for all households (Model I), male respondents (Model II), female respondents (Model III) and female-headed households (Model IV) with a statistically significant fit ($F=32.625$, $p<0.001$).

The results indicate about 17 per cent of the variation in a households' welfare was explained by the groundwater covariates. Running the model for disaggregated samples yielded similar results for female headed households (19%), male respondents (20%) and female respondents (17%). All the models were significant ($p < 0.01$). From Model I (all households), all explanatory variables except 'affordability' and 'only source' were significant. Positive and significant include productive groundwater uses along with water quality (EC) and volumetric usage. Shallower groundwater and living in coastal or inland zones were negative (associated with low welfare) and significant compared to those living in Ukunda/Diani area.

For Models II and III, we observed similarities for drinking water variables but a divergence for productive uses and the water rest level. Female respondents differed to male respondents in positive and significant coefficients for productive uses compared to male respondents who record positive but non-significant estimates.

Table 5-2 Multivariable regression of household welfare on groundwater usage and dependency

		Model I		Model II		Model III		Model IV	
		All Households		Male Respondents		Female Respondents		Female Headed	
		(n=2,007)		(n=653)		(n=1,353)		(n=322)	
	Explanatory Variables	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value	Coeff.	t-value
	(Constant)	0.453	14.126	0.422	8.163	0.465	11.325	0.333	3.769
Safely managed drinking water	Affordable	0.017	1.265	0.032	1.342	0.011	0.667	0.019	0.534
	Safe (to drink)	0.039***	4.129	0.046***	2.797	0.039***	3.340	0.042*	1.719
	Reliable	0.033***	3.329	0.048***	2.828	0.029**	2.358	0.038	1.461
	Close (distance to water source)	0.053***	5.031	0.079***	4.342	0.043***	3.268	0.026	0.951
	Groundwater only source	-0.003	-0.261	0.015	0.708	-0.013	-0.870	-0.006	-0.193
Productive Uses	Irrigation	0.056***	2.940	0.048	1.587	0.057**	2.293	0.089**	2.044
	Livestock	0.047***	3.982	0.029	1.306	0.056***	3.984	0.079***	2.584
Usage	household reported Volume collected per day	0.001***	9.582	0.001***	6.808	0.001***	6.741	0.001***	4.494
Household Location (Reference location is Ukunda)	Coastal	-0.072***	-4.131	-0.081***	-2.587	-0.067***	-3.206	-0.018	-0.335
	Inland	-0.054***	-2.995	-0.053*	-1.676	-0.053**	-2.462	0.021	0.385
Water rest level of boreholes (Reference depth is >21.9 m)	depth between 0 - 3.8m	-0.146***	-4.637	-0.099*	-1.771	-0.164***	-4.251	-0.160*	-1.686
	depth between 3.8 - 7.6m	-0.173***	-7.186	-0.171***	-4.394	-0.176***	-5.713	-0.172***	-2.964
	depth between 7.6 - 15m	-0.097***	-4.714	-0.045	-1.422	-0.122***	-4.536	-0.082	-1.633
	depth between 15 - 17.3m	-0.104***	-4.812	-0.127***	-3.757	-0.095***	-3.370	-0.111**	-2.053
	depth between 17.3 - 21.9m	-0.017	-0.729	0.000	-0.004	-0.026	-0.880	-0.012	-0.227
Quality	Electrical Conductivity	0.000***	3.353	0.000*	1.746	0.000***	3.189	0.000	1.372
<i>R</i> ²		0.17		0.20		0.17		0.19	

*Significant at 10%, **Significant at 5%, ***Significant at 1%. Coeff. =Unstandardized Coefficients. Sample sizes changed due to missing data on either one of the explanatory variables.

In Model IV, the female-headed households' positive and significant coefficients to welfare are perceived water safety (not EC) and volumetric usage with productive uses of groundwater large and significant predictors of welfare. Shallower groundwater differed from female respondents but accorded with the full sample and male respondents as being negative and significant.

5.5 Discussion

Four findings emerge from the results to contribute to the wider scholarship around groundwater and welfare in rural Africa and the global drive to achieve 'safely-managed drinking water' under the Sustainable Development Goals' target 6.1 (WHO & UNICEF, 2017a). First, groundwater depth is related with welfare in two overlapping domains: (a) increasing welfare is strongly associated with deeper groundwater usage, and (b) shallower groundwater dependency has a negative and significant relationship with household welfare. Second, productive uses of groundwater is a positive, significant and comparable determinant of household welfare alongside drinking water services. Third, across four drinking water services' indicators only proximity to a handpump is welfare-neutral with evidence that lower welfare groups have less affordable, safe or reliable drinking water services. Fourth, gendered-differences emerge in women's different use of groundwater to men with equity implications as revealed by the sub-sample of female-headed households.

An intuitive relationship emerges between increasing welfare and access to deeper groundwater supplies. While there is no evidence of the causality or socio-political or economic processes that result in this finding, it is consistent with strands of literature on 'elite capture' in relation to rural water infrastructure (Bardhan & Mookherjee, 2006; Geen

et al., 2016) and the development economics' hypothesis of 'poverty traps' (Banerjee & Duflo, 2011; Barrett & Carter, 2013; Barrett & Swallow, 2006; Carter & Barrett, 2006). Deeper groundwater sources may be desirable on at least two levels: (1) lower risk of contamination from humans or animal waste (Ravenscroft et al., 2017), (2) lower risk of drought events affecting waterpoint reliability (MacDonald & Calow, 2009; Taylor et al., 2012). While there are technical complications and operational subtleties due to the nature of the waterpoint (drilled borehole, dug well) and the quality of the drilling to offset drying of wells in droughts with increased social demands, the 'rational' response of most groundwater users, given a choice and adequate information, would be a deeper groundwater source.

The likelihood that higher welfare groups all stumble upon deeper groundwater as lower groundwater users opt for shallower groundwater seems implausible. However, the political processes and institutional practices which allow such 'elite capture' may reflect emerging evidence of new forms of community management of waterpoints through privatizing common pool resources by creating access restrictions (exclusion boundaries) where demand is high (Foster & Hope, 2016; Koehler et al., 2015). The assumption that rural communities will manage waterpoints in a benign, apolitical and equitable fashion has been widely dismissed in the common pool resources' literature in Africa (Blaikie, 2006; Cleaver, 1999; Mamdani, 1996) with evidence in rural Kenya that local practices often lead to use of unimproved water supplies due to access barriers. The implication for future policy and practice is that investments in safely managed drinking water require greater institutional oversight and regulation if the benefits are to be shared by lower welfare groups. Current government and donor programmes rarely demand such oversight and despite recent

‘sustainability checks’ these are related to infrastructure functionality on the day of an occasional monitoring visit rather than continued delivery of services to all welfare groups, which we discuss further below.

Multiple use systems for rural water have been documented in many countries recognizing that both productive water infrastructure, such as irrigation systems, or drinking water systems, such as piped networks or pumped systems, are commonly used by both groups (Koppen et al., 2006; Meinzen-Dick & Van Der Hoek, 2001; Renwick, 2001; Smits et al., 2010). Often dubbed as the ‘water pays for water’ hypothesis the approach has gained salience from the potential financial sustainability for productive uses to increase both the value and financial resources to manage the system, though the literature shows limited evidence of this in practice. Wider evidence points to the potential conflict over limited water during times of drought when waterpoints may be heavily over-subscribed. While these conditions rarely manifest in our study area, a simplistic reading would belie the potential challenges as well as opportunities from multiple water uses. The findings do underline the positive relationship between livestock watering and small-scale irrigation with welfare, particularly for women. While irrigation from groundwater is extremely limited in both potential yield from handpumps (circa 1 m³ per hour) and current practices (5% of sample households), livestock is more widespread (21%) with widespread use of handpumps for watering at some point during the year. Again, women seem to be engaged in, or more familiar, with this activity than men. As a coefficient in household welfare, livestock watering from groundwater is high, particularly for female-headed households who represent a social group of concern.

The welfare composition of satisfaction with current drinking water services reveals a regressive pattern of higher welfare households with affordable, safe and reliable water. Only proximity to the handpump is welfare-neutral in the sense that there is relatively limited difference between welfare quintiles and that this indicator is the highest of the four in terms of coverage. These findings broadly accord with the disaggregated data analysis by the global Joint Monitoring Program (WHO & UNICEF, 2017a) which highlight similar inequalities in global reporting. Our findings imply that while implementation activities are doing relatively well in locating waterpoints near everyone, the services delivered are unsatisfactory. In many ways this is symptomatic of the Millennium Development Goal (MDG) era of infrastructure provision without ancillary investments in institutions to manage, maintain and regulate services in rural areas. While the data may be read in different ways it would be consistent to think of unaffordable water leading to lower welfare groups using less safe and potentially less reliable sources. The increasing recognition that universal drinking water security may not be consistent with financial sustainability is emerging as a defining challenge of the Sustainable Development Goals where the ambition for safely managed drinking water requires monitoring of services with disaggregated data of vulnerable populations to help identify and inform improved policy and practice.

Gendered inequalities are an increasingly key component of national and global measuring distributional impacts of services for the poor. The well-rehearsed role of African women in rural water management and collection is reinforced by our findings with a concern on the potential marginalisation of female-headed households. It is noteworthy that perceived water safety is the only service indicator of significance to female headed households'

welfare of the four drinking water indicators. While proximity and reliability are positive they are not significant for welfare suggesting a unique and singular prioritization compared to other households. Equally, the significance of productive uses of groundwater for household welfare is noted indicating potentially welfare-enhancing measures to support women who may be situated in inland areas where farming systems are more prominent than fishery-based systems along the coast. The social practices which moderate and reproduce these outcomes is not well-understood or adequately addressed by this research. However, the findings point to the need to better understand and recognize how groundwater provision to vulnerable groups may buffer, exclude or lift people out of poverty across welfare dimensions. The redistributive practices of access to groundwater, particularly in times of high demand or drought, is being documented in Kenya (Foster & Hope, 2016, 2017) underlining local control and management which may, or may not, be equitable and sustainable. What our findings point to is the potential of groundwater to support productive practices but these largely accrue to higher welfare groups, potentially excluding others, due to the inability to purchase livestock or limited access to groundwater. While this is beyond the scope of this study, it is an important and weakly understood area for further analysis. This should go beyond simple binary gendered differences and be centred more broadly on processes of social accumulation, exclusion or loss, which better capture welfare transitions rather than imposing a politically, or donor, favoured social group which potentially misses people of greater but hidden vulnerabilities (Hulme & Shepherd, 2003; Mehta & Shah, 2003; Narayan, Patel, et al., 2000).

5.6 Study limitations

We acknowledge at least five limitations to the study. First, the observed groundwater use data from the waterpoint data transmitters provide a major but singular source of groundwater for households. Others include open, dug wells at the household or in the community, and some springs in the Shimba Hills (inland zone). We also emphasize that the 'litres per month' metric is a proxy and embeds livestock and minor agricultural water use; we have no plausible methodology to differentiating these variable uses of the handpump without heroic assumptions. Second, the usage provides unique hourly records over a year, but this period is not claimed to be representative of the variable climate but had an average rainfall of 1,862 mm which is above the long term mean of 1300 mm. The application of the framework in a more arid environment will likely provide further insights in a more stressed hydrological system. Third, poverty is multidimensional with groundwater as one component of wider health, welfare and economic impacts for different user groups. Ancillary investments in health, education, energy or other sectors need to be examined to have a fuller understanding of the socio-ecological nature of the extent to which groundwater interacts with poverty pathways for different welfare groups over space and time. Fourth, we recognize the uneven nature of spatial resolution of the households across the study area, this has implications on the artificial nature of the welfare predictions although we control for this through geostatistical modelling creating heat maps. Fifth, the household survey was conducted between November 2013 and January 2014 which is during the short rains and beginning of the dry season in East Africa.

5.7 Conclusion

Unlocking the potential of groundwater for the poor has emerged as a global science and policy puzzle. Increasingly unpredictable climate futures, a data deficit in groundwater resource monitoring and unregulated growth in industrial, agricultural and municipal demand for water is placing groundwater under unprecedented stress. In the absence of a plausible theoretical understanding of groundwater and welfare interactions and impacts it is likely that vulnerable and marginalized groups may be excluded from potential developmental pathways as groundwater resources are captured by competing and more powerful users. In coastal Kenya we find evidence that the conceptual framing of groundwater and welfare helps understand part of this dynamic and context-specific puzzle. Welfare-enhancing approaches emerge both in terms of the type and depth of groundwater infrastructure with different domestic and productive uses of groundwater with alternative welfare outcomes for different social groups. The contribution of groundwater to household welfare represents a minor but important component worthy of greater political action and oversight. With advances in groundwater monitoring systems, new streams of data can be marshalled with historical sources to close information asymmetry gaps and guide political action to support welfare-enhancing interventions which work for the poor and support sustainable groundwater management.

6 MODELLING WELFARE TRANSITIONS TO PRIORITISE SUSTAINABLE DEVELOPMENT INTERVENTIONS IN COASTAL KENYA

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Notes:

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Abstract

Understanding welfare transitions can guide policy priorities for sustainable development. Transitions are often weakly understood in sub-Saharan Africa due to limited panel data to analyze trajectories of household escaping from, falling into or remaining out of deprivation. We model data from 3,500 households in coastal Kenya in three panels from 2014 to 2016 to evaluate the determinants of welfare by multidimensional and subjective measures. Findings indicate that more than a half of the households are deprived with female headed households being the most vulnerable and making the least progress. The subjective welfare measure identified three times more chronically poor households than the multidimensional metric (27% vs 9%); in contrast, the multidimensional metric estimated twice as many 'never poor' households than the subjective measure (39% vs 16%). The 'churning poor' were broadly consistently for both measures at roughly half the sample. Households with only female adults were more deprived in all cases. Four welfare priorities converged from modelling multidimensional and subjective metrics. Completing secondary education, expanding network or solar energy access, and improving the reliability and proximity of drinking water services improve welfare outcomes. Eliminating open defecation is the largest determinant of (negative) welfare change. The policy implications do not align neatly to government mandates in Kenya with education and energy with national responsibility compared to drinking water and health under a decentralized county mandate. We argue government and development partners working to fewer Sustainable Development Goals may improve accountability, feasibility and responsibility in delivery if informed by local priorities and political salience.

Keywords: Kenya; multidimensional welfare; subjective welfare; Sustainable Development Goals; welfare transitions

6.1 Introduction

Africa's development pathways in poverty reduction will increasingly be shaped by identifying more effective and equitable policy and practice to balance competing goals of economic growth and environmental sustainability (AfDB Report, 2014; Africa Progress Report, 2013; Barma et al., 2012; Millennium Ecosystem Assessment, 2005). While the Sustainable Development Goals provide some of the development pathways through 17 goals, 169 targets and 230 indicators (United Nations, 2015b), there remains a challenge for most developing countries to balance and prioritise the multiple and overlapping goals given the rapidly changing environmental, economic and political constraints. Progress towards poverty reduction has been characterised by varying degrees of success and failures from one country to another. With the Millennium Development Goals reporting substantial global progress in halving the number of people living below the poverty line of USD 1.25 a day (IMF, 2015; United Nations, 2015a), findings in rural Africa show that there were 50 million more people in 2012 than in 1990 living below the poverty line (Beegle et al., 2016). Lessons from the uneven and unsatisfactory progress in the Millennium Development Goals promote a more pragmatic set of goals which meet social priorities to offer a cost-efficient, welfare-enhancing and politically appropriate approach.

Poverty is a condition of multiple deprivations for different individuals or households and the vulnerable, it also varies substantially between countries and over time (Alkire & Foster, 2011; Ravallion, 2011). The dynamic nature of poverty requires a clear metric and

measurement approach to ensure policies are effective and address the needs of the poor. Common approaches to measuring poverty in literature include income poverty, consumption poverty, multidimensional welfare and subjective welfare (Alkire et al., 2015b; Alkire & Foster, 2011; Alkire & Santos, 2011; Belhadj, 2012; Davis, 2003; Ferreira & Lugo, 2012; Sagar & Najam, 1998). Poverty and welfare differ in the measurement approach with diverging implications on policy and practice. While poverty metrics are mostly generated from income and expenditure data, welfare measurements recognise health, education, assets and some social deprivation. The latter is the focus of this paper with the poor and non-poor being described by low welfare and high welfare statuses respectively. There is a growing interest in subjective welfare measures (Fafchamps & Shilpi, 2009; Sacks et al., 2012) with studies exploring the possibility of such a metric to converge with multidimensional welfare measurements (Beegle et al., 2012; Diener, 1984). While subjective welfare measurements prioritise self-assessments of an individual or household's welfare, they are not perfect and may suffer from limitations relating to bias from cognition, representation and stability (OECD, 2013). Cognition bias relates to the interpretation of the questions on welfare status in a consistent and equivalent manner. Representation refers to whom the respondent can answer for. This is important as multidimensional welfare measures rely on commonly owned assets and other household characteristics. This has implications on the stability of welfare measurements over time demanding the need for consistency in data collection to monitor and evaluate progress while ensuring poverty reduction interventions reflect the needs of different groups.

Robust and replicable welfare metrics are pertinent to assessing welfare transitions to categorise different groups of households such as those churning in and out of poverty, those that are chronically poor and those that are never poor (Edwards, 2015; Hulme & Shepherd, 2003). These categories enable a wider and deeper understanding of welfare and may further be disaggregated by sex of household head. Studies show that chronic poverty is disproportionately common among historically marginalized groups such as women making it harder for female-headed households to escape poverty (Mehta & Shah, 2003). Gender discrimination on the other hand exacerbates inequality in employment and wage compensation, land ownership and inheritance rights, social exclusion in economic and political institutions increasing their vulnerability to chronic poverty (Nilüfer Cagatay, 1998). Further evidence in literature show that female-headed households are more likely to fall into poverty or remain poor compared to male-headed households (Beegle et al., 2016; Bigsten & Shimeles, 2008; Bogale et al., 2005). With the growing number of female-headed households in sub-Saharan Africa (Beegle et al., 2016; KNBS & Macro, 2010), it is becoming increasingly important to shift from viewing the poor as a homogenous group. Policy and practice need to accommodate the needs of different groups in different levels of welfare and vulnerabilities.

The nature of welfare in rural Africa is often characterized by lack of or poor access to public services such as water, education, health, energy, transportation, among others (Cairncross et al., 2003; Haller et al., 2007; Macdonald & Davies, 2000; Willcox et al., 2015). While the effects of these factors vary between different groups of households or individuals in both space and time, their empirical relationships to welfare is often not properly understood due

to limited data availability. The existing information asymmetry in rural Africa clouds objective assessments as baseline conditions for social, economic and environmental systems are commonly absent, unavailable or incomplete to support empirical analysis of the relationships between welfare and its determinants. Distributional implications and impacts for local populations over time and across varying environmental conditions are poorly documented providing a weak platform to inform policy and practice to guide sustainable development pathways. With longitudinal data on welfare, modelling welfare transitions will contribute to understanding the links between welfare and its determinants of welfare to inform policy priorities in the context of varying economic, environmental or political shocks.

Delivery of policy remains a core mandate of governments and their relevant departments and institutions. Where a working form of governance exists with checks and balances, bilateral donor support and institutions mandated to address poverty reduction may accelerate attainment of the Sustainable Development Goals. Kenya is a good example where decentralization of the central government led to formation of 47 county governments with replicated institutions and ministries in each county to offer services and bring resources closer to the people (KIPPRA, 2013; World Bank, 2013). Kenya remains on a trajectory of positive growth under this new form of governance if coherent legal and policy frameworks are strengthened at the county level (KIPPRA, 2013, 2017). The paper models determinants and transitions of welfare to inform and guide policy priorities and practice in coastal Kenya drawing from 3,500 longitudinal household surveys over three waves of data to (a) understand determinants of welfare by location and over time, (b) measure welfare,

(c) evaluate welfare transitions, and, (d) identify policy action to improve welfare. The next section describes the data and methodology used to assess multidimensional and subjective welfare, subjective welfare and modelling random effects of different determinants on welfare. We then report the results by different profiles of poor (low welfare) and non-poor (high welfare) categories as well as sex of household head. Section 4 discusses the results and section 5 concludes.

6.2 Methodology

6.2.1 Study site and Sampling frame

The study site is Kwale county, Kenya, south of Mombasa and adjacent to northern Tanzania (Figure 6-1). The study area covers 2,156 km² in Lunga Lunga, Msambweni and Matuga sub-Counties with around 300,000 residents (KNBS, 2010). The study area's climate has a bi-modal rainfall pattern with an average annual precipitation of approximately 1,380 mm but with significant inter-annual and spatial variability. The coastal lowland of the study area is the wettest with the climate getting drier to the west and north. The average annual temperatures are above 28°C (GOK, 1985). About 90 per cent of the population lives in rural areas with 7 out of 10 people living below the poverty line of less than USD \$1.25 a day, this headcount ratio has remained notoriously high over the last decade (KNBS, 2006, 2018). Since 2013, the pace of environmental, economic, social and political change has increased with the establishment of two new and major economic activities in the area. Kwale International Sugarcane Company Limited (KISCOL) has been progressively rehabilitating 5,500 hectares of sub-surface irrigated sugarcane including the commissioning of its own sugar mill in 2015. Adjacent to the sugarcane plantations is the country's newest and largest mining operation (Kwale Mineral Sands Project). The mine, operated by Base Titanium Ltd.,

is currently projected to export 6.5million tonnes of titanium ore by 2028 from Likoni port, some 30km north of the mine site. Scattered around the mine site and sugarcane plantation are around 300 functional handpumps (5-30m deep) providing drinking water to communities, schools, dispensaries and health centres.

