The Water Poverty Index: A Situational Analysis of Selected Counties in Kenya

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Abstract

Kenya is a water scarce country, and this impacts on the social and economic development goals. This study seeks to develop a Water Poverty Index to assess water resources at the county level. The Water Poverty Index is an inter-disciplinary tool that links physical availability of water with socio-economic factors that impact on access. The index was computed for a sample of four counties, namely Kiambu, Murang'a, Nairobi and Nyandarua.

The findings of the study show that water availability does not necessarily translate into high levels of access at the county level. The two counties that score high on the water availability component score the lowest on access to water and sanitation. Nairobi county has the highest scores in terms of access due to external resources from Nyandarua and Murang'a. Thus, more needs to be done in these counties to bridge the gap between water resource availability and access to water and sanitation. In addition, all the counties in the study need to improve on access to water and sanitation to reach the targets of the National Water Services Strategy.

The study provides several policy recommendations to improve the water poverty situation in the counties. Resource-rich counties such as Nyandarua and Murang'a, can trade in water resources with counties such as Nairobi to generate money for the development and conservation of their own water resources. This is in line with National Water Services Strategy and the new constitution. Legislation governing how counties can share resources through such schemes should be introduced as provided for in the constitution. Performance of Water Service Providers in covered areas such as Nairobi should be improved to reduce their burden on counties that are the source of the water. Also, the study can be expanded to other counties in the country to determine where focus needs to be put so as to improve the water poverty situation in the country, and how counties can effectively manage their shared water resources for the benefit of all.

Abbreviations and Acronyms

CAACs	Catchment Area Advisory Committees
MDGs	Millennium Development Goals
MWI	Ministry of Water and Irrigation
NWRMS	National Water Resources Management Strategy
NWSS	National Water Services Strategy
UN	United Nations
WAB	Water Appeals Board
WASREB	Water Services Regulatory Board
WPI	Water Poverty Index
WRMA	Water Resources Management Authority
WRUA	Water Resource Users Association
WSB	Water Service Boards
WSP	Water Services Providers
WSTF	Water Services Trust Fund

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1. Introduction

1.1 Background

Water is increasingly one of the most critically stressed resources globally. Although water covers over 70 per cent of the planet, only about 2.5 per cent of this is freshwater (Fietelson and Chenoweth, 2002). In addition, these freshwater resources are unevenly distributed with 69.6 per cent of all fresh water stored in ice-caps, glaciers and permanent snow, and another 30.1 per cent stored in ground water. This leaves only about 0.3 per cent of fresh water readily available in rivers and lakes (Fietelson and Chenoweth, 2002). Thus, the proportion of the planet's water resources available for human use is finite, while growth in human populations coupled with rising standards of living,is creating an increased demand for these resources (Sullivan, 2002). At the same time, water resource availability is linked to economic and social development, with the management of water resources influencing how much development takes place in a country (Sullivan, 2002). The link between access to water and development has been recognized in the UN Millennium Development Goals.[1] Water resource availability is also linked to other development goals. For instance, MDG Goal 1, which seeks to "Eradicate extreme poverty and hunger" relies on water resources availability for agricultural production. Water resource availability for sanitation is essential for the achievement of Goal 4, to "Reduce child mortality" since a large proportion (14%) of deaths in children aged below 5 years are related to diarrheal diseases caused by poor sanitation and lack access to safe drinking water (Black *et al.*, 2008).

1.2 Kenya's Fresh Water Resources

Kenya's renewable fresh water resources per capita were estimated at 534m^3 per capita as of 2009, less than the 1000m^3 threshold below which a country is considered as water-scarce (World Bank, 2010). This figure is projected to decrease as the population increases. Moreover, these freshwater resources are unevenly distributed in space and time, leading to inequalities in water available to the population. For example, the average annual rainfall in the country is 630mm, but this

[1] For example, one of the targets of Goal 7, which seeks to "Ensure environmental sustainability" is to "Half by 2015, the number of people without access to safe drinking water" (www.un.org/milleniumgoals/).

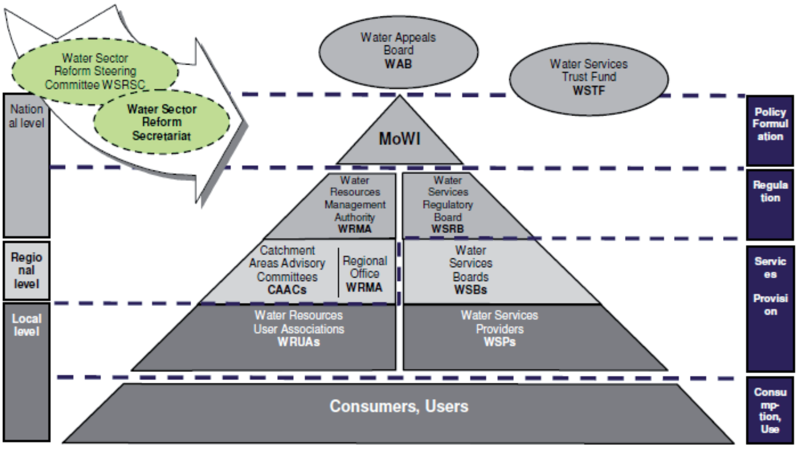
varies between less than 200mm in northern Kenya to over 1800mm in the highlands (FAO, 2005). The country's five drainage basins, Lake Victoria, Rift Valley, Ewaso Nyiro North, Tana River and Athi River also have unequal availability of water. Only the Lake Victoria and Tana basins have a water surplus, while the rest of the basins suffer from water deficit (USAID, 2000). In addition, Kenya experiences drought and flood cycles every three to four years, a factor that contributes to inequalities in water distribution over time and has enormous impacts on all sectors of the economy.

Water Resources Management in Kenya

In Kenya, reforms have been carried out since 2002 to improve management of water resources as well as increase access to water and sanitation for both rural and urban populations. Through the Water Act 2002, re-evaluation of the role of different actors in the sector and re-assignment of roles was carried out. Government, through the Ministry of Water and Irrigation (MoWI), was given the role of regulating and creating an enabling environment for other actors in the water sector. Key to creating this environment has been the creation of the National Water Resources Management Strategy (NWRMS) and the National Water Services Strategy (NWSS). The NWRMS outlines the government's strategy for assessing, managing, developing and maintaining Kenya's scarce renewable fresh water resources. The NWSS aims to ensure adequate provision of water and sanitation services to all Kenyans.

The Water Act 2002 also calls for the establishment of the Water Services Regulatory Board (WASREB) to set standards and regulate the provision of water services. Eight Water Service Boards (WSBs) were licensed by WASREB to manage the efficient and economical provision of water and sewerage services in the country. Water Service Providers (WSPs) act as agents of the WSBs in the actual provision of water and sewerage services. Also created under the Water Act 2002 was the Water Resources Management Authority (WRMA), whose responsibility is to manage water resources at the catchment level. Catchment Area Advisory Committees (CAACs) support the WRMA at regional level, while Water Resource Users Associations (WRUAs) were established as a medium for cooperative management and conflict resolution at the sub-catchment level. Other bodies established by the Water Act are the Water Appeals Board (WAB), which adjudicates on disputes in the

Figure 1.1: Institutional framework under the Water Act, 2002



Source: MoWI (2005)

water sector, and the Water Services Trust Fund (WSTF), whose role is to finance water service investments in poor areas. Figure 1.1 shows the institutional set-up for the water sector as per the Water Act 2002.

Reforms in the water sector have had some positive impact. The engagement of commercial water service providers by Water Service Boards (WSBs) has improved coverage and regulation in urban areas. In rural areas, coverage has been increased through financing for communities by the WSTF. Participatory management has also been improved through the WRUAs and CAACs (MoWI, 2007).