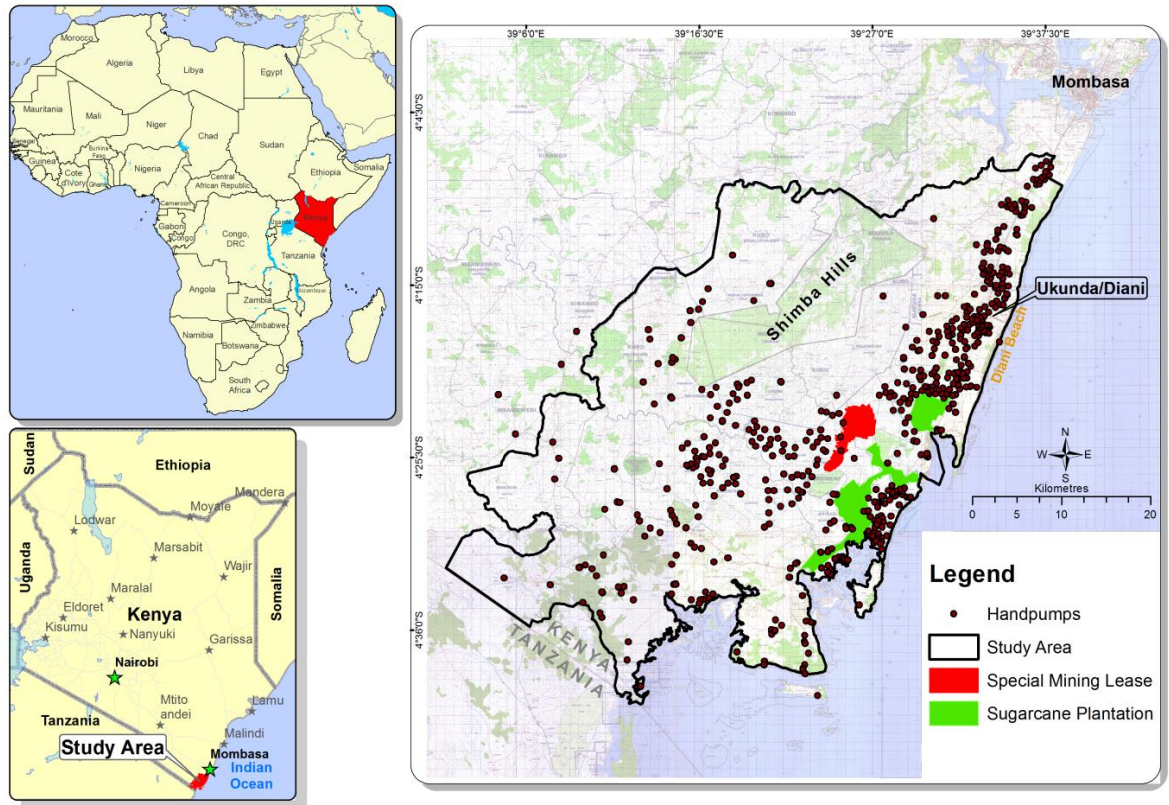


Figure 6-1 Map of study area

In August 2013, a water point survey identified 574 handpumps (all Afridevs) of which 45% were non-functioning (T. Foster & Hope, 2016). A sample of 531 handpump locations was used as a sampling frame for the longitudinal household surveys in 2014, 2015 and 2016. GSM-enabled transmitters were installed on the 300 operational handpumps to transmit and record daily pumping to estimate water usage and functionality (Thomson et al., 2012a). At each of the 531 handpumps, a stratified random sample of households was produced,

yielding 3,500 survey participants. A pilot survey was conducted with 19 enumerators recruited from communities across the study area who administered the survey in local languages (Swahili, 53.8%; Digo, 42.6%; Duruma, 2.1%; other, 1.5%). The main survey entailed a range of themes including demographic, socio-economic status of household (here including livelihood, concerns and subjective welfare), household health status, water sources, water point management, water payments, water resources management, governance and political engagement. All the households surveyed were geo-referenced for mapping purposes. The survey was repeated in the 2015 and 2016 yielding three waves of longitudinal data.

Ethical permission to conduct this survey was provided by the University of Oxford's Central University Research Ethics Committee and research permission granted by the Government of Kenya's National Council of Science and Technology, Kenya (NCST/RCD/17/013/132, September 2013). All interviews were voluntary with informed consent procedures observed in the local language. Data have been anonymised and stored in encrypted files.

6.2.2 Measuring welfare and transitions

A multidimensional asset-based welfare index was constructed using household characteristics, dwelling characteristics (including type of roof of housing, walls and flooring material), assets and consumables (Vyas & Kumaranayake, 2006). This methodology broadly follows the Kenya Demographic and Health Survey and the Kenya Integrated Household Budget Surveys methodology in assessment of welfare (KNBS, 2018; KNBS & Macro, 2010). The weights used to compute the welfare index were generated from principal component analysis (Falkingham & Namazie, 2002; Filmer & Pritchett, 2001; Gwatkin et al., 2007; Vyas

& Kumaranayake, 2006). The computed welfare index ranged between 0 and 1 where households scoring higher values were relatively well-off compared to those scoring values close to zero.

The welfare index generated values from zero to one with welfare quintiles derived from this range with households located by their value in the range. As such, the share of households by welfare quintile is not even but reflects the relative distribution across the welfare scale which permits assessment of welfare movements over time. For the households that fell into the bottom 2 welfare quintiles (welfare index less than 0.40), we categorised them as poor while those that were in the top three welfare quintiles (welfare index equal to 0.40 or greater) we categorised them as non-poor. We defined female-headed households as households with only female adults (above 15 years old) while male-headed households as households with at least a male adult. To understand the dynamics of households moving in and out of poverty we applied a one-way tabulation of the poor and non-poor households and further computed the transition probabilities of either a household remaining poor or transiting to a non-poor state (Hulme & Shepherd, 2003).

To explore welfare heterogeneity across different geographies, we categorized the households into three groups by a simplified typology of three economic geographies in the study area: (1) the south-eastern coastal belt with people living within a 5km strip of the sea (51% of the sample), whose main economic activity is fishing; (2) inland and more remote areas south and south-west of the Shimba Hills and away from the coastal margin (38% of the sample), where the main economic activity is farming; and (3) the small town of

Ukunda/Diani which largely serves the tourism industry along Diani beach (12% of the sample), see Table 6-1.

6.2.3 Measuring determinants of welfare

To assess the determinants of welfare, we considered an analytical approach that applies the random effects model to both a multidimensional welfare index and a subjective welfare index. The subjective welfare index is derived from three categories asked to each household, i.e., 'not well-off', 'average' and 'well-off'. A small fraction of households (less than 0.5%) identified themselves as well-off, this category was excluded from the analysis. The remaining two categories were classified into poor (for households categorising themselves as not well-off) and non-poor (for households categorising themselves as average). The independent variables considered in the analysis include water services (by stated concerns with affordability and reliability, distance and dependence on only one source), type of water infrastructure, geographical location, level of education by household measure, access to energy, agriculture (land ownership and livestock), and sanitation and health (type of latrine and two-week diarrhoea recall).

Our analytical strategy was to use the three waves of longitudinal data to model the effects of independent variables on welfare while controlling for social, environmental or political heterogeneity (Wooldridge, 2010). There are a range of models that can be used in longitudinal data techniques and each model is employed based on a set of conditions. The two common longitudinal data models (in the case of a continuous dependent variable) are the fixed effects model and the random effects model. A fixed effects model is commonly used where the individual specific effects (unobserved heterogeneity across individuals) are

correlated with the regressors (independent variables) while random effects model is used where the individual effects are not correlated with the regressors but rather assumed to be randomly distributed over time (Wooldridge, 2010). The fixed effects model estimates these individual specific estimates using dummy variables with the regressors being considered time-variant. However, in situations where the regressors are time-invariant, the random effects model is more applicable. The random effects model has an additional advantage of estimating lower standard errors compared to the fixed effects model due to the assumption that the individual specific effects are randomly distributed.

There are at least three limitations which emerge from the longitudinal design. First, a substantial proportion of individuals were not interviewed by the same enumerator in every wave (year), this introduced randomness in the survey administration. Therefore, the amount of variability within subjects was considered to be too small for a fixed effects model to be consistent and efficient. While some of the independent variables were time-invariant, the time-variant ones did not change substantially every year, Table 6-1. The key insight being that if the unobserved variable does not significantly change over time, then any changes in the dependent variable must be due to influences other than these fixed effects (Stock & Watson, 2003). Second, the amount of variability among subjects and whether we wished to estimate the effects of time-invariant variables or merely control for them (Allison, 2005). All the three studies included in this analysis were not strictly identical in the sense that the first study was, for example, conducted in the dry season, the second one was conducted during the wet season and the third was conducted in a year that the country experienced one of the worst droughts in history. Third, the nature of the variables omitted

from the regression equation, this is the omitted variable problem (Wooldridge, 2010). The independent variables considered in this study do not account for all the possible covariates of poverty. Some of the omitted variables include, for example, age or employment, which happens to be an exogenous variable therefore may introduce some bias in the case a fixed effects model was considered. We therefore employed the random effects model with the welfare index as the dependent variable.

In the case of binary dependent variables, the commonly used models are probit and logit models. The fundamental differences between probit and logit models is that probit models use the cumulative distribution function of the standard normal distribution while the logit (logistic) model uses the cumulative distribution function of the logistic distribution (Arellano, 2003; Wooldridge, 2010). However, both models are based on probability distributions and yield similar results (Conaway, 1990). The logit model coefficients can be interpreted as odds ratios making it more desirable in this analysis. Given that the subjective welfare measure was binary (in this case well-off and not well-off categories) and longitudinal, the random effects logit model was used. This was necessary to compare the outcomes of both the welfare index and the subjective welfare assessment in assessing the effects of the different independent variables on welfare.

6.3 Results

We report the descriptive findings which reveals the nature of welfare transitions (Table 6-1). First, welfare is generally improving though less so for female-headed households. Second, welfare transitions identify a substantial number of households that are churning poor and chronically poor with implications to design of policy and practice. Third, subjective

welfare is less optimistic than the multidimensional index. Fourth, four policy interventions are identified that reflect the needs of the people to accelerate sustainable growth and development.

6.3.1 Welfare by household categories

Households with only female adults (female-headed households) accounted for 16 per cent of the total sample size with the remainder being male-headed households. About a half of both female and male-headed households reside on the coastal region, less than 10 per cent reside in the more urban area of Ukunda while the rest were observed to reside in the Inland regions. In terms of water services for female-headed households, we saw a reduction in the fraction of households with access to affordable and reliable water services over time. Households with affordable water services (one in ten in wave 1) decreased by half over the three years while those with reliable water services decreased by 9 per cent. While distance to water sources remained more or less the same in all the years, households with alternative water sources increased from 73 per cent to 80 per cent over the three years. Similar changes across the years were observed with male-headed households.

Water supply for the majority of households is from handpumps though there is an almost doubling in growth of access to piped systems over the period. Household water supply is considered 'close' by most respondents with reliability decreasing over time and affordability a concern for almost all households (95%). The most common water infrastructure for over two thirds of all the households was handpumps. While dependence on handpumps was observed to decrease by four to five per cent between wave one and

wave three for all the households, dependence on piped water systems increased by six per cent for male-headed households and eight per cent for female-headed households.

Table 6-1: Summary statistics of variables by sex of household head (n=3,234)

		Households with only female adults, n=526 Mean			Households with at least one male adult, n = 2,708 Mean		
	Variables	Wave 1	Wave 2	Wave 3	Wave 1	Wave 2	Wave 3
Geographical Location	Coastal	0.50	0.50	0.50	0.51	0.51	0.51
	Inland	0.45	0.45	0.45	0.38	0.39	0.38
	Ukunda	0.07	0.07	0.07	0.12	0.12	0.12
Water Services	Affordable	0.10	0.07	0.05	0.13	0.08	0.05
	Close (distance to water source)	0.59	0.60	0.58	0.57	0.63	0.61
	Reliable	0.30	0.25	0.21	0.31	0.29	0.22
	Only source	0.27	0.21	0.20	0.25	0.22	0.22
Water Infrastructure	Handpump	0.67	0.66	0.62	0.64	0.66	0.60
	Piped	0.11	0.14	0.19	0.17	0.17	0.23
	Unprotected well	0.11	0.14	0.15	0.11	0.11	0.12
Highest Education Attained	Primary	0.61	0.68	0.61	0.53	0.49	0.50
	Post Primary	0.02	0.01	0.01	0.02	0.02	0.03
	Secondary	0.27	0.18	0.24	0.35	0.37	0.36
	College	0.03	0.03	0.04	0.06	0.08	0.06
	University	0.02	0.01	0.03	0.02	0.03	0.03
Energy	Electricity (national grid)	0.04	0.04	0.09	0.08	0.09	0.18
	Solar panel	0.02	0.04	0.12	0.05	0.08	0.13
Agriculture	Own Livestock	0.21	0.11	0.41	0.21	0.22	0.49
	Own >2 acres land	0.44	0.44	0.65	0.43	0.49	0.63
Sanitation	Open defecation	0.53	0.44	0.36	0.43	0.38	0.28
	Cases of diarrhoea in last two weeks	0.10	0.10	0.07	0.08	0.10	0.06
Multidimensional Welfare	Poor (bottom 40%)	0.53	0.41	0.33	0.43	0.31	0.24
Subjective Well Being	Poor (not well-off)	0.62	0.70	0.59	0.56	0.59	0.48

Standard deviations not shown since the variables are binary. The totals may not add up to 100% due to rounding.

In terms of access to education, about one in two male-headed households had household members who had attained or were still in primary education level. About 36 per cent of male-headed households had household members who had attained or were still in secondary education level at any point in time over the three waves. Female-headed households were 1.2 times more likely to have household members with or who have had access to primary education compared to male-headed households. However, female-headed households were about 1.6 times less likely to have household members transiting

to secondary schools compared to male-headed households. Households with at least a male adult were 1.5 times more likely to have children in secondary schools and two time more likely to have children in college or university compared to female-headed households.

Access to national grid electricity connection remained low in wave two for female and male-headed households at four and eight per cent respectively compared to the national average of 41 per cent. Similarly, access to solar panels was low for female and male-headed households compared to the national average of 14 per cent (KNBS, 2018). While the overall access to energy was low, we observed two-fold increase in access to electricity from the national grid for both female and male-headed households between wave one and wave three. Similarly, access to solar panels increased six-fold for female-headed households and two-fold for male headed households between wave one and wave three.

Livestock ownership rates for female and male-headed livestock in wave one was similar, however, in wave two, female-headed households who owned livestock decreased by half compared to the male-headed households. In addition, the livestock ownership rates for both female and male-headed households were observed to increase three-fold from wave one to wave three. These substantial changes in livestock ownership from year to year made limited sense and requires further analysis and caution in interpretation. Land ownership on the other hand appeared stable across wave one and wave two. In wave three, land ownership increased by approximately 20 per cent for both female and male-headed households. There were more male-headed households who owned land of more than two acres compared to female-headed households, at any point in time.

In terms of sanitation, open defecation rates among female-headed households were slightly higher than among male-headed households. More than one in two female-headed households were reported to lack any kind of sanitation facility (toilet) in wave one. Open defecation rates were observed to decrease in wave two and three by about 17 per cent points. Male-headed households were 1.2 times less likely to lack any form of toilet compared to female-headed households. However, the open defecation rates among male-headed households were equally high by standards although the rates declined over time by close to 15 per cent points. While diarrhoea cases in the last two weeks for all children under 15 years (based on recall) were observed in less than ten per cent of all the households, they were slightly more common among female-headed households than male-headed households across all the waves.

The multidimensional welfare index was able to classify the poor and non-poor households, also based on sex of household head. Results showed that the number of poor female and male-headed household decreased by 20 per cent points between wave one and wave three. However, the likelihood of female-headed households to be poor compared to male-headed households was observed to increase from 1.2 in wave one to 1.4 in wave three. The subjective welfare index on the other hand classified three out of five female-headed households as poor in wave one and wave three, it also classified two thirds of female-headed households as poor in wave two. Overall, female-headed households were observed to be more likely to subjectively identify themselves as poor compared to male-headed households especially in wave three.

6.3.2 Welfare transitions

Tables 6-2 (a) and (b) summarise welfare transitions by the multidimensional index and the subjective assessment. They are reported by a one-way tabulation of welfare decomposed by counts between and within components in longitudinal data. A summary of transition probabilities of changes in multidimensional welfare and subjective welfare over time. The overall column of Table 6-2(a) shows that we had 6,405 household-cases of data (66 per cent) where the household was non-poor and 3,297 household-cases (34 per cent) where they were poor. The between column shows the total count of households that have been, at least on one occasion over the three waves, poor or non-poor. There were 1,980 households that have been poor while 2,932 households have never been poor in any one occasion. This makes a total of 4,912 households having been either poor or non-poor in any one occasion across the three waves. This contrasts with a total sample size of 3,234 households meaning that some households have been poor in one occasion and non-poor at other times (churning in and out of poverty). The within percent tells us the fraction of the time a household has been poor or non-poor. Looking at the first row, conditional on a household ever being non-poor, 73 per cent of the time that household is non-poor while conditional on a household ever being poor (second row), 56 per cent of the time that household is poor. This is a measure of the stability of households meaning that the non-poor households tend to be more stable than poor households. The overall stability of the households being poor or non-poor, normalized between the weighted average of the within percent, was measured at 66 per cent.

The welfare transitions summary in Table 6-2(a) show that in each period about 81 per cent of those households who were initially non-poor remained non-poor in the next period whereas about 45 per cent of those who were initially poor remained poor in the next year. Although non-poor households had a 19 per cent chance of becoming poor the next year, poor households had a 55 per cent chance of becoming non-poor. Female headed households who were initially non-poor had a 24 per cent chance of becoming poor the next year while those who were initially poor had a 49 per cent chance of becoming non-poor. Around one in two female headed households of those who were poor remained poor every year while 76 per cent of those who were non-poor remained non-poor the next year.

Table 6-2(a) Welfare transitions by multidimensional and subjective measures (2014-2016)
(n=3,234)

multidimensional Welfare	Overall		Between		Within	Welfare Transitions		
	Freq.	Percent	Freq.	Percent	Percent	multidimensional Welfare	Non-poor	Poor
Non-poor	6,405	66	2,932	91	73	Non-poor	81% (76%)	19% (24%)
Poor	3,297	34	1,980	61	56	Poor	55% (49%)	45% (51%)
Total	9,702	100	4,912	152	66	Total	71% (63%)	29% (37%)

Table 6-2(b) Subjective welfare transitions for 2014, 2015 and 2016 (n=3,234)

Subjective Welfare	Overall		Between		Within	Subjective Welfare Transitions		
	Freq.	Percent	Freq.	Percent	Percent	Subjective Welfare	Non-poor	Poor
Non-poor (Average)	4,238	44	2,356	73	60	Non-poor (Average)	59% (51%)	41% (49%)
Poor (not well- off)	5,455	56	2,714	84	67	Poor (not well-off)	34% (27%)	66% (73%)
Total	9,693	100	5,070	157	64	Total	44% (35%)	56% (65%)

NB: numbers in brackets are for female-headed households

The subjective welfare tabulation in Table 6-(2b) reported fewer household-cases categorizing themselves as non-poor, 4,238, in comparison to the welfare index which had 6,405 and the poor category reporting an overall 5,455 household-cases in more than half of the data. The between summary reports a total of 2,356 households that have ever been non-poor (subjectively) on any one occasion with another 2,714 households that have ever

been poor on any one occasion. Again, this makes a total number of households greater than the actual sample size meaning some households have been in one category more than once over the three waves. This is further elaborated in Table 6-3.

The transitions based on the subjective welfare measure showed that over two thirds of the households initially in the poor category remained poor while 59 per cent of these households initially in the non-poor category remained non-poor the next year. Households initially in the non-poor category had a 41 per cent chance of moving into the poor category while those in the poor category had a 34 per cent chance of moving in the non-poor category. Female headed households that were initially non-poor had a 49 per cent chance of becoming poor the next year while those initially in the poor category had a 27 per cent chance of becoming non-poor the next year.

To identify the pattern a household followed across the three waves, we use three categories similar in principle to the poverty tiers conceptualized by (Hulme & Shepherd, 2003), i.e., those who are *chronic poor*, *churning poor*, and the *never poor*. In this case, a household that was *never poor*, could follow the pattern 'non-poor, non-poor, non-poor' in all three waves based on the welfare index measure or it could be 'average' in all the three waves based on subjective welfare measure. The chronic poor could assume a pattern of poor, poor, poor. The churning poor are categorized as households who have been poor in at least one occasion over the three waves.