However, there are still a number of challenges facing this sector. Investment in water provision infrastructure in rural areas has been poor, meaning that these populations lag behind their urban counterparts in terms of access to water. Figures for rural versus urban access to water illustrate this. According to World Bank estimates (2010), 59 per cent to 83 per cent of people in urban areas have access to safe water sources, while the figures for rural areas stand at between 38 per cent and 52 per cent. The problem in urban areas is that many poor people are still not connected to the formal water supply and are therefore forced to purchase their water from vendors. Due to corruption and lack of proper management, the vendors often charge high prices for water which is often of questionable quality. The sector also faces challenges in terms of financing, local capacity building, and monitoring and evaluation of progress in the sector (Mumma, 2005).

1.3 Problem Statement

Water is an important part of any country's social and economic development. It is an important prerequisite to agricultural and industrial production, energy production, and transport, among other sectors. It also impacts on the population's health, thereby affecting the productivity of a nation. In Kenya, the move towards a decentralized system of governance will give an opportunity for development at the local level, thereby bringing basic services, employment and wealth closer to the people. Tied to this development is the issue of water resources and how they can be managed at the county level to ensure equity in achievement of national development goals. This study seeks to develop a Water Poverty Index, which could be used to compare the status of water resources and access to services across counties. The study looks at a sample of four counties in order to highlight the issues of resource availability and how they are linked to access to water and sanitation services in different counties. Furthermore, the counties selected for the study share water resources through inter-basin transfers of water, highlighting the need for future policy to address how counties manage and share water resources.

1.4 Objectives and Research Questions

The broad objective of the study is to develop a Water Poverty Index (WPI) to compare Nairobi, Kiambu, Murang'a and Nyandarua in terms of the water resources available and access to water services.

The specific objectives are to:

- Determine the per capita availability of water resources in each of the four counties;
- Determine demand for water resources in each county for domestic and agricultural use;
- Determine how much financial resources have been invested in developing water in the counties;
- Determine the level of access to water and sanitation in the four counties; and
- Determine the environmental conditions impacting on water in each county.

1.5 Research Questions

The study seeks to answer the following:

- How much water is available per capita in each county?
- How much is the demand for water in each county from major sectors?
- What is the proportion of spending on water management per county?
- What are the levels of access to water and sanitation in the four counties?
- What is the state of the environment as it relates to water in the four counties?

1.6 Justification and Policy Relevance

Going into the county system of government, Kenya faces the challenge of ensuring fair and equitable allocation of water resources and distribution of water services at the county level. The distribution will be important for the development of counties, and will be an issue of importance going forward. Thus, there is need to examine how the counties are faring in terms of water resource availability, including environmental factors impacting on water resources, water use, capacity to manage water and access to water and sanitation. The results of this study will be useful in informing resource-allocation to water-related projects at the county level in order to address both the Millennium Development Goals (MDG) and Vision 2030 targets for water distribution in the country.

2. Literature Review

2.1. Theoretical Literature Review

Until the early 2000s few attempts had been made to link poverty and water explicitly, although attempts had been made to quantify water scarcity (Sullivan, 2002). Prior to this, the most widely used indicator of water stress or scarcity was the Falkenmark water stress indicator, which was based on renewable water resources per capita (Falkenmark, 1986). Falkenmark (1986) defined water stress or scarcity as a function of a nation's ability to maintain food self-sufficiency. According to the Falkenmark indicator, water stress or scarcity is defined as occurring when a country's annual water supply per capita falls below 1,700m^3. Below this level, a country is considered as suffering from water stress. Below 1,000m^3 per capita, a country is considered to be facing water shortages that threaten economic development and human health and well-being. Below 500m^3 per capita, a country is considered to be suffering from absolute water scarcity, where water availability is a main constraint to life.