Table 6-3 Multidimensional and subjective welfare transitions by chronic, churning and never poor categories

Wave 1	Wave 2	Wave 3	Chronic Poor	Churning poor	Never Poor
Poor (not-well-off)	Non-poor (Average)	Non-poor (Average)		17% (10%)	
Poor (not-well-off)	Non-poor (Average)	Poor (not-well-off)		7% (7%)	
Poor (not-well-off)	Poor (not-well-off)	Non-poor (Average)		11% (13%)	
Poor (not-well-off)	Poor (not-well-off)	Poor (not-well-off)	9% (27%)		
Non-poor (Average)	Non-poor (Average)	Poor (not-well-off)		5% (6%)	
Non-poor (Average)	Poor (not-well-off)	Non-poor (Average)		8% (10%)	
Non-poor (Average)	Poor (not-well-off)	Poor (not-well-off)		4% (10%)	
Non-poor (Average)	Non-poor (Average)	Non-poor (Average)			39% (16%)
Total			9% (27%)	52% (56%)	39% (16%)

NB: text and numbers in brackets refer to subjective welfare measures

Looking at the patterns of welfare in Table 6-3 for all the households, we observed that about 39 per cent of the households have never been poor while about one in ten households have been chronically poor and more than a half of all the households have been churning poor. The subjective welfare measures identified fewer households being in the never poor category, 16 per cent, and about three-times more households being in the chronic poor category in comparison to the multidimensional welfare index. Both welfare measures had similar fractions of households in the churning poor category. Table 6-4 disaggregates the data by sex of the household head. The multidimensional welfare index showed that female-headed households were 1.4 times less likely to be non-poor (never poor) and 1.8 times more likely to be chronic poor in all the three waves compared to male-headed households. In contrast, subjective welfare measure showed that female-headed households were 1.4 times more likely to be non-poor and 1.7 times less likely to be chronic poor in all the three waves compared to male-headed households.

Overall, the subjective welfare and the multidimensional welfare index measures appeared to converge for the churning poor households. For all households, we observed that the subjective welfare measure grouped more households in the chronic poor category compared to the multidimensional welfare index while in the never poor category the multidimensional welfare index identified more households compared to the subjective welfare measure, Table 6-3. On the other hand, female-headed households' subjective welfare measure converged closely to the multidimensional welfare index for both chronic, churning and poor categories, however, it was observed to substantially diverge for male-headed households for the chronic poor and the never poor category, Table 6-4.

Table 6-4 Multidimensional and subjective welfare transitions for chronic, churning and never poor categories by sex of household head

Patterns			Households with only female adults, n=526			Households with at least a male adult, n=2,708		
Wave 1	Wave 2	Wave 3	Chronic Poor	Churning poor	Never Poor	Chronic Poor	Churning poor	Never Poor
Poor (not-well-off)	Non-poor (well-off)	Non-poor (well-off)		18% (12%)			17% (10%)	
Poor (not-well-off)	Non-poor (well-off)	Poor (not-well-off)		8% (10%)			6% (10%)	
Poor (not-well-off)	Poor (not-well-off)	Non-poor (well-off)		13% (5%)			11% (6%)	
Poor (not-well-off)	Poor (not-well-off)	Poor (not-well-off)	14% (10%)			8% (17%)		
Non-poor (well-off)	Non-poor (well-off)	Poor (not-well-off)		4% (12%)			5% (14%)	
Non-poor (well-off)	Poor (not-well-off)	Non-poor (well-off)		7% (5%)			8% (7%)	
Non-poor (well-off)	Poor (not-well-off)	Poor (not-well-off)		6% (8%)			4% (10%)	
Non-poor (well-off)	Non-poor (well-off)	Non-poor (well-off)			29% (37%)			41% (25%)
Total			14% (10%)	56% (52%)	29% (37%)	8% (17%)	51% (57%)	41% (25%)

NB: text and numbers in brackets refer to subjective welfare measures

To examine welfare transitions between the welfare quintiles by geographical location, we plotted the overall changes in the fraction of households in each welfare quintile between wave three and wave one, Figure 6-2. Where the graph shows values close to zero means that there were no households transitioning in or out of that welfare quintile. A positive

change depicts household moving into that welfare quintile while a negative change depicts household moving out of that welfare quintile. For the overall households, we observed at least 10 per cent of households transitioning from each of the two lower welfare quintiles, Q1 and Q2, to the higher welfare quintiles indicating an overall improvement in welfare. The geographical location with the most improvement in welfare was the inland region where 10 per cent and 17 per cent of the households transitioned from Q1 and Q2 respectively to higher welfare quintiles. While Ukunda region had the least fraction of households moving out of the bottom four welfare quintiles, the region saw a substantial increase in the fraction of households moving into the topmost welfare quintile, Q5. The coastal region was the least improved in terms of welfare with fewer fractions of households transitioning from the lower welfare quintiles.

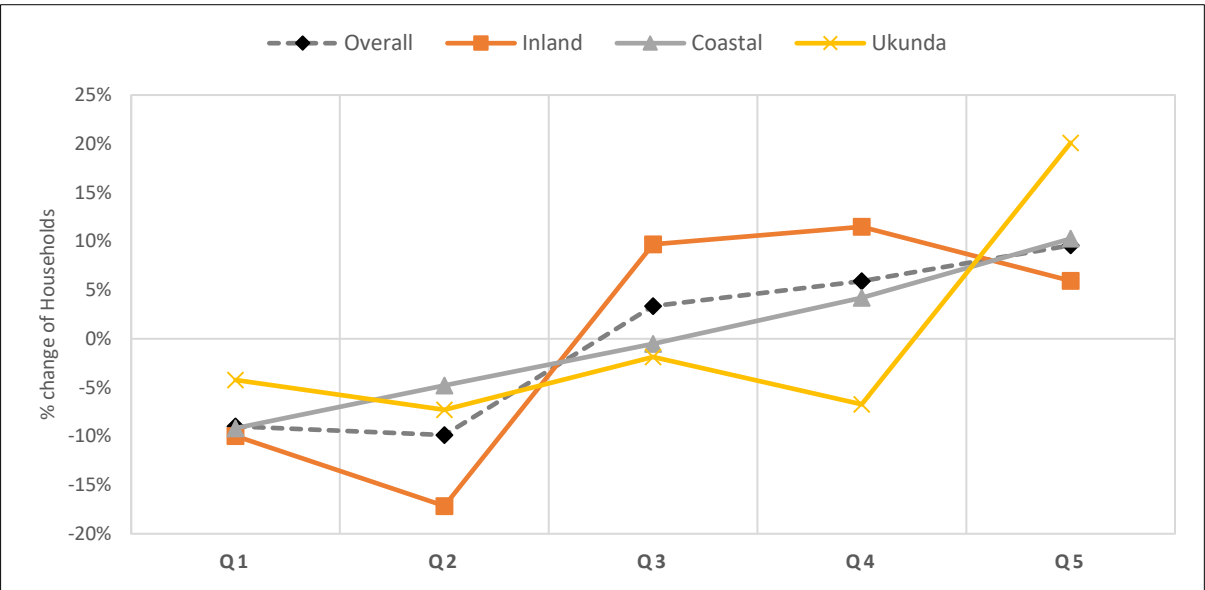


Figure 6-2 Households transitions between welfare quintiles by geographical location

6.3.3 Random effects estimation with welfare measures

The longitudinal dataset made it possible to estimate the effects of the independent variables on both multidimensional welfare index and the subjective welfare measure across

households and over time. The random effects model, Table 6-5, was used with the multidimensional welfare index as it is a continuous dependent variable while the random effects logit model, Figure 6-3, was used with the binary subjective welfare measure with poor and non-poor categories. The outcome of the random effects model were percentage points effects on multidimensional welfare index while for the logit model were odds ratios. Given the data and the model had both cross-sectional and time series dimensions, it was possible to evaluate the variation of the dependent variable over time and household. The within variation refers to the variation over time for each household (time-variant) while between variation refers to variation across the households (time-invariant). Understanding the within and between variation of the households' welfare is important as it reflects whether these variations are more substantial across different households over space or whether there are substantial variations in welfare in the same household over time. The random effects model applied in this study showed substantial variation on the multidimensional welfare index between households compared to within the households overtime. This was reflected in the R-squared estimate of 0.37 for within households variation and 0.50 for between households variation.

Table 6-5 Random effects coefficients for multidimensional welfare

Category	Variables	Coef.	Std. Err.	z	[95% Conf. Interval]	
Water Services	Affordable	0.01164	0.00845	1.38	-0.00493	0.02820
	Close (distance to water source)	0.03919***	0.00523	7.49	0.02894	0.04943
	Reliable	0.01671***	0.00525	3.18	0.00641	0.02700
	Only source	0.00797	0.00614	1.30	-0.00407	0.02000
Water Infrastructure	Unprotected well	-0.01357*	0.00814	-1.67	-0.02953	0.00239
	Piped	0.04270***	0.00711	6.01	0.02877	0.05663
Highest level of education	Primary	0.03371**	0.01213	2.78	0.00993	0.05749
	Post primary	0.09317***	0.02250	4.14	0.04906	0.13727
	Secondary	0.10160***	0.01267	8.02	0.07676	0.12643
	College	0.11875***	0.01598	7.43	0.08744	0.15007
	University	0.18903***	0.02202	8.58	0.14587	0.23219
Energy	Electricity (national grid)	0.16500***	0.00904	18.26	0.14729	0.18271
	Solar panel	0.14386***	0.00969	14.84	0.12486	0.16286
Sanitation	Open defecation	-0.20281***	0.00550	-36.84	-0.21360	-0.19202
	Cases of diarrhoea in last two weeks	-0.02149**	0.00856	-2.51	-0.03826	-0.00471
Agriculture	Own livestock	0.02024***	0.00556	3.64	0.00934	0.03113
	Own >2 acres land	0.03576***	0.00508	7.04	0.02580	0.04572
Geographical Location	Coastal	-0.04179***	0.01010	-4.14	-0.06158	-0.02200
	Inland	-0.07028***	0.01075	-6.54	-0.09135	-0.04921
Sex of Household head	Female headed household	-0.01341*	0.00795	-1.69	-0.02900	0.00217

Coefficients with *** are statistically significant at $p < 0.001$ while ** at $p < 0.05$ and * at $p < 0.10$. R-sq overall=0.37, between=0.50, within=0.15.

The random effects model identified most of the variables as statistically significant at a p-value of less than 0.1 with the exception of affordability of water services and dependence on a single source of water. While agriculture variables were statistically significant and positively correlated with welfare, the size of their coefficients was smaller compared to the other variables. Geographical location was statistically significant with reference to households living in the more urban area of the study area (Ukunda). Similarly, sex of the household head was statistically significant but at a much higher p-value ($p < 0.1$) though it revealed that female-headed households were more likely to have lower welfare but the

effect size on welfare was smaller, 1.3 per cent points. We therefore identified four categories that emerged as potential priority interventions: (a) water services (distance to water sources and reliability), (b) education, (c) energy and, (d) sanitation.

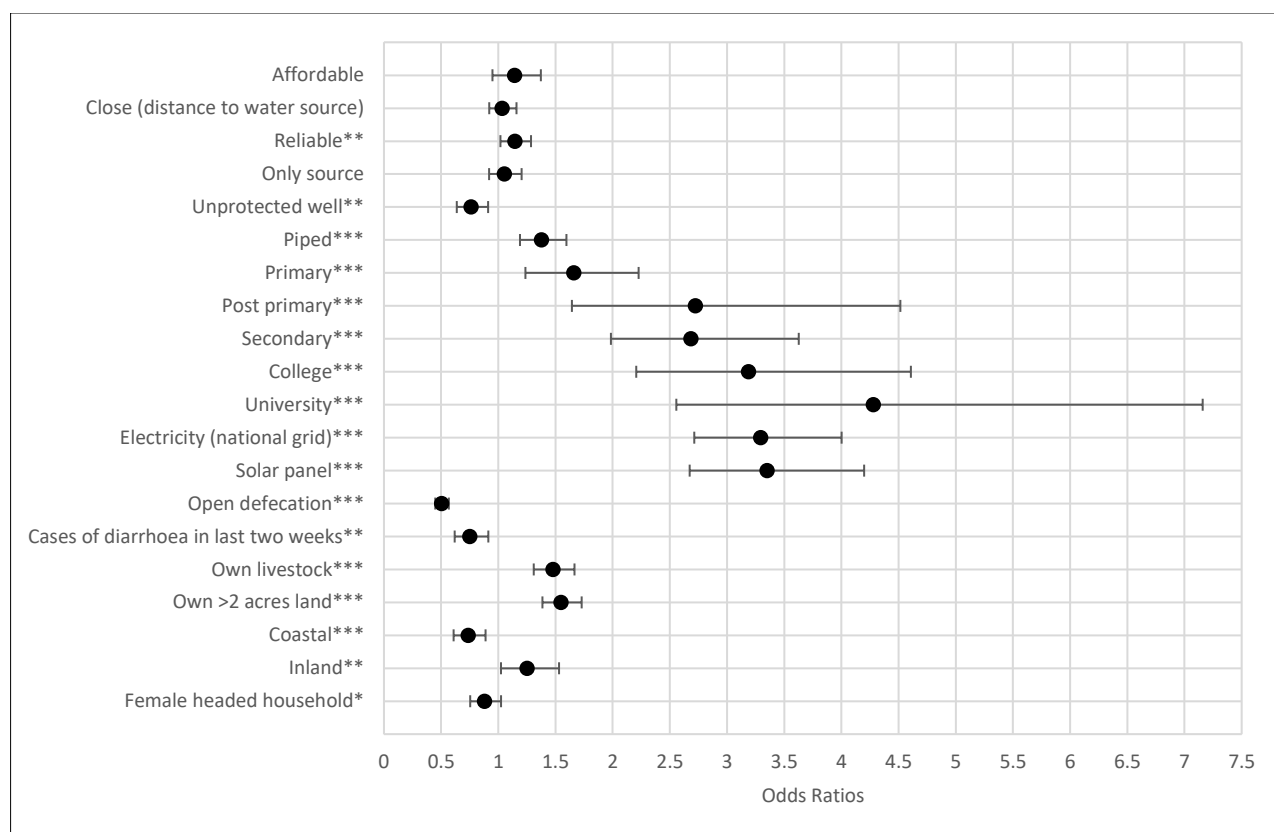
First, households with water sources close to their homes experienced a 3.9 percent point increase in welfare while those with reliable water sources experienced a further 1.7 percent point increase in welfare. As for water infrastructure, dependence on piped water connection was observed to increase welfare by 4.2 per cent points in comparison to households who depend on handpumps. Second, households with at least a household member who had attained secondary education experienced a 10 per cent point increase in welfare, this was three times greater than those with household members in or with primary education. While access to primary education is free, paid for by the government (Mulinya, 2015), access to secondary education remains a challenge to most households due to fee constraints and low transition rates (County Government of Kwale, 2018). Access to secondary education remains a national goal to make it accessible to all. We recognize access to college and university education had the greatest effect on welfare albeit very few households had attained these high levels of education.

Third, access to energy was observed to have a significant and positive effect on welfare with households connected to the national grid experiencing 16.5 per cent point increase in welfare while those with solar panels experiencing a 14.4 per cent point increase in welfare. This finding provides a clear relationship between electricity and reduction in welfare, however, more work is needed to understand the level of access and how it is being utilized to realize such benefits. Fourth, open defecation had a significant and negative effect on

welfare. Households which open defecate experienced close to 20 per cent points decrease in welfare while households who had cases of diarrhoea, within the last two weeks from the date of survey, experienced a 2 per cent points decrease in welfare.

Results from the logit model were generally similar to the random effects model, Figure 6-3. The degree of influence (size) of the coefficients of the independent variables in the random effects logit model was broadly similar to these of the random effects model. Four similar categories of statistically significant variables were observed in the random effects logit model however only reliability of water services was statistically significant at 0.05 level in the water services category. The outcomes were in odds ratios as reported. The odds of a household with access to reliable water services being non-poor were 1.14 times more than the odds of those without reliable water services.

All education variables were statically significant at 0.001 level depicting higher odd ratios for those with some form of education level in comparison to those with no education. These odd ratios ranged from 2.7 for households with at least a member with primary education as the highest level of education to 4.3 for those with university education. The odds of a household connected to the national grid (electricity) being non-poor were 3.3 times higher than those who were not connected to the national grid while for those with solar panels were 3.4 times higher than those without any solar panels. The odds of a household without a toilet (open defecation) being non-poor was 0.5 times that of one with a toilet while households with cases of diarrhoea were observed to have lower odds of being non-poor, 0.75 times of those who did not have diarrhoea cases in the last two weeks for either under 5 or 15-years old.



Variables with *** are statistically significant at $p < 0.001$ while ** at $p < 0.05$ and * at $p < 0.10$.

Figure 6-3 Odds ratio random effects coefficient for subjective welfare measure

6.4 Discussion

Our findings provide evidence and direction to our four questions on (a) understanding determinants of welfare by location and over time, (b) measuring welfare, (c) evaluating welfare transitions, and, (d) identifying policy action to improve welfare. The latter also considers the nature and limits of policy action in a decentralized governance context as emerged in Kenya in 2013.

Households with no male adults differ in terms of welfare to the broader sample in the quality and type of services. By location, they turn to be more commonly located inland which is, on average, a poorer region away from the coast and the urban centre of Ukunda. The women heading these households have lower education attainment by primary and

secondary levels and are classified by lower multidimensional welfare and also by their own subjective assessment of welfare. This is supported by the level of quality of services the household enjoys, particularly energy and sanitation services. Despite doubling access to grid electricity over the three years this is half the progress made by households with male adults. In contrast, women have been able to share the same level and rate of access to off-grid energy through the rapid growth of solar home solutions, which rose from a couple of percentage points to around one in ten households in three years. The positive news that open defecation has reduced by almost 20 percentage points over three years is dampened by the initial high starting point of one in two families and the existing burden for one in three families. Households without male adults are most vulnerable making the least progress and thus likely to bear a higher health burden, though the (crude) diarrhoea measure shows no major difference between the groups.

In contrast, community water supplies appear more equitable in access though unsatisfactory in service delivery. Around two out of three households depend on handpumps with common and high concerns on affordability and, to a lesser degree, reliability. In comparison, proximity to handpumps is slightly improved though around two in five households view this as a concern. While this public service falls short across the normative criteria of the SDG for safely managed drinking water, it provides a materially better service than energy or sanitation. The latter, as largely private investments by households, are improving but suggest there is demand and need for more public support to accelerate progress particularly in sanitation and the associated public health hazards of open defecation.

Welfare analysis reveals three key findings. First, welfare is, on average, improving. Second, welfare measures markedly determine the rate of progress. Third, households with no male adults are most vulnerable and most likely to suffer deprivation. For all groups, and by all welfare measures, life seems to be getting better. Multidimensional welfare for all groups has fallen by almost 20 percentage points in three years, which is remarkable progress, and, if sustained, would substantially reduce welfare deprivations in five years. However, measurement matters. Subjective welfare is stickier with limited to no progress recorded by all households, if asked directly. They feel no better off and while it is a crude and somewhat arbitrary measure, unless one dismisses poor people's own perceptions, it provides evidence that all is not well as it may seem.

The transitions' analysis is helpful to examine the intensity and stability of welfare by the different measures across groups. The multidimensional index paints a more optimistic picture with less than one in ten households as 'poor' and a one in two chance of exiting from one period to the next. Equally, for the non-poor, there is a fairly low chance (19%) you will fall into poverty in the next period. This stable and progressive position is contrasted by the subjective view which suggests lower welfare is the norm with a lower chance of exiting poverty (34%). Low subjective welfare is three times more common than the multidimensional measure (27% vs. 9%). If you are subjectively poor in one period, then the chances are you will remain poor in the next period (66% chance). For households with no male adults the situation is most acute. The transition from non-poor to poor doubles for these households from the multidimensional index (24%) to subjective welfare (49%) measures. While the two measures are estimating different aspects of welfare space from

quantifiable assets or services to personal perceptions, the policy implication is clear that they are not equivalent and assuming improving all assets in the index leads to a perception of higher welfare is not justifiable. This supports our proposition that the Sustainable Development Goals will have varying importance subject to the local context and priorities of the poor.

We formally test this position through the modelling of both welfare measures. The results indicate relative conformity to four priority welfare domains – (a) education, (b) energy, (c) drinking water, and (d) sanitation. Increasing education attainment from primary to secondary would provide significant and positive welfare returns; this substantiates government policy and reflects the current low and unsatisfactory transition from primary completion to secondary completion. Despite public commitments to meet higher education goals, progress here, and across Kenya (Kikechi et al., 2012), has been slow and uneven with the cost burden of maintaining children in secondary schools too high for many families.

Increasing energy access also provides a high and positive welfare impact either for grid or solar supplies. While the study area has had major growth in electricity network investments over the last four years with the national connections nearly doubling up from 26 per cent to 46 per cent, rural countrywide average connections remain at a low of 5 per cent (KPLC, 2013; Power Africa, 2015). The cost and speed of household-level connections was perceived as relatively high, USD 325. To increase the number of rural connections a new connectivity model was launched that allows users to pay USD 150 upfront and the balance in instalments over 36 months. This placed Kenya ahead of other African countries in terms of expansion of off-grid energy solutions. While the major push has been in small towns in initial phases with

higher unit costs and multiple services (lighting, phone-charging, tv, radio), many companies are now targeting rural areas which is illustrated by the uptake by one in ten of our sample. Off-grid solar is commonly supplied with a pay-as-you-go model with an initial down payment. This is a flexible and popular approach but does not address the wider energy gap for cooking. Fuelwood remains the dominant energy source for cooking for nine out of ten of our households with associated biodiversity and carbon externalities. With major interest in green climate funds, there is the opportunity to think strategically about a sustainable and affordable solution to combine private investments with public finance to accelerate progress to universal energy.

Drinking water services are a third welfare priority. Across the models, reliability and piped water supplies emerge as a bundle of welfare-enhancing interventions. Affordability and proximity are positively associated with welfare change, but they are not significant in both models. The increasing coverage of piped water systems is reinforced by these findings with the associated finding that reliability of systems promotes welfare too. The latter is a consideration for the majority access to handpumps which are known to have challenges under community management (Chowns, 2015; Hope, 2015; Koehler et al., 2015) with evidence from the study area that handpump failures often take weeks or months for repairs when left solely to the community (Foster & Hope, 2016). Welfare interventions may consider sequencing investments in piped supplies for higher population density areas, such as the coast or Ukunda, with greater support for ensuring reliability of handpumps in more remote and lower density communities.