Water poverty as a concept has been discussed in depth in recent years, although its definition is still being disputed. For example, Fietelson and Chenoweth (2002) defined water poverty as "a situation where a country or region cannot afford the cost of sustainable clean water to all people at all times". This definition attempts to include the elements of cost and affordability. Cost in this case includes the cost of ensuring adequate supply of good quality for future generations, and providing clean water to all sectors of society. Affordability is defined as the potential to pay for sustainable water resources at all times. Salameh (2000) described WPI as "the ratio of the amount of available renewable water to the amount required to cover food production and the household uses of one person in one year under the prevailing climate conditions". However, this definition has been criticised for ignoring notions of poverty as they are defined, and failing to sufficiently address the non-food aspects that are becoming increasingly important (Sullivan, 2001).

Sullivan (2001) suggested that water poverty should be an aggregate index based on percentage of water in use in a region, combined with the percentage of people with access to clean water and sanitation in the region, and the percentage of the population with easy access to water for domestic use. This study looks at the concept of water poverty proposed by Lawrence *et al.* (2002). It elaborates on Sullivan's by combining measures of water availability and access with measures of people's capacity to access water. The authors state that people can be water poor because they lack sufficient water to meet basic needs because it is not available, or because they are unable to pay for water that is available because of being income-poor. "Water poverty" and "income poverty" are thus closely linked (Sullivan, 2002). Lack of adequate water supplies has adverse effects on health and output in a community or country. However, even where water supply is adequate and reliable, lack of income to pay for that water may force people to use inadequate and unreliable sources of water.

Although there is consensus on the usefulness of the Water Poverty index, there have been several criticisms levelled against it. Fietelson and Chenoweth (2002) and Gine and Prez-Foguet (2010) addressed the conceptual weaknesses inherent in the index, including redundancy among variables, weights assigned to individual components and how the data is aggregated to come up with the index. However, the Water Poverty Index is still useful to combine interdisciplinary factors that impact on water resources. Care must be taken to select appropriate indicators for the scale under study, linking this data logically with the WPI and considering data availability (Sullivan and Meigh, 2003; Sullivan and Meigh, 2006).

2.2 Empirical Literature Review

A WPI is a useful tool in communicating the status of existing water resources (Policy Research Initiative, 2007) and enabling decision-makers to prioritize issues and resources related to water management (Juwana *et al.*, 2009). Conventional approaches to water assessment are inappropriate for addressing the full complexity of water issues. Such traditional approaches often assess the physical factors affecting water without incorporating socio-economic factors that impact on service provision. The WPI is an integrated tool that uses objective indicators to focus on the structural impediments to a sustainable water supply, allowing policy makers, resource managers and government to develop appropriate policy responses (Gine and Perez-Foguet, 2010).

The WPI concept has been applied in various forms to compare water resources across countries and regions.

(i) Application of the WPI at national level

Lawrence *et al* (2002) used the WPI to perform an international comparison of the water situation in 147 different countries with relatively complete data. The index looked at five components of water poverty, namely resources available, use of water, capacity to manage water resources, access to water and sanitation, and environmental factors impacting on water resources. Their results showed that most of the countries that scored highly on the index are either developed or richer developing countries. A few notable exceptions include developing countries such as Guyana, which score highly on the resources component due to their abundance of water resources, thus giving them a high position on the index. Conversely, Belgium's relatively low position (56^{th}) is caused by its low score on resources despite scoring highly on other components of the index. Despite having a low score on the resources component, South Africa scored highly on other components due to its progressive policies on access and management of water resources, thus giving it a high score on the index.

(ii) Application of the WPI at community level

While the Water Poverty Index was being developed by Sullivan and colleagues, a composite index methodology was tested at 12 pilot sites in Tanzania, Sri Lanka and South Africa using household level data (Sullivan *et al*., 2003). It was found that in developing the methodology, further work needed to be done to identify appropriate variables. The WPI was further applied in three villages in Bulilima District, Zimbabwe (Dube, 2003). The results of studies at this scale provide useful information on where development assistance can be targeted to provide maximum benefit.