Finally, a large, significant and negative impact on household welfare is practicing open defecation. While there is evidence of major reductions in open defecation over the three-year period, the practice is associated with welfare loss. Current behaviour is higher amongst households without adult males, which are also most deprived and of lower education attainment. This provides a strong case for public policy support rather than assuming private investments will be sufficient. The public health implications are well-documented of failing to provide comprehensive coverage at a community, or relevant geographic area (Cairncross & Valdmanis, 2006; Curtis & Cairncross, 2003; Hammer & Spears, 2016; Luby, 2014). The positive spillovers of eliminating open defecation will disproportionately accrue to vulnerable groups, including children, as well as improving environmental health with likely reductions in health expenditure. The case for public investment is compelling.

Policy action to address these welfare-enhancing domains will be moderated by Kenya's decentralized government structures (World Bank, 2013). For example, education and energy are national responsibilities with water and health managed at the county level. The process of coordination and collective responsibility is recognized though political structures at the national and county level may mean these processes vary by county. Wider agency support can facilitate these emerging government structures at the county level which have started their second term in 2017. For example, the Water Sector Trust Fund is a nationally incorporated entity within the Ministry of Water and Irrigation and recognized in the 2016 National Water Act to support drinking water services for non-commercial (rural) areas where poverty is high. With significant bilateral donor support this agency has the mandate and funding to support county governments deliver on welfare-enhancing interventions

consistent with the constitutional right to safe drinking water for every Kenyan citizen. Other agencies and mechanisms, such as Kenya Medical Research Institute and the Energy Regulatory Commission, exist to support equivalent interventions and policy development for health and energy in alignment with constitutional commitments and the Sustainable Development Goals.

6.5 Conclusion

Progress to achieve and sustain the Sustainable Development Goals presents significant financial, operational and institutional challenges in Africa. Uneven and often unsatisfactory progress in the Millennium Development Goal era suggests a more pragmatic set of goals which meet social priorities to offer a cost-efficient, welfare-enhancing and politically appropriate approach. Trying to do everything is simply not realistic and, likely, counter-productive. Alternatively, identifying a sub-set of targets which maximise welfare for the most vulnerable would be consistent with social justice goals (John Rawls, 1971) and constitutional requirements. We argue that traditional multidimensional welfare metrics may be misleading and fail to adequately represent varying welfare intensity and stability of vulnerable groups. We make the case for the application of subjective welfare measures as a validation and triangulation tool at limited to no cost in most surveys. This approach identifies potentially deeper-rooted welfare concerns and point to interventions which satisfy both multidimensional and subjective welfare priorities. Education, energy, water and sanitation are well-rehearsed development priorities which this analysis supports as candidate interventions in this study. Kenya's newly decentralized government structures pose opportunities and limits in coordinated responses which will likely require facilitation

by other agencies to ensure and support action to deliver and sustain sustainable development outcomes.

6.6 Notes

1. While making inferences as to which of the two models to use, some researchers advice using certain statistical tests of heterogeneity such as the Hausman-Taylor test (Arellano & Bond, 1991; Hausman & Taylor, 1981), a standpoint which is strongly contested on grounds that it tends to over reject the null hypothesis. Other studies suggest an alternative decision making processes, which we considered in this study, based on the factors described by Borenstein et al., 2010. This approach helped to decide on which model fit the distribution of effect sizes and takes account of the relevant error sources, based on the nature of the data at hand as well as the process of data collection.
2. We acknowledge two limitation to the study;
 - a. First, the surveys were not conducted in the same weather season and the time intervals between the surveys was not constant. The first survey was conducted late Nov 2013 to Jan 2014, the second survey was conducted in Mar-May 2015 and the third survey conducted in Sep-Nov 2016.
 - b. Second, not all dimensions of poverty in literature were used as explanatory variables, some of the missing variables include employment, age of respondent, broader aspects of health beyond diarrhoea, among others.

7 CONCLUSION

7.1 Motivation

This thesis is motivated by the Sustainable Development Goals and the extent to which water may play an important but often unquantifiable role in improving welfare in challenging environmental contexts, such as rural Africa. The research provides conceptual and empirical contributions exploring the links between water and welfare to inform policy choices in rural water service delivery, advancing knowledge in the assessment of multidimensional and subjective welfare metrics and measurements and modelling welfare transitions to prioritize sustainable development. To this end, the water-welfare framework is a tool to illustrate and examine the interactions between water resources, water services and welfare. The framework builds on the socio-ecological systems approach that requires identification and measurement of the relationships across multiple levels at different spatial and temporal scales (Millennium Ecosystem Assessment, 2005; Ostrom, 2009). Identification and measurement are central to understanding welfare transitions and is a contested area of development research where the thesis aims to provide new evidence and insights. Given the scale, scope, data availability and complexity of water and welfare relationships amid rapidly changing economic, environmental and political factors in the study area, the thesis focused on the relationship between groundwater resources for drinking and productive uses and welfare dynamics. These include groundwater extracted through handpumps and the drinking water services, and productive water uses for livestock and irrigation with an overarching theme of multidimensional welfare.

The study context of coastal Kenya does not claim to be representative of rural Africa but does exhibit many of the features of environment and development challenges where governments are trying to balance economic growth, environmental risks and poverty reduction. In Kwale county, as in much of rural Africa, achieving sustainable groundwater resources development for both domestic and commercial demands is compounded by environmental, economic and political factors. The application of the framework in coastal Kenya provides a relevant context to understand the role of waterpoints (handpumps) in the lives and livelihoods of rural people. The aspect of measuring multidimensional and subjective welfare was of specific focus as it estimated who the poor were, where they lived and how welfare changed over time. The findings provided insights into: (1) the role of multidimensional and subjective welfare measures in understanding welfare transitions (2) the overall association between water services and welfare with specific insights into the relationship between depth of groundwater and welfare and variations in level of access to water services by welfare categories and sex of the household head and finally (3) priority goals for sustainable development. The conceptual and empirical contributions and their implications are discussed below.

7.1.1 Welfare metrics and measurements

The starting point of assessing the associations between water and welfare was development of multidimensional welfare indices. While assessment of progress on the Sustainable Development Goals largely remains pegged on traditional poverty metrics of income and expenditure, there is a consensus that poverty is multidimensional. The poverty metric and measurements based on income and expenditure have been challenged for not

capturing the multidimensionality nature of poverty. The value and need to have accurate welfare metrics and measurements to track progress in developing countries has seen many methodologies developed to measure welfare using multidimensional indicators. One such metric is the multidimensional poverty index (Alkire & Foster, 2011) that received criticism due to its bold assumptions that all the dimensions of welfare considered in the metric have equal effect on the livelihoods of the person or household in question (Decancq & Lugo, 2013). This is the measurement problem that raises concerns over the intrinsic and instrumental importance of the indicators (Ravallion, 2011). The thesis tried to address this issue through development of multidimensional welfare indices with statistically generated weights. Findings from the thesis suggest that a dynamic multidimensional welfare index constructed from a smaller basket of indicators is feasible and could reasonably capture the temporal and spatial variations in welfare dynamics by household characteristics, education, wage earnings, basic consumable and sanitation facilities. The notion behind the fewer choice of indicators in the dynamic multidimensional welfare index is to improve the sensitivity of the index to short term changes in welfare likely to occur due to unprecedented environmental, economic and political factors.

The thesis also looked at an alternative measure that uses subjective assessment of welfare. There is increasing interest in this form of measurement as decision-makers seek to understand whether the formal welfare measurements correspond to the preferences of the people. This is of particular importance to policy and practice as decisions on interventions are based on formal poverty metrics. While the multidimensional and subjective welfare measurements differed in terms of empirical measurement, they converged in identifying

the priorities of the people. These priority goals for sustainable development were modelled using both multidimensional and subjective welfare measures and both approaches identified the same four priority goals needed for moving people out of poverty (these are discussed in detail in section 7.1.3). Furthermore, both the multidimensional and subjective welfare measures were able to identify patterns in welfare transitions albeit with diverging findings. The multidimensional welfare index identified about one in ten households as chronically poor while the subjective measure captured three times as many households. While both measures disagreed on how many households are chronically poor, they identified the existence of a group that might be left behind. The policy implications presented by these findings suggests the opportunity to use simpler welfare measures that are cost effective and applicable in understanding the impacts of the turbulent and rapidly changing environmental, economic and political factors. This make a case for investments in welfare monitoring to ensure interventions are properly targeted and reflect the needs of the people. While I do not claim that the multidimensional and subjective welfare measures developed and tested in this thesis are superior, they offer an intuitively simple approach to assessing the socio-economic status of households. They are capable of identifying who the poor are, where they are, what their needs may be, and welfare transitions.

7.1.2 Groundwater services and welfare

The multidimensional welfare indices were used in the identification and analysis of relationships between water and welfare among multiple levels at different spatial and temporal scales (Ostrom, 2009). Following Ravallion (2011) insights on the identification and measurement problem, different levels of water services from groundwater sources, mainly

handpumps, were assessed against welfare. Three significant findings on association between water and welfare were found: (a) groundwater services and characteristics account for less than a fifth of the variation in welfare (b) low welfare groups are dependent on shallow groundwater sources while increasing welfare is associated with deeper groundwater sources and (c) female-headed households and low welfare households are characterised by poor drinking water services. The policy implications are discussed below.

a) Groundwater services and welfare variation

The overall finding suggests that water resources characteristics and services emanating from the water infrastructure were associated with welfare but account for less than a fifth of the variation in welfare across different social groups. While this reaffirms the role of groundwater to welfare (MacDonald & Calow, 2009; Mukherji, 2005; Shah, 2004; Sharma et al., 2006), it also implies that water and welfare are interconnected in the sense that an intervention in one will directly or indirectly affect the other. While other strands of literature have partially demonstrated the benefits of productive use of groundwater to livelihoods through small-scale irrigation (Ghosh & Verma, 2012; Namara et al., 2013; Villholth, 2013), further empirical evidence in the thesis demonstrated broader associations of welfare with other uses such as livestock watering and drinking water services. This has implications for the decisions and approaches that should be taken to improve rural water services and reduce poverty. The evidence from this study provides a basis for the push towards development of better rural water supply models in rural Africa. The service models of choice will need to support ancillary investments to improve the affordability and reliability of rural water services to enhance welfare of the poor. Reliability of water

infrastructure is a widespread problem in rural Africa where over a quarter of all the drinking water infrastructure are non-functional (T. Foster et al., 2018). The model of choice will need to deliver effective maintenance of existing water infrastructure while ensuring that rehabilitations are apt. This will be important in ensuring no further welfare deteriorations occur as a result of failing drinking water infrastructure while reinforcing the positive impacts of improved water services on welfare.

b) Welfare and aquifer depth

The finding that low welfare groups were more dependent on the shallower groundwater sources while increasing welfare was associated with deeper groundwater usage suggests that the design and development of groundwater resources needs additional monitoring and regulation. The rationale here is that deeper boreholes tend to be more resilient to droughts and offer safer water compared to shallow boreholes that are more susceptible to contamination from pit latrines or fertilisers from agricultural fields (Baguma et al., 2017; Macdonald & Davies, 2000; Macdonald et al., 2009). These factors, combined, dictate the reliability and safety of the groundwater resources with potentially unforeseen consequences on welfare. What is not clear and warrants further investigations is whether having access to deeper aquifers potentially moves people out of poverty due to the inherent benefits of deep groundwater resources or whether it is the case that high welfare people simply have the resources to develop deeper groundwater resources making this finding a statistical artefact. Nevertheless, the international guidelines and standards for borehole drilling provide an opportunity here for sustainable groundwater development and subsequent poverty reduction (RWSN, 2010a). This is provided for within the water-welfare

framework where legal and policy frameworks can influence governance of water resources for sustainable management. Enacting or integrating such codes and practices within the legal frameworks of developing countries in sub-Saharan Africa will guide actors and stakeholders in the water sector to adopt sustainable groundwater development approaches resulting in substantial impact in the progress towards universal access to safe drinking water and subsequently poverty reduction.

c) Gender, welfare and water services

Findings highlighted two social groups that were of equal and particular concern; specifically, female-headed households and low welfare households. The majority of these households were observed to reside in areas with poor water services, poor transport infrastructure and limited access to health and education services. While low levels of welfare were observed to correlate with drinking water services that were unaffordable, unreliable and less safe, proximity to water infrastructure appeared welfare neutral. The latter is symptomatic of the historically poor water service provision in rural areas which saw governments taking the dominant role of investing in infrastructure construction with little to no efforts in maintenance of the existing infrastructure. This is similarly picked up by the global Joint Monitoring Programme where proximity to water infrastructure is seen to improve over the years but access to improved water services in terms of affordability, reliability, safe and accessibility still remains low (WHO & UNICEF, 2017b). While the Joint Monitoring Programme provide data to guide policy and practice in the water, sanitation and hygiene sector, the evidence here implies that those who lack improved water services are most likely the same people reported as poor in rural Africa. This finding is sobering as it provides

a basis for policy makers and institutions to merge both water and welfare datasets to better understand the underlying processes that influence progress in attainment of the Sustainable Development Goals. It also underlines the potential value of developing monitoring multidimensional and subjective welfare metrics for use within existing global frameworks that collect water, sanitation and hygiene data in developing countries. Furthermore, with the global push for equitable access to water services, the evidence shows that interventions that take the needs of female-headed households into account will be required to achieve gender-neutral outcomes, which appeal to donors and investors.

7.1.3 Priority goals for sustainable development

The role of water services in improving welfare in rural Africa will remain important. While the thesis investigated the conceptual and empirical associations between water and welfare, the multidimensionality nature of welfare suggests that other factors will be in play to either limit or accelerate sustainable development. The modelling results identified four priority goals necessary for poverty reduction, these include; (1) improving access to safely managed drinking water services, specifically addressing affordability and reliability of existing water infrastructure. (2) broadening access to secondary education while maintaining access to primary education. (3) increasing household energy access through expansion of the national electricity grid and small scale- solar power and (4) ending open defecation by improving broader access to basic sanitation services. These findings illustrate that water alone is just but one component of the complex interlinkages of welfare and its determinants. The priority goals identified are not exhaustive as there may be other factors at play not investigated by this thesis. Nevertheless, the findings suggest ancillary

investments in water, education, energy and sanitation will be required to support economic growth and poverty reduction.

While identification of the priority goals is a step forward towards economic growth and poverty reduction, expecting the government to take the lead on these issues may be overly optimistic. This is confounded by the fragmented nature of most government structures in rural Africa which places the Sustainable Development Goals under the mandate of different institutions with independent budgets and strategies. This complicates service delivery and slows down progress due to lack of coordination across these institutions (J. Koehler et al., 2018). This can however be achieved with the right partnerships, coordination and support from other stakeholders. Policy, legal and institutional arrangements in both water, education, energy and sanitation sectors will need to converge and identify strategies that benefit both goals of universal access to improved water services and poverty reduction (Mumma et al., 2011b). To guide and sequence strategies towards poverty eradication and universal access to improved drinking water services, policy will need to (1) ensure welfare measurements approximate the real situation on the ground and are consistent and tracked at a higher frequency to inform interventions (2) ensure the goal in universal access to improved drinking water services takes into account the potential positive and negative interactions with welfare and (3) ensure pragmatic sustainable development goals are prioritised given the rapidly changing environmental, economic and political factors.

7.2 Recommendations

The lessons from this research highlight important recommendations in coastal Kenya where the majority of the poor are characterised by poor public services in water, education,

energy, and basic sanitation, among others. While these recommendations are applicable in Kwale county, the methodology, approach and the water-welfare framework could be adopted by developing countries in the wider sub-Saharan Africa with modifications to suit the environmental, economic and political context.

1. First, recognise the value of multidimensional and subjective welfare metrics and measurements to inform policy and practice at the county and national level.

The current national and county governments' institutional framework does not provide for high frequency socio-economic monitoring data. Advancing socio-economic monitoring systems to track poverty and welfare related indicators at a higher frequency may help in understanding the underlying processes between water and welfare and improve service delivery. While the existing Demographic and Health Surveys and the Kenya Integrated Household Budget Surveys collect indicators suitable for welfare measurements, they have coarse temporal resolution of five and ten years, respectively. In addition, the asset-based welfare measurements are often ignored and not computed. The coarse temporal scale confounds meaningful analysis on the dynamics and transitions of welfare and effects of environmental, economic and political shocks on welfare dynamics. This presents a gap in information that would otherwise be important to inform policy priorities and guide targeted interventions for economic growth and development. Adoption of multidimensional and subjective welfare measures, assessed at a finer temporal resolution within the existing data monitoring frameworks will help track progress and appraise policy while ensuring interventions reflect the needs of the

vulnerable and the poor in the context of rapidly changing environmental, economic and political factors.

2. *Second, ensure interventions aimed at improving water services and poverty reduction target female-headed households and the poor*

Interventions are more often than not politically decided and implemented in rural Africa (Esteves, 2008; Esteves & Barclay, 2011) with outcomes expected to be gender-neutral. These interventions may end up disproportionately benefiting some groups while leaving others behind. Female-headed households tend to be more vulnerable and often neglected due to cultural and institutional factors (Hulme & Shepherd, 2003; Nilüfer Cagatay, 1998). From a policy perspective, specific interventions should target female-headed households and the poor to accelerate their access to improved water services and move them out of poverty.

3. *Third, make progressive investments in four policy priorities for sustainable development.*

Water, education, energy and sanitation are well-rehearsed development priorities which this thesis supports as candidate interventions in coastal Kenya. Kenya's newly decentralized government structures provide opportunities for and limits to coordinated responses which will likely require facilitation by other agencies to ensure and support action to deliver and sustain sustainable development outcomes. Four policy priorities include;

- a. improving access to safely managed drinking water services, specifically addressing reliability of existing water infrastructure,

- b. broadening access to secondary education while maintaining access to primary education,
- c. increasing household energy access through expansion of the national electricity grid and small scale- solar power and
- d. ending open defecation by improving broader access to basic sanitation services.

7.3 Opportunities for further research

1. Ancillary investments in water, health, education and energy need to be examined in detail to provide insights of the actual impacts and pathways to economic growth and development for different social groups over space and time.
2. The water-welfare framework explored only a fraction of the complex interaction between water and welfare. Future works can explore the feasibility of the framework to assess the wider interactions between other socio-ecological components to guide policy and practise.
3. Future work needs to advance and test the water-welfare framework in different context with varying environmental, economic and political factors to ascertain its replicability and robustness in assessing the associations between water and welfare to support interventions and appraise policy.

In conclusion, while the thesis identified quantitative differences between multidimensional and subjective welfare measurements, they are shown to converge in terms of identifying priority policy goals. Despite the well-known issues of bias from self-reported data, including income and expenditure, similar trends are observed between multidimensional and subjective welfare measures. This has implications on how policy identifies and measures welfare. I argue that simple and rapid data collection on multidimensional and subjective welfare measures, either indirectly or directly, may give reasonable estimates of welfare levels and transitions. Given coastal Kenya, as in many African countries, has infrequent welfare data, there is an opportunity for longitudinal data linked to interventions to be collected. The longitudinal welfare metrics may be used in a water-welfare framework to advance knowledge on the complex interactions between water resources and welfare to inform policy choices in rural water services delivery and poverty reduction. The welfare modelling results question the logic of isolated and independent Sustainable Development Goals targets and the need for decision makers to consider a basket of development interventions which prioritise the needs of the poor.

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9 APPENDICES

9.1 Declaration of authorship

I, Jacob Mutua Katuva, hereby declare that this thesis is my own work, except where otherwise stated.

Signed:

A handwritten signature in black ink, appearing to read 'J. Mutua', with a stylized flourish at the end.

Date:

9th April 2019

Place:

Oxford University, UK

Co-author agreements

Detailed contribution of co-authors for paper 1 (Chapter 4)

Title: Do the poor think they're poor? Welfare metrics, monitoring and mapping in Coastal Kenya

First Author: **Jacob Mutua Katuva** (School of Geography and the Environment (SoGE) and Smith School of Enterprise and the Environment (SSEE), University of Oxford)

Co-authors:

Rob Hope (SoGE, SSEE)

- Feedback for the development and framing of the paper
- Provided substantial edits and comments for the paper

I confirm that Jacob Katuva led the paper design and methodology, analysed the data, drafted the paper and managed the submission and revision process with my contributions as specified above.

Rob Hope, 10 th April 2019	
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Detailed contribution of co-authors for paper 2 (Chapter 5)

Title: Groundwater and welfare: A conceptual framework applied to Coastal Kenya

First Author: Jacob Mutua Katuva (School of Geography and the Environment (SoGE) and Smith School of Enterprise and the Environment (SSEE), University of Oxford)

Co-authors:

Rob Hope (SoGE, SSEE)

- Feedback for the development and framing of the paper
- Provided substantial edits and comments for the paper

Tim Foster (Institute for Sustainable Futures, University of Technology Sydney)

- Provided comments for the paper

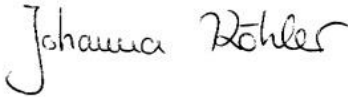
Johanna Koehler (SoGE, SSEE)

- Provided comments for the paper

Patrick Thomson (SoGE, SSEE)

- Provided comments for the paper

We confirm that Jacob Katuva led the paper design and methodology, analysed the data, drafted the paper and managed the submission and revision process with our contributions as specified above.