(iii) Application at the catchment-scale

The WPI methodology has been applied at the catchment scale in Nepal, India and Pakistan (Merz, 2003, Manandhar *et al*., 2006). In the study by Merz (2003), the Bhetagad catchment in India scored the worst of all the study sites, indicating that urgent attention needed to be focused there. The study by Manandhar *et al*. (2006) was able to identify differences in the components of the index at the various scales studied, which pointed to a need for scale-specific interventions to improve the overall water poverty situation in the index. A water poverty mapping approach has also been applied to analyse linkages between poverty and agricultural water management in the Volta Basin (Cook *et al*, 2007).

(iv) Application of the WPI at the administrative level

With most operational water-management decisions being made at the municipal scale, and this being the unit at which most census and other data are usually reliable, this is the scale at which the most cost effective use of the WPI can be made (Sullivan and Meigh, 2006). However, municipality and watershed scales often do not correspond directly, and data collected at the watershed or national level masks geographical variability at a smaller scale. An attempt to show how existing national data sources can be used to calculate WPI in South Africa illustrated the importance of scale (Cullis and O'Regan, 2004). For example, collecting data at the sub-catchment level may identify one area as water-poor, whereas finer resolution data is needed to pinpoint the exact locations within that area that are water-poor. In West Java Province of Indonesia, a composite index based in part on the WPI has been used to develop a sustained and integrated water management approach on the island (Juwana *et al.*, 2009). In South Africa, a water poverty mapping approach has been used to demonstrate how it can assist in water management at the municipal level (Van de Vyer and Jordaan, 2011). In Kenya, Gine Garriga *et al.* (2009) looked at a case study of Turkana district to analyze a government programme launched to tackle water and sanitation issues in parts of the country. The programme, known as the Water, Sanitation and Hygiene (WASH) programme aimed to improve access to water supplies, sanitation infrastructure and hygiene in 22 districts. The authors simulated future scenarios in the district using the Water Poverty Index approach. The results showed that the WASH programme would be effective to address overall water poverty in the district.

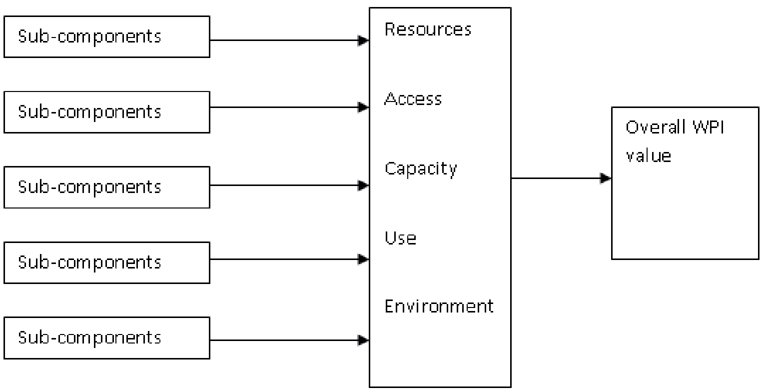
3. Methodology

3.1 Conceptual Framework

The WPI is made up of five components that touch on the factors affecting water scarcity in a country or region. The resources component captures the amount of water available in the area. The access component captures the extent of coverage of water services. The use component captures how effectively water is used. The capacity component captures the financial and social capacity to manage the water resources available. Finally, the environment component captures the environmental factors that impact on water quality. Figure 3.1 illustrates this structure.

The WPI value is given by the weighted arithmetic mean of the five components described above. The five components are themselves obtained by deriving sub-components (henceforth referred to as indicators) from a range of data available on the factors described above. The resulting index can be used to judge the performance of one community relative to others, or the performance of a community over different time periods. Corresponding to the conceptual framework described above, the main components of the index are: resources, access, capacity, use and environment. Nine sub-components are used to calculate the components of the index (section 3.2).

Figure 3.1: Structure of the WPI



Source: Sullivan (2008)

3.2 Study Area and Component Calculation

The four counties chosen for the study are Nairobi, Kiambu, Murang'a and Nyandarua. The county of Nairobi has been chosen because, as the country's capital, it has a huge population, over 50 per cent of whom live in peri-urban areas (K'Akumu and Olima, 2007) where they lack proper access to water and sanitation. Currently, only 50 per cent of the population in low income areas in Nairobi have access to safe drinking water (MoWI, 2011). There is need to determine the levels of water poverty in this area. The rationale for choosing Kiambu, Murang'a and Nyandarua counties is that the main sources of water for Nairobi County (Sasumua dam, Kikuyu springs, Ruiru Dam and Thika Dam-Ndakaini) are located within these three counties. In addition, two of the counties are urban (Nairobi - 100% urban, Kiambu - 60% urban), and two are rural (Nyandarua 18.5% urban, Murang'a - 16.5% urban), allowing a comparison of rural versus urban counties in terms of water poverty. There is need to analyse the situation of water resource availability and

Table 3.1: Components and data used to develop a water poverty index for Kenya's counties

Component	Sub-component	Data used to arrive at sub-component	Sources
Resources	Resources	Water flows at the basin level Population in the counties within the basin	NEMA State of the Environment 2010 report 2009 Census (Open data portal-Government of Kenya)
Use	Domestic water use Agricultural water use	Domestic water use per capita (m^3/cap/year) Percentage of irrigated land in the county	WASREB impact report 2011 2009 Census (Open data portal-Government of Kenya)
Capacity	Financial capacity Social capacity	CDF spending on water projects % of the population with secondary education or higher	2009 Census (Open data portal-Government of Kenya)
Access	Access to water Access to sanitation	% of population with access to an improved water source % of population with access to an improved sanitation source	2009 Census (Open data portal-Government of Kenya)
Environment	Environmental integrity Forest cover	Percentage of parcels that use chemical in the county Percentage of forested land in the county	2009 Census (Open data portal-Government of Kenya)

condition, capacity for water management and how these translate into access to water and sanitation in the four counties.

(i) Resources

This indicator refers to the amount of renewable freshwater available per capita which gives an indication of population pressure on water resources (Sullivan, 2001). Since data on water availability is not given at the county level, water availability in cubic metres per year at the basin level, was divided by the total population in the basin. This gives a crude measure of per capita water availability in each county. Per capita water availability in the Tana and Athi River basins was calculated by dividing the water resources available in each basin, by the total populations in the counties falling within the basins.

The data was normalized using a min-max approach as follows:

$$R = \left(\frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \right) X100 \qquad \text{..(3.1)}$$

Where X_i is the per capita water availability in the basin, X_{max} is the value for per capita water availability in the basin with the highest per capita availability (Lake Victoria basin), and X_{min} is the per capita water availability of the basin with the lowest per capita availability (Athi River basin).

(ii) Use

The use component reflects the ways in which water is used for various purposes. Domestic and agricultural water uses were considered as the two major indicators of water use in the study as Kenya uses 64 per cent and 30 per cent of her water for agricultural and domestic use, respectively.[2] The two indicators were calculated as follows:

Domestic water use (U_1): This was measured as per capita water use in litres per day and normalized using a min-max approach as shown in equation 3.2.

$$U = \left(\frac{X_i - X_{\min}}{X_{\max} - X_{\min}} \right) X100. \qquad \text{..(3.2)}$$

Where X_i is average domestic water use for the county in litres (*l/c/d*), X_{min} = 20 l/c/d and X_{max} = 100 *l/c/d*. If $X_i > 100$, U_1=100; if $X_i < 20$, $U_1 = 0$.