Rob Hope, 10 th April 2019	
Tim Foster, 9 th April 2019	
Johanna Koehler, 9 th April 2019	
Patrick Thomson, 10 th April 2019	

Detailed contribution of co-authors for paper 3 (Chapter 6)

Title: Modelling welfare transitions to prioritise sustainable development interventions in Coastal Kenya

First Author: **Jacob Mutua Katuva** (School of Geography and the Environment (SoGE) and Smith School of Enterprise and the Environment (SSEE), University of Oxford)

Co-authors:

Rob Hope (SoGE, SSEE)

- Feedback for the development and framing of the paper
- Provided substantial edits and comments for the paper

Tim Foster (Institute for Sustainable Futures, University of Technology Sydney)

- Provided comments for the paper

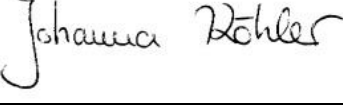
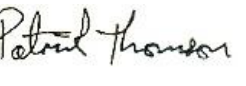
Johanna Koehler (SoGE, SSEE)

- Provided comments for the paper

Patrick Thomson (SoGE, SSEE)

- Provided comments for the paper

We confirm that Jacob Katuva led the paper design and methodology, analysed the data, drafted the paper and managed the submission and revision process with our contributions as specified above.

Rob Hope, 10 th April 2019	
Tim Foster, 9 th April 2019	
Johanna Koehler, 9 th April 2019	
Patrick Thomson, 10 th April 2019	

9.2 Kwale household survey questionnaire

Main Household Survey

Unique ID

Mwandishi [*name of enumerator*]

Date

Nambari ya handpump (bomba la maji) [*Handpump ID*]

Kijiji [*location/town/village*]

Je bomba linafanya kazi? [*Functionality status of handpump*]

- ✓ Ndio, linafanya kazi [*yes, it works*]
- ✓ Halifanyi kazi (chini ya mwaka moja) [*it does not work for less than one year*]
- ✓ Halifanyi kazi (zaidi ya mwaka moja) [*it does not work for more than one year*]

Name of 2015 respondent at this handpump / Previous respondent

Wave 1/2 previous respondents / Names 2015/ 2014

Nambari ya nyumba [*household number*]

Majina ya wengine wanoishi kwa numba hii [*Names of other household members*]

Introduction

Habari ya asubuhi/jioni, ninafanya utafiti kuhusu handpumps hapa Kwale nikiwa na ruhusa kutoka Wizara ya Maji na Baraza la kitaifa la Sayansi na Teknologia (National Council of Science and Technology). Jina langu ni _____ na mimi ni miongoni mwa watafiti wanaoongozwa na kampuni ya Rural Focus Ltd. *Good morning/day, I am doing research on handpumps here in Kwale with permission from the Ministry of Water and the National Council of Science and Technology. My name is _____ and I am among researchers led by the company Rural Focus Ltd.*

Tulikuja kwa nyumba yako mwaka wa (2013/2014/2015)? (Hakikisha). *Did we come to your house in 2013/2014/2015? (Make sure).*

Maelezo uliyotupa wakati huo yanasaidia sana kuimarisha usambazaji wa maji Kwale. Kwa mfano, mradi wa kurekebisha bomba za maji (hand pumps) kwa haraka umeanzishwa na unasaidia jamii nyingi. Tumerudi tena ili tupate maelezo zaidi kwa ajili ya kuimarisha mabadiliko na mda wa kurekebisha bomba za maji zikiharibika. Tunashukuru sana kwa usaidizi na mda wako. *The information you gave us at that time is very helpful in strengthening the Kwale water supply. For example, a handpump repair project has recently been developed and supports many communities. We have come back for more information for enhancing the change and timing of fixing the handpumps. We are very thankful for your support and time.*

Zoezi hili litachukua takriban dakika 30 na litatoa habari muhimu. *This exercise will take about 30 minutes and will provide important information.*

Maelezo utakayonipa yatakuwa ya siri na hakuna yeyote atakaye jua majibu yako. Maarifa haya yatapelekwa kwa Wizara ya maji ama unaweza nipigia simu kujua matokeo kwa hii namba 0719723000. *The information you give me will be confidential and no one will know your answers. This knowledge will be send to the Ministry of Water or you can call this number for the results: 0719723000.*

Kushiriki kwa hili zoezi ni kujitolea na kama kuna maswali hautataka kujibu nitayaruka ama pia unaweza simamisha zoezi zima wakati utataka lakini natumai utashiriki katika hili zoezi kwa sababu maoni yako ni ya muhimu mno. *Sharing for this exercise is optional and if there are questions you will not want to answer I'll jump or you can stop the whole exercise when you want but I hope you'll participate in this exercise because your comments are very important.*

Je, kuna mhusika mwenye umri zaidi ya miaka 18?

Is there a respondent present at the household who is over 18 years? Kama la, umshukuru na uende kwa mwingine [If not, thank them and go to another]

- ✓ Ndio [yes]
- ✓ La [no] - Unavailable today (follow-up required)
- ✓ La [no] - Household moved closeby
- ✓ La [no] - Household permanently moved away

Conditional: if household moved closeby

Umeipata nyumba mpya (mahali alipo hamia)? *Found new location of household?*

- ✓ Ndio [yes]
- ✓ Ndio [yes] – but unavailable today
- ✓ La [no]

Chagua nyumba mpya iliyo karibu na utafute mhusika kwa hiyo nyumba.

If no, select a new household to interview in the vicinity.

Conditional: if household permanently moved away

Sababu ya familia kuhama? *Reason family has moved away?*

- ✓ Alipata kazi mahali pengine [*respondent found work elsewhere*]
- ✓ Alifiwa [*respondent was killed*]
- ✓ Nyumba iliharibika [*the house was damaged*]
- ✓ Shida za kijamii [*social problems*]
- ✓ Nyingenizo [*other*]
- ✓ Sijui [*don't know*]

Chagua nyumba mpya iliyo karibu na utafute mhusika kwa hiyo nyumba.

Select a new household to interview in the vicinity.

Je mhusika amekubali kushiriki? *Has the respondent agreed to participate?*

Kama la, umshukuru na uende kwa mwingine [*If not, thank them and go to another*]

- ✓ Ndio [*yes*]
- ✓ La [*no*]

Conditional: if respondent not willing to participate

Chagua nyumba mpya iliyo karibu na utafute mhusika kwa hiyo nyumba.

Select a new household to interview in the vicinity.

Je mhusika alishiriki katika utafiti wa hapo awali (2015)?

Is the respondent the same respondent as last time (2015)?

- ✓ Ndio [*yes*]
- ✓ La [*no*] - but same respondent as 2014
- ✓ La [*no*] - but an adult from the same household
- ✓ La [*no*] - it is a new household

About the Respondent

"Sasa ningependa kukuuliza maswali machache"

"Now I'm going to ask a few questions about you"

Hakikisha majina kamili ya mhusika?

Confirm respondent's name? ____

Jinsia ya mhusika

Respondent's gender

- ✓ Mume [*male*]
- ✓ Mke [*female*]

Umri wa mhusika

Respondent's age in years ____

IT APPEARS THE RESPONDENT IS BELOW 18. IS THIS CORRECT?

Yes - Skip to end of survey

No - Age was incorrectly entered (return to previous question)

Umefikia kiwango gani cha elimu?

Level of education you have reached?

- ✓ Hakuna [*none*]
- ✓ Chekechea [*kindergarten*]
- ✓ Shule ya msingi [*primary school*]
- ✓ Chuo cha Ufundi [*technical college*]
- ✓ Shule ya upili [*high school*]

- ✓ Chuo cha mafunzo [*college training*]
- ✓ Chuo kikuu [*university*]
- ✓ Hajui [*you do not know*]
- ✓ NR [*no response*]

Conditional: if primary school

Ulifikia darasa la ngapi? *Highest primary school class completed?*_____

Conditional: if secondary school

Ulifikia kidato cha ngapi? *Highest secondary school class completed?*_____

What is your main religion?

- ✓ Mkristo [*Christian*]
- ✓ Mwiislamu [*Muslim*]
- ✓ Hana dini [*Hana religion*]
- ✓ Ingingine [*other*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? *Specify if other*_____

Government

"Iwapo Serikali ya kaunti ingependa kusaidia kijiji hiki, ni mambo yapi matatu muhimu ambayo familia yako ingependekeza yafanywe". *If the County government would like to help this village, what are three important things that your family propose be done?*

Usimuelekeze mhusika. Chagua majibu 3 (Do NOT prompt. Tick only THREE)

____ *Concern 1 options:*

- Afya na huduma za afya [*health and health care*]
- Usafi (vyoo na upitishaji wa maji machafu) [*sanitation*]
- Usafiri na barabara [*transport and roads*]
- Usalama na uhalifu [*security and crime*]
- Huduma za umeme [*electrical services*]
- Kazi na ukosefu wa ajira [*work and unemployment*]
- Elimu [*education*]
- Usaidizi wa kilimo [*agricultural support*]
- Huduma za usamabazaji wa maji [*water supply services*]
- Nyenginezo [*other*]
- NR [*no response*]

____ *Concern 2*

____ *Concern 3*

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other*_____

Ni shirika gani la serikali linahusika na kushughulikia suala hili? *What level of government is involved in dealing with this issue?*

___ *Concern 1 options:*

- Serikali kuu [*central government*]
- Serikali ya Kaunti [*county government*]
- Serikali kuu na ya Kaunti [*central and county governments*]
- Nyenginezo [*other*]
- Sijui [*don't know*]
- NR [*no response*]

___ *Concern 2*

___ *Concern 3*

Je, unadhani kampuni ya Base na/ama KISCOL inachangia katika kuleta maendeleo kwa Kaunti? *Do you think Base and/or KISCOL contributes to development in the County?*

Chagua yote yatakayotajwa. *Tick ALL that apply.*

	Base	KISCOL	Neither	Sijui [DK]	NR
Afya na huduma za afya <i>Health and health services</i>					
Usafi (vyoo na upitishaji wa maji machafu na mazingira) <i>Sanitation</i>					
Usambazaji / upatikanaji wa maji <i>Water supply</i>					
Stima <i>Electricity</i>					
Barabara <i>Roads</i>					
Shule <i>Schools</i>					
Kazi <i>Jobs</i>					
Chakula <i>Food</i>					
Nyinginezo <i>Other</i>					

Kama ni nyenginezo, tafadhali fafana kwenya nafasi. *Specify if other.*___

Taja mambo matatu ambayo Serikali ya Kaunti imeimarisha tangu kuchaguliwa. *Name three things that the County government has maintained since devolution.*

___ *Response 1 options:*

- Usimamizi wa maji, mito, visima and chemichemi [*water management, rivers, wells and fisheries*]
- Usambazaji / upatikanaji wa maji kwa wanavijiji (bomba za maji) [*water supply / access to villagers (water pipelines)*]
- Stima kwa wanavijiji
- Stima kwa Kaunti
- Ujenzi na usambazaji wa kliniki na huduma za afya katika vijiji [*construction and distribution of clinics and health care in the villages*]
- Miundombinu ya shule [*school infrastructure*]
- Ubora wa elimu [*quality of education*]
- Kuleta kazi [*employment*]
- Miundombinu ya barabara [*road infrastructure*]
- Nyenginezo [*other*]
- Hamna [*none*]
- Sijui [*don't know*]
- NR [*no response*]

___ Response 2

___ Response 3

Ni mambo gani yanakukera kuhusu hali ya usambazaji wa maji.

Usimuelekeze mhusika. Chagua yote yatakayotajwa. (*Do NOT prompt. Tick ALL that apply*).

- ✓ Maji yanasambaziwa mbali sana [*too far*]
- ✓ Maji hayatoshi kwa matumizi ya nyumbani [*insufficient water for domestic use*]
- ✓ Maji hayatoshi kwa kilimo [*insufficient water for farming*]
- ✓ Maji hayatoshi kwa mifugo [*insufficient water for livestock*]
- ✓ Usambazaji wa maji ni ghali [*water supply is expensive*]
- ✓ Maji si salama kwa kunywa [*water is not safe to drink*]
- ✓ Hakuna mahali pa kuhifadhi maji nyumbani [*no place to store water at home*]
- ✓ Usambazaji wa maji haitegemeeki
- ✓ Maji ni ya msimu
- ✓ Mlolongi wa kupata maji ni mrefu sana
- ✓ No concern
- ✓ Nyenginezo [*other*]
- ✓ NR [*no response*]

Conditional: if other

Mambo mengine yanayokera kuhusu usambazaji wa maji? Other concern relating to water supply___

About the Household Members

"Ningependa kukuuliza kuhusu watu wengine wanaoishi katika nyumba yako"

"Now I'm going to ask you about other members of your household"

Je, ni watu wengine wangapi wanaoishi katika nyumba yako? *What is the number of other people in your household?* (Mhusika asiwe katika idadi ya wanaoishi katika hiyo nyumba. Jumlisha wote wanaokula ama wanaolala kwa hiyo nyumba).____

"Tuanze na yule mkubwa ki umri"

"Let's start with the oldest member of your household"

Jina la kwanza? First Name____

Jinsia? Gender?

- ✓ Male
- ✓ Female

Umri wake? Age in Years____

Under 5? Autoresponse

Conditional: if <24

Je amehudhuria shule mwaka jana 2015? *Did they attend school last year 2015?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if >15

Anafanya kazi gani? *Job status?*

- ✓ Ameajiriwa [employed]
- ✓ Kibarua
- ✓ Amejiajiri mwenyewe [self-employed]
- ✓ Anasoma
- ✓ Hana kazi [does not work]
- ✓ Zinginezo [other]
- ✓ NR [no response]

Conditional: if >4

Amefikia kiwango gani cha elimu? *What level of education have they reached?*

- ✓ Hakuna [none]
- ✓ Chekechea [kindergarten]
- ✓ Shule ya msingi [primary school]

- ✓ Chuo cha Ufundi [*technical college*]
- ✓ Shule ya upili [*high school*]
- ✓ Chuo cha mafunzo [*college training*]
- ✓ Chuo kikuu [*university*]
- ✓ Hajui [*you do not know*]
- ✓ NR [*no response*]

Conditional: if primary school

Ulifikia darasa la ngapi? *Highest primary school class completed?*____

Conditional: if secondary school

Ulifikia kidato cha ngapi? *Highest secondary school class completed?*____

Conditional: if <15

Sasa nitakuuliza kuhusu hali yake ya afya (1)

"Now I'm going to ask you about the health of [NAME]"

Je, amewahi kuharisha ndani ya wiki mbili zilizopita (Kuwa na choo chepesi (kuhara) mara tatu au zaidi kwa siku)? *Has he/she had diarrhea in the last 2 weeks (loose stool three or more times a day)?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if yes

Je, kulikuwa na damu kwenye kinyesi? *Blood in stools?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Je, amewahi kuwa na ugonjwa wa kisonono/kichocho ndani ya mwezi uliopita? *Has he/she every had schistosomiasis or blood in urine in the last month?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Je, amewahi kuwa na ugonjwa wa kukohoa ndani ya wiki mbili zilizopita? *Has he/she ever had a cough in the last 2 weeks?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if yes

Alipokuwa na ugonjwa wa kukohoa je, alikuwa akipumua karaka kuliko au kupata ugumu wa kupumua? *Did he/she breath faster than usual with sport, rapid breaths or have difficulty breathing?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, ana ugonjwa wowote wa ngozi? *Does he/she have any skin infections?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Ndani ya kipindi cha wiki mbili zilizopita je alikuwa na madhara katika macho yake? *Has he/she had eye infection in the last 2 weeks?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, ameugua malaria mwaka uliopita? *Has he/she had malaria in the last 12 months?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Are there other household members? If so, now ask about the next oldest person in the household.

Income and Employment

Sasa ningependa kukuuliza maswali kuhusu kuajiriwa au mapato yako.

"Now I'm going to ask you about your income/employment"

Je, unafanya kazi gani? *What kind of job are you doing?*

- ✓ Ameajiriwa [*hired*]
- ✓ Kibarua [*laborer*]
- ✓ Amejiajiri mwenyewe [*self-employed*]
- ✓ Anasoma
- ✓ Hana kazi [*does not work*]
- ✓ Zinginezo
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? *Specify if other*_____

Conditional: if self-employed or does not work

Mhusika anajipatia mapato kwa nija gani? *What work?*

- ✓ Ukulima [*farming*]
- ✓ Uvuvi [*fishing*]
- ✓ Biashara ndogo ndogo [*small business*]
- ✓ Usaidizi kutoka kwa jamaa [
- ✓ Nyenginezo [*other*]
- ✓ NR [*no response*]

Conditional: if self-employed or does not work

Je, alipata au kupokea malipo au fedha kwa siku, kwa wiki au kwa mwezi? *Did you receive money or get paid per day, per week or per month?*

- ✓ Kwa siku [*per day*]
- ✓ Kwa wiki [*per week*]
- ✓ Kwa mwezi [*per month*]
- ✓ Other
- ✓ NR [*no response*]
- ✓ Sijui [*don't know*]

Conditional: if per day/week/month

Fedha alizopokea au kulipwa kwa siku? *Money received or paid per day/week/month?*_____

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? *Specify if 'other'?*_____

Conditional: if other

Fedha alizopokea au kulipwa kama ni nyinginezo? *Payment per other time period?*_____

Health

Je, watu katika nyumba yako wakiwa wogonjwa huenda kliniki aghalabu mara ngapi?

How often do members of your household go to a medical facility when they are sick?

- ✓ Kawaida [*common*]
- ✓ Mara kwa mara [*regularly*]
- ✓ Si sana
- ✓ Wakati wamezidiwa sana
- ✓ Hawaendi kliniki/hospitali [*do not go to clinic / hospital*]
- ✓ Wanaendelea na matibabu [*undergoing treatment*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Ni kliniki/hospitali gani wao huenda? *Which medical facility do they go to?*_____

Kuna nyakati ambazo afya ya watu wazima na watoto zaidi ya miaka 5 katika familia yako hudhoofika kwa sababu ya magonjwa yafuatayo? *Are there times when the health of adults and children over 5 years in your family is weakened due to the following diseases?*

	Malaria	Kuhara	Kukohoa/Kupumua vibaya	Kugonjeka ngozi / macho	Kisonono / kichocho
Msimu wa mvua <i>Wet season</i>					
Msimu wa kiangazi <i>Dry season</i>					
Mwisho wa kiangazi <i>End of dry season</i>					
Wakati bomba la maji limeharibika <i>When HP breaks</i>					
Nyinginezo <i>Other time</i>					

Kuna nyakati ambazo afya ya watoto chini ya miaka 5 katika familia yako hudhoofika kwa sababu ya magonjwa? Are there times when the health of children under 5 years of age in your family is weakened due to the following diseases?

	Malaria	Kuhara	Kukohoa/Kupumua vibaya	Kugonjeka ngozi / macho	Kisonono / kichocho
Msimu wa mvua <i>Wet season</i>					
Msimu wa kiangazi <i>Dry season</i>					
Mwisho wa kiangazi <i>End of dry season</i>					
Wakati bomba la maji limeharibika <i>When HP breaks</i>					
Nyinginezo <i>Other time</i>					

Conditional: if other

**Kama ni nyenginezo, tafadhali fafana kwenye nafasi? Specify if
other____**

Ni mabadiliko gani mazuri yamechangia kuboresha afya yako katika mda wa miezi 12 iliyopita?

What has changed positively to improve your family's health in the last 12 months? Tick ALL that apply.

- ✓ Hakuna mabadiliko [*no change*]
- ✓ Mafunzo katika elimu ya afya [*training/education about health*]
- ✓ Kuongezeka kwa fedha ninazopata [*increased earnings*]
- ✓ Umbali wa kliniki kupungua [*shorter distance to a clinic*]
- ✓ Kuboreka kwa huduma za kliniki [*improved clinical services*]
- ✓ Kuboreka kwa upatikanaji wa vifaa vya usafi [*improved access to sanitaty facilities*]
- ✓ Kuboreka kwa upatikanaji wa maji ya matumizi nyumbani [*improved access to water for household use*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if training/education about health

Nani aliwaelimisha juu ya fya? *Who provided the education/training on health practices?*

- ✓ Serikali kuu [*central government*]
- ✓ Serikali ya Kaunti [*county government*]
- ✓ Shirika lisilo la Kiserikali [*NGO*]
- ✓ Jamaa wa vijijini [*indigenous rural people*]
- ✓ Nyinginezo [*other*]
- ✓ DK [*don't know*]
- ✓ NR [*no response*]

Conditional: if increased earnings

Je, kuongezeka kwa fedha unazopata kumewasaidia aje? *How has more household income helped? Tick all that apply.*

- ✓ Serikali kuu [*central government*]
- ✓ Serikali ya Kaunti [*county government*]
- ✓ Shirika lisilo la Kiserikali [*NGO*]
- ✓ Jamaa wa vijijini [*indigenous rural people*]
- ✓ Nyinginezo [*other*]
- ✓ DK [*don't know*]
- ✓ NR [*no response*]

Conditional: if shorter distance to a clinic or improved clinical services

Nani alichangia katika ujenzi/uboreshaji wa kliniki? *Who funded the building/improvement of the clinic?*

- ✓ Serikali [*government*]
- ✓ Base Titanium
- ✓ KISCOL
- ✓ Nyinginezo [*other*]
- ✓ NR [*no response*]

Conditional: if improved clinical services

Ni sababu gani zimechangia kuimarika kwa kliniki? *Which factors contribute to improved clinic conditions? Tick all that apply.*

- ✓ Daktari na wauguzi kuongezeka [*increase in number of doctors and nurses*]
- ✓ Dawa kuongezeka [*pharmaceuticals increase*]
- ✓ Mda wa kingojea kutibiwa kliniki umepungua [*waiting times for treatment have decreased*]
- ✓ Nyinginezo [*other*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? Specify if other___

Conditional: if improved access to water

Nini iliboresha upatikanaji wa maji? What improved your water supply access? Tick all that apply.

- ✓ Bomba la maji kuwa karibu [*water tap is now available*]
- ✓ Urekebishaji wa bomba la maji uko haraka [*fast repair of pipeline*]
- ✓ Upatikanaji wa maji safi katika sehemu zingine mpya [*new access to clean water*]
- ✓ Fundifix Kwale / Kwale Handpump Services Ltd.
- ✓ Nyinginezo [*other*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? Specify if other___

Ni changa moto gani za ki afya nyumba yako hupata? What health-related challenges does your household face? Tick ALL that apply

- ✓ Kliniki ziko mbali [*clinics are far away*]
- ✓ Bei ya matibabu iko juu [*the price of treatment*]
- ✓ Bei ya dawa iko ghali sana [*the price of medicine*]
- ✓ Huduma za kliniki zimedhoofika [*worsened clinical services*]
- ✓ hamna [*none*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? Specify if other___

Household Assets

Je, nyumba yako ina vitu vifuatavyo? Does your home have the following items?

	Ndio [yes]	La [no]	NR [no response]
Umeme [<i>electricity connection</i>]			
Sola [<i>solar panel</i>]			
Televisheni / Runinga [<i>television</i>]			
Kompyuta / Tarakilishi [<i>computer</i>]			
Redio [<i>radio</i>]			

Baiskeli [<i>bicycle</i>]			
Pikipiki [<i>motorcycle</i>]			
Dhow [<i>dhow</i>]			
Simu ya mkononi / rununu [<i>mobile phone</i>]			

Je, nyumba yako ina vitu na vyakula vifuatavyo? *Does your home have the following food items?*

	Ndio [<i>yes</i>]	La [<i>no</i>]	NR [<i>no response</i>]
Mafuta ya kupikia [<i>cooking oil</i>]			
Sukari [<i>sugar</i>]			
Unga [<i>flour</i>]			
Majani chai [<i>tea leaves</i>]			
Sabuni [<i>soap</i>]			

Conditional: if have mobile phone

Je, kuna mtu yeyote wa nyumba hii amewahi tuma au kupokesa pesa kutumia simu ya mkononi kwa mwaka uliopita? *Has anyone in the household sent or received money by mobile phone for the past year?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ NR [*no response*]

Conditional: if have cooking oil

Unatumia nini kupikia? *Type of fuel used for cooking?*

- ✓ Umeme [*lightning*]
- ✓ Gesi [*gas*]
- ✓ Mafuta ya taa [*kerosene*]
- ✓ Makaa [*hearth*]
- ✓ Kuni [*wood*]
- ✓ Nyasi [*grass*]
- ✓ Mahunzi (Maguguta)
- ✓ Mavi ya ngombe [*cattle dung*]
- ✓ Hatupiki
- ✓ Nyinginezo [*other*]
- ✓ NR [*no response*]

Mnatumia choo cha aina gani? *Type of toilet facility used?*

- ✓ Choo cha kusukuma kwa kupitia bomba [*toilet to piped system*]
- ✓ Choo cha kusukuma kwa kupitia tangi [*toilet to tank*]
- ✓ Choo cha kusukuma hadi kwenye shimo [*toilet to pit*]

- ✓ Shimo la choo lenye hewa nzuri [*pit latrine with good air*]
- ✓ Choo cha shimo kilichojengewa [*built pit latrine*]
- ✓ Choo cha ndoo [*toilet bucket*]
- ✓ Choo cha kuhifadhi mbolea
- ✓ Choo kando kando ya maji
- ✓ Hakuna choo/ Choo cha msituni/uwanjani [*no toilet, use bush*]
- ✓ Nyinginezo [*other*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi? Specify if other_____

Je, mnatumia hiki choo pamoja na watu wengine? *Share toilet with other households?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ NR [*no response*]

Conditional: if share toilet

Kama ndio, mbali na nyumba yako, ni ngapi zingine zinatamia choo hiki? *How many other households share the facility?*_____

Je, mnamiliki ardhi ya nyumba hii? *Does the household own the land on which the dwelling sits?*

- ✓ Tunamiliki [*we own it*]
- ✓ Tumekodi ardhi [*don't own or have consent, just living on it*]
- ✓ Hatukukodi-tumepewa kwa ridhaa
- ✓ Hatukukodi-ni maskwata [*we don't own it but we have consent to live*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Mnamiliki hekari ngapi za shamba? *How many acres of land are owned by the household?*_____

Kuna yeyote anaelima? *Does the household grow any crops?*

- ✓ Ndio, mimea hukuzwa kwa ajili ya matumizi ya nyumbani [*yes, plants are grown for home use*]
- ✓ Ndio, mimea hukuzwa kwa ajili ya kuuza [*yes, plants are grown for sale*]
- ✓ Ndio, mimea hukuzwa kwa ajili ya matumizi ya nyumbani na pia kuuza [*yes, plants are grown for home use and sale*]
- ✓ La [*no*]
- ✓ NR [*no response*]

Conditional: if plants grown for sale

Je mnakuza miwa kwa ajili ya KISCOL? *Does household grow sugarcane for KISCOL?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Ni hekari ngapi zilizopandwa miwa kwa ajili ya KISCOL? *How many acres under sugarcane for KISCOL?*_____

Je, mnamiliki mifugo wa aina yoyote? *Does the household own any kind of livestock/herd?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Mna ng'ombe wa kienyeji wangapi? *Number of indigenous cattle?*_____

Conditional: if yes

Mna ng'ombe wa maziwa wangapi? *Number of dairy cattle?*_____

Conditional: if yes

Mna ng'ombe wa kulima wangapi? *Number of oxen?*_____

Conditional: if yes

Kuku wangapi? *Number of chickens?*_____

Wealth and Expenditure

Sasa ningependa kujua kiwango cha pesa nyumba yako inatumia kwa vitu kadha wa kadha.

"Now I would like to know how much money you spend on different things"

Matumizi ya nyumbani kwa wiki/mwezi uliopita. Kama hakuna matumizi, andika 0 (sufuri). Spending for home use per week/month. If no use, write 0.

Kitu [item]	Kiasi cha pesa [Amount Kshs]	Per day/week/month
Chakula [food]		
Usafiri [transport]		
Matibabu / Dawa [health / medicine]		
Karo ya Shule [school fees]		
Maji [water]		
Matumizi kwa umeme na nguvu ya kupikia (kuni, makaa n.k) [energy]		
Matumizi kwa simu [mobile phone]		

Kwa ujumla, utasema familia yako ni tajiri, inajiweza au ni maskini? Does household think they are well-off, average or not well-off in terms of assets and income?

- ✓ Tajiri [rich]
- ✓ Inajiweza [average]
- ✓ Maskini [poor]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je hali ya maisha ya nyumba yako ni bora Zaidi, hamna mabadiliko mbaya zaidi ikilinganishwa na mwaka jana? Does household think they are better-off, the same or worse-off than last year?

- ✓ Better-off
- ✓ Same
- ✓ Worse-off

Conditional: if better-off or worse-off

"Sasa ningependa tuzumzie kuhusu sababu ya kuboreka au kudhoofika kwa familia yako tukilinganisha na mwaka jana. Ni sababu gani mabadiliko hayo yametokea?" "Now I would like to know about the cause of the improving or worsening of your household compared to last year. What is the reason for this change?"

Je, kumekuwa na kifo, magonjwa, au watoto kuzaliwa? *Have there been deaths, diseases or births?*

	Male adult	Female adult	Male child	Female child	No change
Vifo [<i>Deaths</i>]					
Ugonjwa mkuu [<i>Serious illness</i>]					
Watoto kuzaliwa [<i>Births</i>]					

Je, nyumba yako ina kiasi cha mali sawa na ya mwaka jana? *Does your house have the same amount of assets last year?*

	More	Less	No Change
Shamba [<i>land</i>]			
Mifugo [<i>livestock</i>]			
Uvuvi [<i>fishing</i>]			
Biashara ya usafiri [<i>transport</i>]			
Ukulima [<i>farming</i>]			

Je, kuna mabadiliko yoyote makubwa katika mapato au matumizi ya nyumbani kulingana na mwaka jana? *Is there any major change in income or home use compared to last year?*

	More	Less	No Change
Pesa kutoka kwa wanafamilia [<i>remittances</i>]			
Pesa kutoka kwa serikali/shirika lisilo la kiserikali [<i>cash transfers</i>]			
Mabadiliko katika ajira [<i>change in employment</i>]			
Malipo ya shule [<i>school fees</i>]			
Bei ya chakula [<i>food prices</i>]			

Je, kumekua na mabadiliko yoyote kwa huduma nyumba yako hupokea? *Has there been any change in the services your home receives?*

	Better	Worse	No Change
Huduma ya maji ya kunywa [<i>drinking water services</i>]			
Huduma ya afya [<i>health services</i>]			
Huduma ya elimu [<i>education services</i>]			
Huduma ya usafi wa vyoo [<i>sanitation services</i>]			

Huduma ya usafiri wa barabara [road/transport]			
Huduma ya umeme/stima [energy services]			
Huduma za ulinzi [political stability/security]			

Mabadiliko mengine amabayo hatujayazungumzia? *Specify any other changes.*____

Water Sources

"Sasa nitakuuliza njia unazotumia kupata maji ya KUNYWA."

"Now I will ask you about how you get drinking water."

Wakati wa kiangazi, mnapata maji ya kunywa wapi? *Main source of drinking water in the dry season?*

- ✓ Reference handpump
- ✓ Handpump nyengine [other handpump]
- ✓ Mashine ya kupamp maji (ya umma) [public submersible pump]
- ✓ Mashine ya kupamp maji (ya binafsi) [personal submersible pump]
- ✓ Kisima kilichofunikwa (cha umma) [public protected well]
- ✓ Kisima kilichofunikwa (cha binafsi) [personal protected well]
- ✓ Kisima kilichowazi (cha umma) [public unprotected well]
- ✓ Kisima kilichowazi (cha binafsi) [private unprotected well]
- ✓ Maji ya ardini (mito, ziwa, kidimbwi, mito midogo, kishimo) [surface water (rivers, lakes, dams, small rivers)]
- ✓ Maji ya mfereji nyumbani [canal water at home]
- ✓ Maji ya mfereji kwa jirani [canal water for the neighbourhood]
- ✓ Mfereji wa umma [public canal]
- ✓ Gari la maji [truck vendor]
- ✓ Mkokoteni/baiskeli iliyo na madebe/ mitungi [bicycle vendor]
- ✓ Maji ya mvua [rainwater]
- ✓ Maji ya chupa [bottled water]
- ✓ Nyenginezo [other]

Conditional: if surface water

Ni mto gani unaotumia? *Which river to you use?*

- ✓ Mkurumudzi
- ✓ Ramisi
- ✓ N'Gade
- ✓ Pongwe Kidimu
- ✓ Mwena
- ✓ Mwakwembe
- ✓ Nyinginezo [other]

Conditional: if other

Kama ni nyenginezo, tafadhali fafana kwenye nafasi. *Specify if other.*____

Ni sababu gani zinazofanya uchague kupata maji ya kunywa kwa njia hiyo wakati wa kiangazi? *What factors make you choose to use this source in the dry season?*

Usimuelekeze mhusika. Chagua yote yatakayotajwa. *Do not prompt. Tick ALL that apply.*

- ✓ Iko karibu na nyumba [it is near the house]
- ✓ Ladha ya maji [the taste of the water]

- ✓ Harufu ya maji [*the smell of the water*]
- ✓ Rangi ya maji [*the colour of the water*]
- ✓ Usalama wa kunywa [##]
- ✓ Yananulika kwa bei nafuu [##]
- ✓ Ni bure [*it's free*]
- ✓ Yanategemeeka [##]
- ✓ Ndio njia ya pekee [*it's the only option*]
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Conditional: if any source other than reference handpump

Wakati wa kiangazi, maji haya ni salama kwa kunywa? Is water source safe to drink in dry season?

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if any source other than reference handpump

Unalipa pesa ngapi kutumia maji haya wakati wa kiangazi?

Kiasi cha pesa (Amount Kshs)	Jinsi ya malipo (Frequency)

Wakati wa masika, mnapata maji ya kunywa wapi? Main drinking water source in the wet season?

- ✓ Reference handpump
- ✓ Handpump nyengine [*other handpump*]
- ✓ Mashine ya kupamp maji (ya umma) [*public submersible pump*]
- ✓ Mashine ya kupamp maji (ya binafsi) [*personal submersible pump*]
- ✓ Kisima kilichofunikwa (cha umma) [*public protected well*]
- ✓ Kisima kilichofunikwa (cha binafsi) [*personal protected well*]
- ✓ Kisima kilichowazi (cha umma) [*public unprotected well*]
- ✓ Kisima kilichowazi (cha binafsi) [*private unprotected well*]
- ✓ Maji ya ardhini (mito, ziwa, kidimbwi, mito midogo, kishimo) [*surface water (rivers, lakes, dams, small rivers)*]
- ✓ Maji ya mfereji nyumbani [*canal water at home*]
- ✓ Maji ya mfereji kwa jirani [*canal water for the neighbourhood*]
- ✓ Mfereji wa umma [*public canal*]

- ✓ Gari la maji [*truck vendor*]
- ✓ Mkokoteni/baiskeli iliyo na madebe/ mitungi [*bicycle vendor*]
- ✓ Maji ya mvua [*rainwater*]
- ✓ Maji ya chupa [*bottled water*]
- ✓ Nyenginezo [*other*]

Conditional: if surface water

Ni mto gani unaotumia? Which river to you use?

- ✓ Mkurumudzi
- ✓ Ramisi
- ✓ N’Gade
- ✓ Pongwe Kidimu
- ✓ Mwena
- ✓ Mwakwembe
- ✓ Nyinginezo [*other*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Ni sababu gani zinazofanya uchague kupata maji ya kunywa kwa njia hiyo wakati wa masika? What factors make you choose to use this source in the dry season?

- ✓ Iko karibu na nyumba [*it is near the house*]
- ✓ Ladha ya maji [*the taste of the water*]
- ✓ Harufu ya maji [*the smell of the water*]
- ✓ Rangi ya maji [*the colour of the water*]
- ✓ Usalama wa kunywa [##]
- ✓ Yananulika kwa bei nafuu [##]
- ✓ Ni bure [*it’s free*]
- ✓ Yanategemeeka [##]
- ✓ Ndio njia ya pekee [*it’s the only option*]
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don’t know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Conditional: if any source other than reference handpump

Wakati wa masika, maji haya ni salama kwa kunywa? Is water source safe to drink in dry season?

- ✓ Ndio [*yes*]
- ✓ La [*no*]

- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if any source other than reference handpump

Unalipa pesa ngapi kutumia maji haya wakati wa masika?

Kiasi cha pesa (Amount Kshs)	Jinsi ya malipo (Frequency)

Kwa mwaka uliopita, ni njia gani mbadala munayotumia kupata maji ya kunywa wakati wa kiangazi na wakati wa masika? *For the past year, what alternatives did you use for drinking water during the dry season and wet season?*

	Dry season	Wet season
Handpump nyengine [<i>other handpump</i>]		
Mashine ya kupamp maji (ya umma) [<i>Submersible pump (public)</i>]		
Mashine ya kupamp maji (ya binafsi) [<i>Submersible pump (private)</i>]		
Kisima kilichofunikwa (cha umma) [<i>Protected well (public)</i>]		
Kisima kilichofunikwa (cha binafsi) [<i>Protected well (private)</i>]		
Kisima kilichowazi (cha umma) [<i>Unprotected well (public)</i>]		
Kisima kilichowazi (cha binafsi) [<i>Unprotected well (private)</i>]		
Maji ya ardhini (mito, ziwa, kidimbwi, mito midogo, kishimo) [<i>Surface water</i>]		
Maji ya mfereji nyumbani [<i>Piped to yard/dwelling</i>]		
Maji ya mfereji kwa jirani [<i>Piped to neighbour's yard/dwelling</i>]		
Mfereji wa umma [<i>Public tap / kiosk</i>]		
Gari la maji [<i>Tanker truck</i>]		
Mkokoteni/baiskeli iliyo na madebe/ mitungi [<i>cart/bicycle vendor</i>]		
Maji ya mvua [<i>Rainwater collection</i>]		
Maji ya chupa [<i>Bottled water</i>]		
Nyenginezo [<i>other</i>]		

Conditional: if surface water

Ni mto gani unaotumia? *Which river to you use?*

- ✓ Mkurumudzi
- ✓ Ramisi
- ✓ N'Gade
- ✓ Pongwe Kidimu
- ✓ Mwena
- ✓ Mwakwembe
- ✓ Nyinginezo [*other*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*__

Je, huwa mnatibu maji kabla ya kunywa? *Does household treat water before drinking?*

- ✓ La [no]
- ✓ Ndio - wakati wa kiangazi [yes – during the dry season]
- ✓ Ndio - wakati wa masika [yes – during the wet season]
- ✓ Ndio - nyakati zote [yes – always]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if yes

Ni nija gani mnayotumia kuyatibu maji ya kunywa? *Methods used to treat drinking water?* Tick all that apply.

- ✓ Kuchemsha [boiling]
- ✓ Kuongeza dawa
- ✓ Kuchuja na nguo [filter with cloth]
- ✓ Kutumia kichungio cha maji
- ✓ Kutumia miale ya jua
- ✓ Kuyaacha yatulie
- ✓ Nyenginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if boiling

Je, unatumia nija gani kuchemsha maji ya kunywa? *What fuel do you use to boil water for drinking?*

- ✓ Umeme [electricity]
- ✓ Gesi [gas]
- ✓ Mafuta ya taa [lamp oil]
- ✓ Makaa [coal]
- ✓ Kuni [##]
- ✓ Nyasi [##]
- ✓ Mahunzi (Maguguta) [##]
- ✓ Mavi ya ngombe [##]
- ✓ Hatupiki [##]
- ✓ Nyenginezo [other]
- ✓ NR [no response]

Conditional: if other

**Kama ni nyenginezo, tafadhali fafania kwenye nafasi.
*Specify if other.*__**

**Je, mbali na kunywa, una matumizi yapi mengine ya maji kutoka kwenye handpump?
*Other than drinking, do you use the handpump water for other uses?***

	Dry season	Wet season	NR
Kupika, kufua na kuonga [cooking, washing, bathing]			
Kunyunyizia mimea [irrigation]			
Kunywesha mifugo [livestock watering]			

Nani mwenye bomba la maji? *Who owns the reference handpump?*

Usimuelekeze mhusika. *Do NOT prompt.*

- ✓ Nyumba fulani [a certain house]
- ✓ Kikundi cha maji pamoja na kamitii [water committee]
- ✓ Jamii ya kijiji [village community]
- ✓ Shirika la kidini [religious organization]
- ✓ Shule [school]
- ✓ Kliniki [clinic]
- ✓ Chifu [chief]
- ✓ Serikali ya Kaunti [County government]
- ✓ Serikali kuu/Wizara/WRMA [Central Government / Ministry / WRMA]
- ✓ Coast Water Services Board
- ✓ KWAWASCO
- ✓ Shiriki lisilo la Kiserikali [NGO]
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Nani mwenye shamba lenye bomba la maji? *Who owns the land where the reference handpump is located?* Usimuelekeze mhusika. *Do NOT prompt.*

- ✓ Nyumba fulani [a certain house]
- ✓ Kikundi cha maji pamoja na kamitii [water committee]
- ✓ Jamii ya kijiji [village community]
- ✓ Shirika la kidini [religious organization]
- ✓ Shule [school]
- ✓ Kliniki [clinic]
- ✓ Chifu [chief]
- ✓ Serikali ya Kaunti [County government]
- ✓ Serikali kuu/Wizara/WRMA [Central Government / Ministry / WRMA]
- ✓ Coast Water Services Board
- ✓ KWAWASCO
- ✓ Shiriki lisilo la Kiserikali [NGO]
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]

- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Nani mwenye maji yanayopigwa kutoka kwa bomba la maji? Who owns the water drawn from the reference handpump? Usimuelekeze mhusika. Do NOT prompt.

- ✓ Nyumba fulani [a certain house]
- ✓ Kikundi cha maji pamoja na kamitii [water committee]
- ✓ Jamii ya kijiji [village community]
- ✓ Shirika la kidini [religious organization]
- ✓ Shule [school]
- ✓ Kliniki [clinic]
- ✓ Chifu [chief]
- ✓ Serikali ya Kaunti [County government]
- ✓ Serikali kuu/Wizara/WRMA [Central Government / Ministry / WRMA]
- ✓ Coast Water Services Board
- ✓ KWAWASCO
- ✓ Shiriki lisilo la Kiserikali [NGO]
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Nani anasimamia na kudumisha bomba la maji? Who manages and maintains your drinking water supply infrastructure?

- ✓ Mtu binafsi kutoka kwa kaya [individuals from the household]
- ✓ Kamitii ya bomba la maji [water committee]
- ✓ Kampuni ya kibinafsi (Fundifix, Kwale Handpump Services Ltd.) [private company]
- ✓ Serikali ya Kaunti [County government]
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Kwa maoni yako, ni nani unadhani anafaa kudumisha shina la maji ya kunywa? Who do you think would be best placed to maintain your drinking water supply infrastructure?

- ✓ Serikali ya kaunti/huduma za uma/kampuni ya kutoa huduma ya maji
- ✓ Muungano wa uma-na kampuni za kibinafsi [*the County government / service provider*]
- ✓ Kampuni za kibinafsi [*private companies*]
- ✓ Wana vijiji [*the villages*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Unadhani sahihi ni msimu wa kiangazi au wa mvua. *Right now, would you consider this to be dry season or wet season?*

- ✓ Msimu wa kiangazi [*seasonal*]
- ✓ Msimu wa mvua [*rainfall*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Reference Handpump

NOTE: All the following questions relate to the reference handpump.

Je, unaamini kuwa wale wenye maisha magumu katika jamii wanafaa kupewa maji bila kulipia katika handpump? *Do you think that the most vulnerable households (old, poor etc) of your community should have free access to water at the handpump?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, kuna amri/kanuni katika handpump hii inayo waruhusu msilipie maji wakati wa Ramadhan?

Is there a specific rule that you do not have to pay handpump user fees during Ramadhan?

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, handpump imerekebishwa kwa mwaka mmoja uliopita? *Has handpump been repaired in the last 12 months?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if yes

Mara ya mwisho iliporekebishwa, ilikaa siku ngapi bila kuhudumu? *Last time handpump was repaired, for how many days was it broken? ____*

Conditional: if yes

Malichanga pesa ngapi kwa ajili ya urekebishaji wa handpump? *How much money did your household contribute for these repairs? If no contribution enter '0'. ____*

Nani alirekebisha hand pump? *Who carried out the repairs?*

- ✓ Mmoja wa jamii ya Kijiji [someone from the village]
- ✓ FundiFix/Kwale Handpump Services Ltd. (Idd Mwaropia, Okoti Omayo)
- ✓ Mafundi wengine kutoka inje [other technicians]
- ✓ Sijui [don't know]
- ✓ NR [no response]
- ✓ Other

Conditional: if other

Kama ni nyenginezo, tafadhali fafana kwenye nafasi. *Specify if other.*____

Je, umeridhika na mpangilio unaotumika kwa urekebishaji wa handpump? *Currently how satisfied are you with handpump repair arrangements?*

- ✓ Nimeridhika sana [*very satisfied*]
- ✓ Nimeridhika [*satisfied*]
- ✓ Naona kawaida [##]
- ✓ Sijaridhika [*dissatisfied*]
- ✓ Sijaridhika kabisa [*very dissatisfied*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if satisfied

Mbona umeridhika? *Why are you satisfied?*

Chagua yote yatakayotajwa. Tick all that apply.

- ✓ Urekebishaji unafanyika haraka [*repair is quick*]
- ✓ Handpump haiharibiki kila wakati [*handpump is not often damaged*]
- ✓ Maekebisho sio ghali [*not expensive*]
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafana kwenye nafasi. *Specify if other.*____

Conditional: if dissatisfied

Mbona umeridhika? *Why are you satisfied?*

Chagua yote yatakayotajwa. Tick all that apply.

- ✓ Urekebishaji unafanyika polepole [*repair is slow*]
- ✓ Handpump inaharibika mara kwa mara [*handpump is often damaged*]
- ✓ Maekebisho ni ghali [*expensive*]
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafana kwenye nafasi. *Specify if other.*____

Je, ungependa handpump irekebishwe? *Would you like the handpump to be repaired?*

- ✓ Ndio [*yes*]

- ✓ Sijiali [*don't care*]
- ✓ La [*no*]
- ✓ NR [*no response*]

Conditional: if yes or don't care

Nyumba yako iko tayari kulipia pesa kiasi gani kwa ajili ya marekebisho ya handpump? *How much would you be willing to contribute to have the handpump repaired? (Kshs)_____*

Maintenance Service

Tumekua tukizungumzia kuhusu jamii yako na udumishaji wa hand pump. Jamii nyingi hazipendezwi na mda unaochukua kurekebisha hand pump zikiharibika. Kuimarisha matumizi ya hand pump, kampuni ya kibinafsi iliyosajiliwa imeajiri mafundi kutoka kwa jamii za huku ili kurekebisha hand pump zikiharibika kwa njia iliyo ya haraka na ya kiasili. huduma hii imekuwa ikiendelea huku Kwale na kila handpump imekua ikilipa shilingi 1000/- kila mwezi ili kupokea huduma hizi za kiasili, sasa tungependa kuona jamii nyingi zaidi zikijisajilisha ili kuboresha huduma ya maji katika kaya zao. *We have been talking about your community and the handpump. Most ### are not appreciated by the time it takes to repair the handpump. Stengthenning the use of the hanpump, a registered private company has hired technicians from the community to fix the handpump in a rapid and direct wat. This service has been continuing with Kwale and every handpump has been paying Kshs 1000 per month to receive these indigenous services, so we would like to see more communities sign-up to improve water services in their households.*

Je, unaafahamu kuhusu huduma hii ya udumishaji wa handpump (Fundifix/KHSL)? *Are you aware of this handpump maintenance service company?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Ulijuaje kuhusu mradi huu? *How did you hear of the company?*

Usimuelekeze mhusika. *Do not prompt.*

- ✓ Walirekebisha hand pump katika jamii yangu [*they fixed the hand pump in my community*]
- ✓ Walirekebisha hand pump katika jamii jirani [*they fixed the hand pump in neighboring communities*]
- ✓ Walirekebisha hand pump katika jamii ya mbali [*they fixed the hand pump in a distant community*]
- ✓ Nawajua Idd, Okoti na/au Banje [*I know Idd, Okoti or Banje*]
- ✓ Kusikia [*heard about it*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi.

Specify if other.____

Je, mmesajilisha bomba lenyu la maji na kampuni ya huduma ya urekebishaji ya Fundifix? *Has your handpump registered for the Fundifix maintenance service?*

- ✓ Ndio [yes]
- ✓ La [no]

- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if yes

Je, umeridhika kiwango gani na huduma ya FundiFix? *How satisfied are you with the FundiFix maintenance service?*

- ✓ Nimeridhika sana [*very satisfied*]
- ✓ Nimeridhika [*satisfied*]
- ✓ Sijaridhika [*dissatisfied*]
- ✓ Sijaridhika hata kidogo [*very dissatisfied*]
- ✓ Sijui [*don't know*]
- ✓ No response

Conditional: if no or don't know

Je, mngpenda kujisajilisha katika mradi huu wa urekebishaji wa haraka wa Handpump na wenye manufaa katika uimarishaji wa huduma ya maji? *Would you like to sign up for Fundifix Kwale?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Don't know
- ✓ No response

Conditional: if yes

Je, ungependa FundiFix wawatembelee kwa maelezo Zaidi kuhusu mradi huu wa kudumisha bomba la maji? *If yes, would you be willing for FundiFix to contact you with more information/registration documents?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ No response

Water Storage

Familia yako inahifadhi maji ya kunywa? *Does household store drinking water in the house?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Unahifadhi kiasi cha maji yanayotosha matumizi ya siku ngapi wakati wa msimu wa kiangazi? *How many days' worth of water do you store at home in the dry season?* ____

Conditional: if yes

Unahifadhi kiasi cha maji yanayotosha matumizi ya siku ngapi wakati wa msimu wa mvua? *How many days' worth of water do you store at home in the wet season?* ____

Water Resources Management

Ni nani ana jukumu la kutunza na kusimamia maji kwenye mito, visima na chemichemi?

Who is responsible for managing water in rivers, wells and springs?

Usimuelekeze mhusika. *Do NOT prompt.*

- ✓ Mzee wa kijiji [##]
- ✓ Kamati ya maji [water committee]
- ✓ Water Resources Management Authority (WRMA)
- ✓ Water Resources Users Association (WRUA)
- ✓ Serikali ya kaunti [County government]
- ✓ Chifu [chief]
- ✓ KWAWASCO
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.* ____

Ni mashirika au tahasisi gani yananufaisha watumizi wa maji sehemu hii? (serikali, shirika la kibinafsi, shirika lisilo la kiserikali) *Which institutions (government, private, NGO) benefit water users in this area?*

Usimuelekeze muhusika, Jaza zaidi ya majo. *Do NOT prompt. Tick ALL that apply.*

- ✓ Kamati ya chama cha watumizi wa maji [Water Resources User Association]
- ✓ Chama cha watumizi wa maji [Water Supply Association]
- ✓ Wizara ya maji ya Kaunti [County Water Ministry]

- ✓ Baraza la Kaunti [*County Council*]
- ✓ Kwale Handpump Services Limited
- ✓ KWAASCO
- ✓ Shirika kuu la kiserikali la kudhibitisha usmbazaji wa maji [*central government agency with water supply mandate*]
- ✓ Shirika kuu la kiserikali lenye mamlaka ya Kumudu 'RasiliMaji' [*central government agency with rural development mandate*]
- ✓ Wizara ya maji, mazingira, na rasilimali [*Ministry of Water, Environment and Resources*]
- ✓ Shirika kuu la kiserikali la mazingira [*central governmental organization with environment mandate*]
- ✓ South Coast Development Agency
- ✓ Base Titanium Ltd
- ✓ KISCOL
- ✓ Team & Team International
- ✓ Rural Focus Limited
- ✓ World Wildlife Fund
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafana kwenye nafasi. Specify if other.____

Je, unadhani mito/visima/chemchemi zimedumishwa vizuri na Serikali ya Kaunti iliyo chaguliwa kulingana na hoja zifuatazo? Do you think the rivers/wells are well cared for by the County Government according to the following arguments?

	Negative change	No change	Positive change	DK
Ubora wa maji [<i>water quality</i>]				
Wingi wa maji [<i>water quantity</i>]				
Jamii ya vijiji kuhusika katika kumudu mito [<i>greater community participation</i>]				
Rasilimali kuongezeka na kupatikana kwa matumizi ya 'Chama cha watumizi wa maji' [<i>more resources for WRUA (Water Resources User Association)</i>]				
Jamii za vijiji kujua Zaidi kuhusu kumudu mito [<i>more awareness raising for communities</i>]				
Nyenginezo [<i>other</i>]				

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Je, unajua chama cha watumizi wa maji (WRUA) kinafanya nini? *Do you know what the Association of Water Users (WRUA) does?*

To confirm, ask respondent to explain what they believe the local WRUA does.

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Je, unajua mwanachama yeyote wa WRUA? *Do you know any members of the local WRUA?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Umewahi kuhudhuria mkutano wa WRUA? *Have you ever attended a WRUA meeting?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Conditional: if yes

Umeridhika na utendakazi wa WRUA? *Are you satisfied with the performance of the WRUA?*

- ✓ Nimeridhika sana [very satisfied]
- ✓ Nimeridhika [satisfied]
- ✓ Naona kawaida
- ✓ Sijaridhika [dissatisfied]
- ✓ Sijaridhika kabisa [very dissatisfied]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Kwa maoni yako, ni nani mtumizi mkuu wa maji sehemu hii? *Who would you identify as the major water users in the area?* Usimuelekeze mhusika. *Do NOT prompt. Tick all that apply.*

- ✓ Base Titanium Ltd (Kampuni ya madini)
- ✓ KISCOL
- ✓ Utalii/mahoteli [tourism/hotel]
- ✓ Miji mikuu [big cities]
- ✓ Jamii za vijijini [rural communities]
- ✓ Mashule [schools]

- ✓ Kliniki/Hospitali [*clinic / hospital*]
- ✓ Misikiti / Mekanisa [*mosques/churches*]
- ✓ Mazingira [*environment*]
- ✓ Nyenginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafaua kwenye nafasi. Specify if other. ____

Una wasiwasi wowote kuhusu matumizi ya maji sehemu hii? *Do you have any major concerns about water use in the area?*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if yes

Ni hoja/mada gani tatu kuu zinakutia wasiwasi kuhusu matumizi ya maji sehemu hii? *What three main topics about water do you worry about?*

Usimuelekeze mhusika. [*Do not prompt.*]

____ *Concern 1 options:*

- Kuchafuka wa maji
- Upungufu wa maji/shina kukauka [*water shortage*]
- Mafuriko [*floods*]
- Watu kutolipa ada/karo [*people do not pay fees*]
- Ufisadi
- Hatari ya kuharibu mazingira
- Matumizi haramu [*illegal use*]
- Nyenginezo [*other*]
- Sijui [*don't know*]
- NR [*no response*]

____ *Concern 2*

____ *Concern 3*

Conditional: if other

Kama ni nyenginezo, tafadhali fafaua kwenye nafasi. Specify if other. ____

Conditional: if yes

Kati ya hizi, ni gani KUU zaidi? *Of these concerns, which is your greatest concern?*

- ✓ Kuchafuka wa maji

- ✓ Upungufu wa maji/shina kukauka [*water shortage*]
- ✓ Mafuriko [*floods*]
- ✓ Watu kutolipa ada/karo [*people do not pay fees*]
- ✓ Ufisadi
- ✓ Hatari ya kuharibu mazingira
- ✓ Matumizi haramu [*illegal use*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Conditional: if yes

Ni nani anayechangia kwa hoja/mada hii inayokutia wasiwasi mkuu? Who do you think is responsible for causing the problem about which you are most concerned?

Usimeulekeze mhusika. Do NOT prompt.

- ✓ Watu binafsi [*individuals*]
- ✓ Jamii za vijiji [*village communities*]
- ✓ Shirika za kidini [*religious organizations*]
- ✓ Kampuni [*company*]
- ✓ Serikali [*government*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Conditional: if village communities

Ni jamii gani unadhani zinahusika? Which community do you think is responsible?

- ✓ Jamii yetu [*our community*]
- ✓ Jamii jirani [*neighbouring community*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Conditional: if company

Ni kampuni gani unadhani inahusika? *Which company do you think is responsible?*

- ✓ Base Titanium Ltd. (Kampuni ya madini)
- ✓ KISCOL
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

**Kama ni nyenginezo, tafadhali fafania kwenye nafasi.
*Specify if other.*____**

Conditional: if government

Ni Serikali gani inahusika? *Which level of government do you think is responsible?*

- ✓ Serikali ya Kaunti
- ✓ Serikali kuu
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

**Kama ni nyenginezo, tafadhali fafania kwenye nafasi.
*Specify if other.*____**

Governance

Kwa ujumla, uliridhika kiwango gani na utelekezaji wa katiba ya Kenya 2010? Overall, how satisfied are you so far with the implementation of the Kenya Constitution 2010?

- ✓ Nimeridhika sana [*very satisfied*]
- ✓ Nimeridhika [*satisfied*]
- ✓ Naona kawaida
- ✓ Sijaridhika [*dissatisfied*]
- ✓ Sijaridhika kabisa [*very dissatisfied*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Je, unapendelea ugatuzi? Do you support devolution (i.e. having county governments in Kenya)?

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if yes

Kwa nini unapenda ugatuzi? Why do you support devolution? Tick ALL that apply.

- ✓ Unaleta rasiilmali na kugawa kwa usawa vijijini
- ✓ Unaleta huduma ya haraka na ya karibu kwa watu [*provides a fast and closer service to people*]
- ✓ Unaleta kazi nyingi kwa watu [*it has a lot of work for people*]
- ✓ Unaleta amani katika vijiji [*it brings peace to the villages*]
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other. ____

Conditional: if no

Kwa nini haufurahii ugatuzi? Why do you NOT support devolution?

Tick ALL that apply.

- ✓ Ni ghali sana [*it's very expensive*]
- ✓ Una siasa nyingi [*too many politics*]
- ✓ Unaleta mgawanyiko katika nchi na kuharibu amani na umoja wan chi [*it creates division in the country and destroys peace and unity*]
- ✓ Unaongeza ushuru [*increases tariffs*]
- ✓ Unaleta utumizi mbaya wa uongozi/rasilimali/ufisadi [*it brings misuse of leadership/resources/corruption*]

- ✓ Uongozi mbaya [*bad leadership*]
- ✓ Huduma mbaya [*bad service*]
- ✓ Kutotekelezwa kwa katiba
- ✓ Kukosa elimu juu ya ugatuzi/hatujui vile ugatuzi unafanya kazi
- ✓ Nyinginezo [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Je, unaridhika na ugatuzi katika idara ya maji? *How satisfied are you with devolution in the water sector?*

- ✓ Nimeridhika sana [*very satisfied*]
- ✓ Nimeridhika [*satisfied*]
- ✓ Naona kawaida
- ✓ Sijaridhika [*dissatisfied*]
- ✓ Sijaridhika kabisa [*very dissatisfied*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Je, kwa maoni yako, hoja zifuatazo zinatimizwa katika huduma ya usambazaji wa maji ya kunywa? *In your opinion, the following arguments are being fulfilled in drinking water distribution service?*

maji ya kutosha | *Sufficient Quantity*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ NR [*no response*]

maji safi | *potable quality*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ NR [*no response*]

maji kwa bei nafuu | *water you can afford*

- ✓ Ndio [*yes*]
- ✓ La [*no*]
- ✓ NR [*no response*]

maji yako karibu na unaweza kuyafikia kwa urahisi (chini ya dakika 30 kwenda na kurudi) | *Physical access to functioning drinking water source (within 30 minutes roundtrip)*

- ✓ Ndio [*yes*]

- ✓ La [no]
- ✓ NR [no response]

hakuna ubaguzi wa nani anateka maji na udumishaji wa bomba la maji (watu wote waka na haki ya kuteka maji? wake/waume, Watoto/Watu wazima, kabila tofauti, waislamu/wakiristo) | *Non-discrimination in the collection and management of drinking water*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ NR [no response]

Je, unaridhika na ugatuzi katika idara ya afya? *How satisfied are you with devolution in the health sector?*

- ✓ Nimeridhika sana [very satisfied]
- ✓ Nimeridhika [satisfied]
- ✓ Naona kawaida
- ✓ Sijaridhika [dissatisfied]
- ✓ Sijaridhika kabisa [very dissatisfied]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, unaridhika na ugatuzi katika idara ya mashamba? *How satisfied are you with devolution in the lands sector?*

- ✓ Nimeridhika sana [very satisfied]
- ✓ Nimeridhika [satisfied]
- ✓ Naona kawaida
- ✓ Sijaridhika [dissatisfied]
- ✓ Sijaridhika kabisa [very dissatisfied]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, unaridhika na mafanikio ya Serikali ya Kaunti ya Kwale tangu mwaka 2013? *Are you satisfied with the achievements of the Kwale County Government since 2013?*

- ✓ Kuridhika sana [very satisfied]
- ✓ Kuridhika [satisfied]
- ✓ Kutoridhika [dissatisfied]
- ✓ Kutoridhika sana [very dissatisfied]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je unatarajia serikali ya kaunti iwapunguzie gharama ya usambazaji wa huduma ya maji ya kunywa? *Do you expect the County Government to subsidise drinking water service provision?*

- ✓ Ndio [yes]

- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, serikali ya kaunti imerekebisha bomba la maji ya kunywa au shina la maji ya kunywa wakati wowote mwak uliopita? *Has the County Government repaired your drinking water service supply in the last year?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, ulikuwa ukiridhiswa na huduma ya IEBC (Independent Electorate and Boundaries commission)? *Have you been satisfied with the services of the IEBC (Independent Electoral and Boundaries Commission)?*

- ✓ Kuridhika sana [very satisfied]
- ✓ Kuridhika [satisfied]
- ✓ Kutoridhika [dissatisfied]
- ✓ Kutoridhika sana [very dissatisfied]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, Utapiga kura mwaka 2017 katika uchaguzi mkuu? *Are you going to vote in the 2017 general elections?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]

Chama chako cha kisiasa ni kipi? *Which political party do you feel closest to, if any?*

- ✓ Amani Coalition
- ✓ CORD supporters
- ✓ Jubilee supporters
- ✓ None
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Je, kuna yeyote kwa nyumba yako anahudhuria mikutano ya kisiasa ya huku vijijini. *Does any member of your household attend local political meetings?*

- ✓ Ndio [yes]

- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if yes

Ni mara ngapi amehudhuria mikutano hiyo kati ya miezi 12 iliyopita?
How many times has this member attended local political meetings in the last 12 months?___

Ni nani wanagombea kiti cha ugavana kaunti ya Kwale mwaka wa 2017? *Who are campaigning for the Governor's seat for the 2017 elections in Kwale?*

DON'T PROMPT. Select all that apply.

- ✓ Mvurya
- ✓ Sonko
- ✓ Mwakwere
- ✓ Dori
- ✓ Dena
- ✓ Boi Juma
- ✓ Chidzuga
- ✓ Mwachai
- ✓ Nyinginezo [other]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*___

Kuna Uwezekano gani utampigia kura Gavana wako wa sasa? *How likely are you to vote for your current Governor?*

- ✓ Uwezekano mkubwa sana [very likely]
- ✓ Kuna uwezekano [likely]
- ✓ Hakuna uwezekano [unlikely]
- ✓ Hakuna uwezekano sana [very unlikely]
- ✓ Sitaki kusema [I do not want to say]
- ✓ Simjui Gavana wangu [I do not know my governor]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Kuna Uwezekano gani utampigia kura MCA wako wa sasa? *How likely are you to vote for your current MCA?*

- ✓ Uwezekano mkubwa sana [very likely]
- ✓ Kuna uwezekano [likely]
- ✓ Hakuna uwezekano [unlikely]

- ✓ Hakuna uwezekano sana [*very unlikely*]
- ✓ Wanapendelea kutosema [*prefer not to say*]
- ✓ Simjui MCA wangu [*I do not know my MCA*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Ni huduma gani katika wadi yako ambazo zimeboreshwa tangu 2013? *Which services in your ward have improved since 2013?*

- ✓ Afya [*health*]
- ✓ Kilimo [*agriculture*]
- ✓ Huduma ya maji ya kunywa barabara [*water service*]
- ✓ elimu [*education*]
- ✓ umeme [*electricity*]
- ✓ ajira/kazi [*employment/work*]
- ✓ hakuna [*nothing*]
- ✓ nyinginezo - specify [*other*]
- ✓ Sijui [*don't know*]
- ✓ NR [*no response*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Ni nani aliye boresha huduma hizo? *Who improved those services?*

- ✓ MCA
- ✓ Governor's office
- ✓ County Ministries
- ✓ County Women Representative
- ✓ County Government
- ✓ National Government
- ✓ NGOs
- ✓ Base
- ✓ KISCOL
- ✓ GDF
- ✓ Other private companies
- ✓ Other - specify
- ✓ Sijui
- ✓ NR

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Je, umewahi kuhusika au kuulizwa kutoa maoni yako kwa ajili ya utengenezaji wa mswada(sheria) wa huduma za maji ya kaunti wa kwale? *Have you been engaged in the public engagement process in the making of the Kwale County Water Services Bill?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Je, ushawai kuhusishwa katika uamuzi wa bei ya maji ya kunywa katika bomba la maji mnalolitumia? *Have you ever been consulted about water-tariff setting for your drinking water source?*

- ✓ Ndio [yes]
- ✓ La [no]
- ✓ Sijui [don't know]
- ✓ NR [no response]

Conditional: if yes

Kama jawabu ni ndio, nani alikuhusisha? *Who consulted you for tariff-setting?*

- ✓ Serikali ya Kaunti [County government]
- ✓ KWAWASCO
- ✓ Kampuni ya kibinafsi [private company]
- ✓ Wana vijiji/Kamitii ya maji [village water committees]
- ✓ Nyinginezo [other]
- ✓ NR [no response]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. *Specify if other.*____

Mobile Survey

Habari tunayokusanya leo itasaidia serikali ya kaunti na mashirika mengine kupanga mikakati ya kuimarisha huduma za maji na uendelevu wa kaunti kwa ujumla. Ili tueleze kuona mabadiliko yanayotokea kwa ajili ya mikakati hiyo, tutanzisha kukusanya habari kupitia kwa simu. Wenyeji wa kaunti watakuwa wakipigiwa simu na kuulizwa maswali machache, hii haitachukua mda zaidi ya dakika kumi na tano. Baada ya mazungumzo hayo kwa kupitia njia ya simu, utapokea 'airtime' ikiwa utapeana ujumbe ulio sahihi. *The information we collect today will help the County government and other organizations arrange strategies to strengthen water services and overall comforts. Let's try to see the changes that come from those strategies, and we will start collecting information via the phone. Enumerators will call up and ask a few questions, this will not take longer than fifteen minutes. After the conversation through the phone, you will receive airtime if you provided the correct message.*

Introduction to mobile survey.

Je ushawahi kushiriki katika utafiti wowote kwa njia ya simu?

- ✓ Ndio [yes]
- ✓ La [no]

Je, ungependa kushiriki katika utafiti huu kwa nia ya simu? *Would you like to participate in this mobile study?*

- ✓ Ndio [yes]
- ✓ La [no]

Conditional: if yes

Tafadhali nisaidie na nambari yako ya simu. Pia ningependa unisaidie na nambari za simu za wengine wanaoishi katika nyumba yako ambao tunaweza kuwahoji ikiwa hautapatikana kwa nu va simu. *Please tell me your phone number. I would also like to know the phone numbers of others living in your home that we can ask if you are not available for phone calls.*

Name	Relationship	Mobile #1	Mobile #2
	✓ Respondent ✓ Mother ✓ Father ✓ Husband ✓ Wife ✓ Uncle ✓ Aunt ✓ Other adult child ✓ Other		

Note to enumerator: Please try calling the current respondent's numbers to ensure that you noted them correctly. Thank respondent for providing the phone numbers and share FundiFix Kwale hotline number: (+254) 0719723000 with him/her in case there are any follow-up questions.

About the Dwelling

Vifaa husika kwa ajili ya sakafu. **MAIN MATERIAL OF FLOOR** (record observation)

- ✓ Mchanga [*sandy*]
- ✓ Mavi ya ng'ombe [*cow patties*]
- ✓ Mbao [*wood*]
- ✓ Bambo
- ✓ Mbao zilizopakwa rangi [*painted wooden*]
- ✓ Vinyl or asphalt strips
- ✓ Vigae
- ✓ Simiti
- ✓ Mpira
- ✓ Nyenginezo [*other*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Vifaa husika vya paa. **MAIN MATERIAL OF ROOF** - Record observation

- ✓ Makuti [*coconut*]
- ✓ Mabati
- ✓ Vikebe, Matope
- ✓ Mavi ya ng'ombe
- ✓ Asbestos
- ✓ Zege
- ✓ Vigae
- ✓ Nyenginezo [*other*]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other.____

Vifaa husika vya ukuta. **MAIN MATERIAL OF WALLS** - Record observation

- ✓ Mawe na udongo [*stone and clay*]
- ✓ Mawe na simiti [*stones and stems*]
- ✓ Matofali ya zege [*concrete bricks*]
- ✓ Mbao na udongo [*wood and clay*]
- ✓ Mabati
- ✓ Mbao za mtumba [*wooden boards*]

- ✓ Makuti [coconut]
- ✓ Simiti
- ✓ Vipande vya miti
- ✓ Matofali [bricks]
- ✓ Matofali ya udongo [clay bricks]
- ✓ Plaiwudi [plywood]
- ✓ Cardboard
- ✓ Fito
- ✓ Takataka [waste]
- ✓ Hakuna kuta [no walls]
- ✓ Nyenginezo [other]

Conditional: if other

Kama ni nyenginezo, tafadhali fafania kwenye nafasi. Specify if other. ____

Conditional: if stone and clay, stone and stems, concrete bricks, wood and clay, bricks, clay bricks

Are the walls rendered?

- ✓ Rendered
- ✓ Unrendered

Chukua picha ya nyumba | take a picture of a house

Only take photo if existing photo is inadequate or dwelling has changed since first photo was taken.

End.

Huu ni mwisho wa mahojiano, asante sana kwa kunipa muda wako, tabasamu, jibu maswali yoyote utakayoulizwa ni mhusika na uondoke ili kukamilisha maswali. Kazi nzuri! *This is the end of the interview, thank you very much for giving me your time, smile, ... Good work!*

Onyesha jinsi mhusika alivyoielewa maswali? HOW WELL WAS INTERVIEW UNDERSTOOD?

- ✓ Ufahamu mzuri [good understanding]
- ✓ ufahamu wastani [average understanding]
- ✓ ufahamu mbaya [bad understanding]

Kwa maoni ya mwandishi, unadhani kwamba majibu uliyopewa na mhusika ni ya kweli na hakika? In the opinion of the enumerator, do you think the majority of answers given by the respondent are true and correct?

- ✓ Nakubali sana [strongly agree]
- ✓ Nakubali [agree]
- ✓ Tashwishi juu ya baadhi ya maswali - (ELEZEA kupitia njia ya sauti)

Je, mahojiano yalikuwa kwa lugha gani? *In what language was the interview?*

- ✓ Swahili
- ✓ Digo
- ✓ Duruma
- ✓ Kamba
- ✓ English
- ✓ Other

Conditional: if respondent over 18 is not available today (follow-up required)

Phone number of respondent or household member? ____

Save as incomplete and record this with the Team Leader.

If you would like to add any other comments about the interview, please include them here.

Time end.

9.3 Policy Brief: Poverty transitions in Kwale County

Poverty Transitions in Kwale County

Policy Brief, February 2017

Introduction

Kwale County Government is responding to improving the lives of 7 out of 10 residents who live below the poverty line of USD1.25 a day. Reliable and regular data on welfare are essential to leave no one behind. This policy brief reports on findings of the longitudinal socio-economic household surveys in 2014 (n=3,349) and 2015 (n=3,567) in Matuga, Msambweni and Lunga Lunga sub-Counties. The areas include major economic sectors such as tourism, mining and commercial irrigated agriculture as well as livelihoods supported by fishing, farming and small scale enterprises.

Subjective Welfare Transition between 2014 and 2015 (n=3,237)

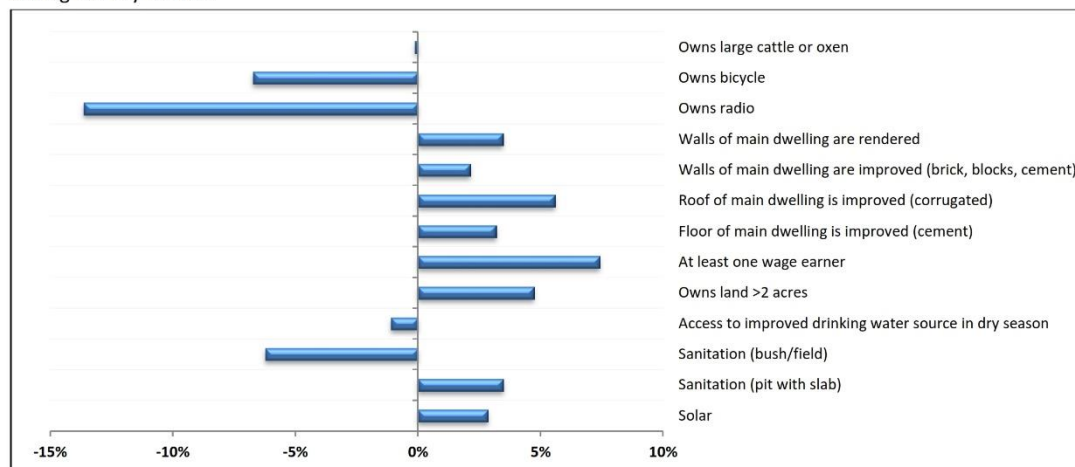
		2015	
		Not well off	Average
	2014		
	Not well off	71%	29%
	Average	49%	51%

Subjective welfare of households was assessed using two categories: 'Not-well-off' and 'Average'

- 7 out of 10, felt they were still 'Not-well-off' in 2015.
- Nearly 3 in 10 households felt they had transitioned from the 'Not-well-off' category and were better off in 2015.
- Of those households who felt they were better off in 2014, nearly 1 in 2 felt they were 'Not-well-off' in 2015.

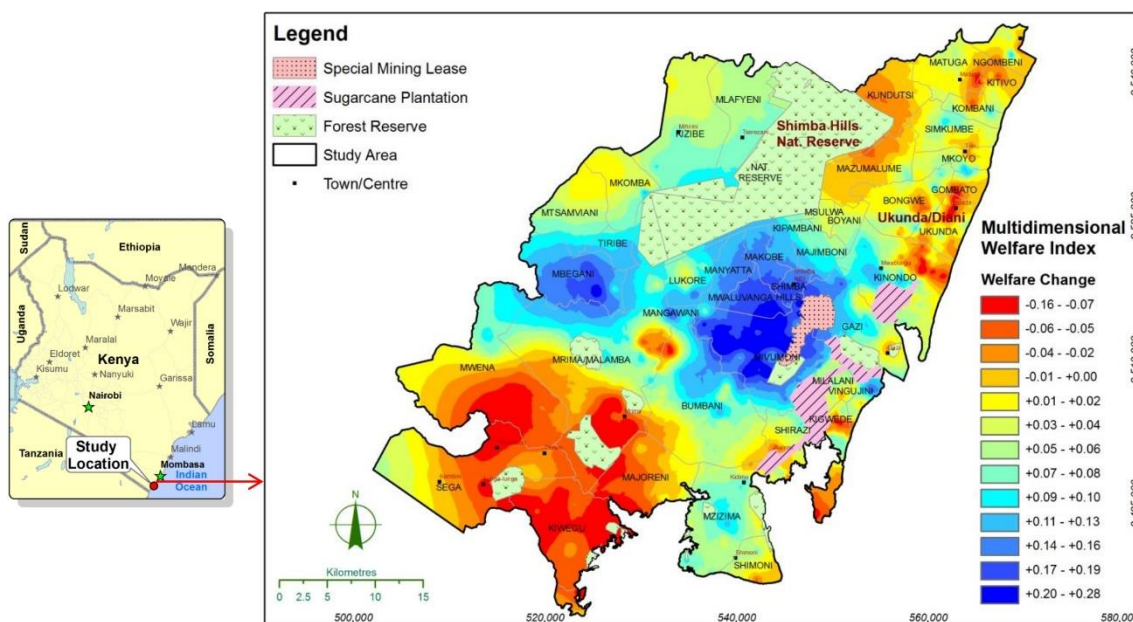
Multidimensional Welfare Transitions between 2014 and 2015 (n=3,329)

Household composition, dwelling characteristics, assets, sanitation and health, and drinking water data was used to construct and map households' multidimensional welfare changes between year 2014 (baseline) and 2015. Between 2014 and 2015, 7% more households found wage labour. Sanitation access improved by 4% with the number of people using bush/field decreasing by 6%. People's dwellings saw a modest rise in improvements including 3% more households installing solar panels. There was slight decline in the number of people with improved access to water during the dry season.

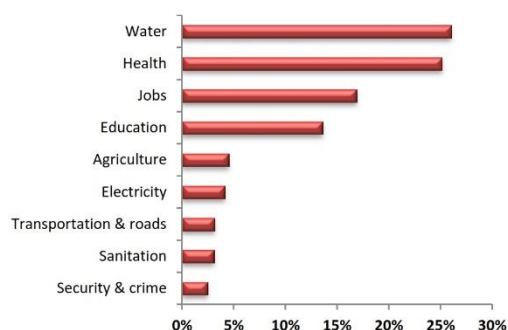


Where is Welfare Rising or Falling?

Households experiencing declining welfare are observed to be near Ukunda/Diani and towards the border with Tanzania. However, some pockets within the coastal strip (Kinondo and Vingungini) estimated a positive welfare change. Areas with households that experienced positive welfare changes include Lukore, Shimba hills, Mivumoni, Mbegani, Majimboni, Mangawani, Mzizima, Kinondo and Mwaluvanga. The Lunga Lunga sub-County had a majority of households falling in welfare. Further research is currently on-going to understand the determinants of poverty and links between the environmental, economic and political factors that drive welfare in Kwale County.



Major Household Concerns (2015, n=3,329)



Policy Implications

These results provide insights for **planning, budgeting and policy on poverty reduction programmes in Kwale**. It provides credible information on **where the poor are**, which regions have experienced positive/negative welfare changes as well as starting **discussions on community investment priorities**. For example, **water, health, job and education** being cited as the top four priorities.

Poverty reduction strategies should be **focused on 'leaving no one behind'**. **Monitoring and mapping of welfare** should be conducted more **frequently** to evaluate **impacts** of different **poverty reduction strategies**.

More Information

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9.4 Policy Brief: Delivering water security and welfare in Kwale County

This briefing note is included here to highlighted the contribution of the findings of this thesis to the policy and practice in Kwale County through the 'Groundwater Risk Management for Growth and Development' Project funded through 'Unlocking the Potential of Groundwater for the Poor' programme (<https://upgro.org/consortium/gro-for-good/>).



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For the attention of **H.E. Governor Salim Mvurya**, Kwale County, Kenya

Briefing Note – 4th October 2018

Delivering Water Security and Welfare in Kwale County

The Gro for Good project has identified four areas for action by Kwale County based on research findings from 2013-2018 conducted by a consortium of world-class research partners consisting of the University of Oxford, University of Nairobi and Rural Focus Ltd., Jomo Kenyatta University of Agriculture and Technology, Universitat Politècnica de Catalunya.

1. Groundwater resources for growth and development.

Significant groundwater resources have been identified for the first time in Msambweni sub-County. Detailed geophysical and geological studies indicate that there are two zones running NW-SE across Msambweni sub-county which will sustain high yielding boreholes that provide potable quality groundwater. The larger of these “paleochannels” (ancient filled-in and buried river channels) is in the southern part in the Milalani area, and the smaller one in the Kinondo area (see map on page 4). Kwale County government can target these two aquifer systems to provide safe and sustainable water supplies for its growing urban and rural populations. These aquifers, like the Tiwi and Baricho aquifers, can be developed and protected in order to supplement regional supplies. We draw particular attention to the southern paleochannel which could serve the Msambweni area, whose current supply is at risk of become more saline due to its proximity to the sea.



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2. Interventions to improve rural welfare.

A three years (2014-2016) longitudinal household survey on over 3,500 households in Kwale County on socio-economic development and water services has revealed that poverty can be reduced through four key interventions. These findings support the County's Transformation Agenda highlighted in the Annual Development Plan 2017/2018. The four priority interventions area:

1. Increase household energy access through expansion of the grid or small-scale solar power.
2. Broaden access to secondary education and maintain primary education access.
3. Improving the proximity and reliability of drinking water supplies.
4. Ending open defecation.

Open defecation is the *single largest cause of welfare reduction*. Working towards ending it will complement the County's other efforts to improve rural health and nutrition.

3. Drought Resilience

Much of Kenya was affected by a severe drought in late 2016 and early 2017, with parts of Kwale being badly affected. In collaboration with NDMA, the County Government can improve drought resilience by:

1. Initiating a programme of deepening hand-dug wells which are at risk of going dry during drought periods.
2. Ensuring emergency water supplies are available (to reduce communities' reliance on extremely expensive vended water during droughts).



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4. Invest in rural water maintenance systems.

Four years of research in Kwale County have demonstrated that a performance-based water maintenance programme can guarantee handpump repairs in less than three days ensuring access to water services to Kwale County residents. 13,000 people and 4,000 school children continue to receive these services.

The performance-based maintenance programme has been replicated in Kitui with success and is now the best-in-class in Kenya. It however requires County Government's support to continue increasing access to improved water services for rural communities. County Government can play a vital role by:

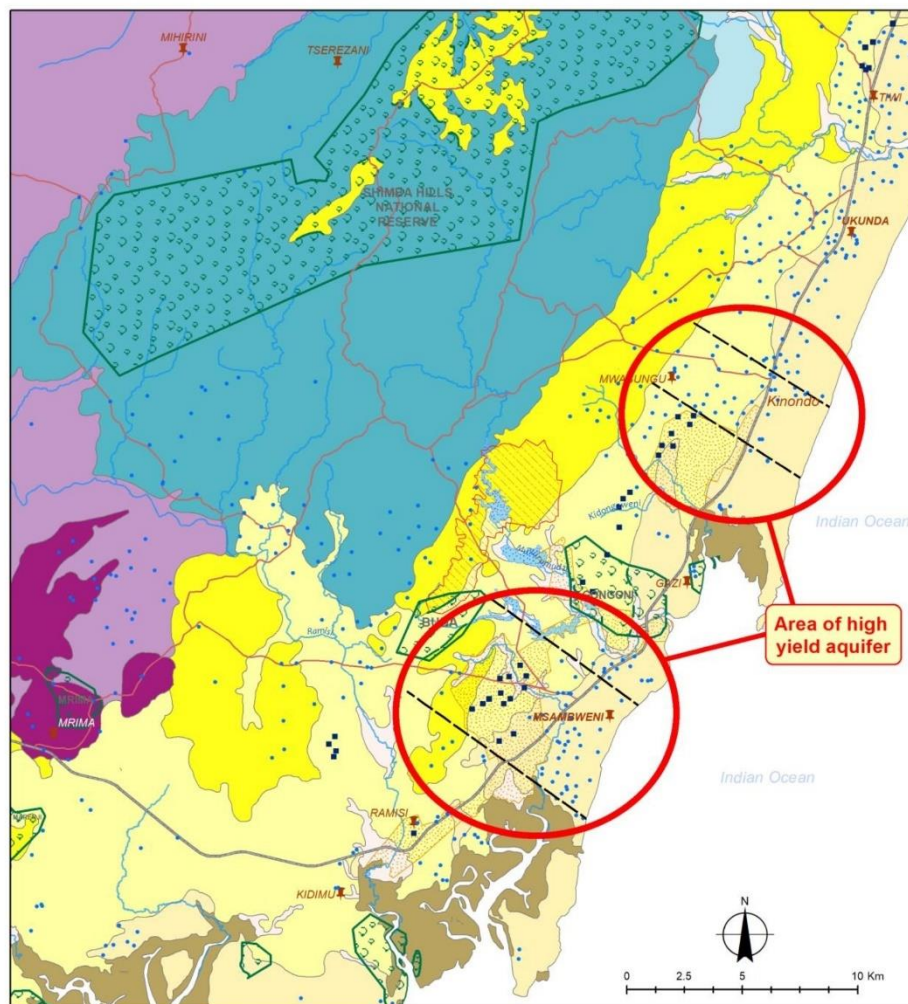
1. Supporting performance-based maintenance service providers through investing in a County Trust Fund to ensure sustainable services.
2. Convening all water supply stakeholders (government, NGOs, donors, private sector) in quarterly forum to coordinate activities, promote accountability and increase efficacy of investments.
3. Ensuring that new infrastructure development is accompanied by a sustainably-funded maintenance plan and service providers working in Kwale are committed to providing sustainable services to 2030.

This briefing note was prepared by the Gro for GooD project team. The Gro for GooD research was funded by the UK government through DFID, NERC and ESRC.

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Legend

- Palaeochannel
- River
- Deep Borehole
- Handpump
- ✱ Town Centre
- A14 Road
- Other Roads
- Kwale Forests
- Special Mining Lease
- KISCOL Sugar Fields
- Dam

Geology

- Holocene
- Holocene Marine Deposits
- Pleistocene Coral Limestones
- Pleistocene Sands
- Pliocene Magarini Sands
- Lower Jurassic Shimba Grits and Mazeras Sandstones
- Permo-Triassic Mariakani Sandstones and Maji-ya-Chumvi Beds

- Alkaline Intrusives (Cretaceous)
- Kambe limestone
- Lower Maji-ya-Chumvi beds
- Lower Maji-ya-Chumvi beds/Taru grits
- Taru grits
- Upper Jurassic shales
- Various parent materials soils in minor valleys
- Various parent materials soils in the bottomlands

The End