The minimum water use value used in the normalization is taken from the WHO/UNICEF Joint Monitoring Programme (JMP) for water

[2] CIA World Fact Book http://www.cia.gov/library/publications/the-world-factbook/fields/2202.html

supply and sanitation definition of the minimum requirement for domestic hygiene (WHO-UNICEF, 2000). The maximum water use value is the water ceiling that fulfils all domestic water requirements (Howard and Bertam, 2003). The average value for water consumption is taken from the Water Services Regulatory Board (WASREB) data on consumption of water produced by the Water Service Providers in each county in 2011. This figure may be an over-estimation as it considers only piped water use. Studies such as Thompson *et al.* (2001) have found that water users with access to piped water used nearly three times more water than users with un-piped water sources. However it does give an indication of domestic water consumption in urban and rural areas, since WSPs cover both populations, although rural and peri-urban populations are under-served by formal water provision channels (WASREB, 2011).

Agricultural water use was calculated using a ratio of irrigated land to cultivated land as a proxy, as this indicates improvements in agricultural production (Sullivan *et al.*, 2003). The indicator is calculated as follows:

$$U2 = \left(\frac{X_i}{x}\right) X100 \quad \text{...} \quad (3.3)$$

Where X_i is the total irrigated area in each county, X is the total cultivated area in each county.

(iii) *Capacity*

The capacity component is used to assess people's ability to manage water resources. This capacity is reflected both as financial and social capacity. Financial capacity allows the purchase of improved water and access to technology to help cope with water-related stress, while social capacity indicates people's awareness of health and environmental issues related to water and their ability to lobby for more effective management of water resources (Sullivan *et al.*, 2003).

Financial capacity (*C1*): Proportion of CDF spending on water resources is used to indicate the prioritization of water spending in the county. It is calculated as:

$$C1 = \left(\frac{X_i}{x}\right) X100 \quad \text{...} (3.4)$$

Where X_i is the amount of CDF spending on water resources in the county, and X is the total amount of CDF spending on all projects in the county.

Social capacity (*C2*): The proportion of the population with secondary education or higher is used to indicate social capacity and was calculated as:

$$C2 = \left(\frac{X_i}{x}\right) X.100 \qquad \text{..................................} \quad (3.5)$$

Where X_i is the population with secondary education or higher and X is the total population in the county.

(iv) Access

This component was calculated by measuring the proportion of the population with access to an improved water source and access to an improved water facility. According to the WHO-UNICEF Joint Monitoring Programme (JMP) for Water Supply and Sanitation (WHO/UNICEF, 2000), the following are considered as improved water sources:

- household connections
- public standpipes
- boreholes
- protected dug wells
- protected springs
- rainwater collection

Water sources not considered as improved are: unprotected dug wells, unprotected springs, vendor-provided water, bottled water and tankers. This definition of an improved water source has limitations. For example, public standpipes (an "improved water source") can be contaminated through source pollution or poor treatment, while bottled water, though not considered as improved, is usually perfectly safe despite it being expensive. Regardless of these limitations, the already mentioned definition of an improved water source is used to assess progress towards achieving the Millennium Development Goal 7's target of reducing the proportion of the population without access to safe drinking water (WHO/UNICEF, 2000).

An improved sanitation facility is defined as one where human excreta is successfully separated from human contact (WHO/UNICEF, 2000). This definition includes:

- Flush/pour flush to:

- Piped sewer system
- Septic tank
- Pit latrine

- Ventilated Improved Pit (VIP) latrine
- Pit latrine with slab
- • Composting toilet

The indicator value was calculated as:

$$A1 = \left(\frac{Xw}{X}\right) X100 \quad A2 = \left(\frac{Xs}{X}\right) \quad \text{.......................................(3.6)}$$

Where X_w is the population with access to an improved water source, Xs is the population with access to an improved sanitation facility, and X is the total population in the county, respectively.

(v) Environment

The environment component captures indicators that are related to the environmental integrity of water resources. The two indicators used are as follows:

Environmental integrity (E1): The amount of chemical fertilizer used to indicate environmental stress on the ecosystem. The indicator is calculated as:

$$E1 = \left(\frac{Xi}{X}\right) X100 \quad \text{...(3.7)}$$

Where Xi is the proportion of parcels of cultivated land that do not use chemical fertilizer and X is the total number of cultivated portions of land.

Forest cover (E2): The amount of vegetation cover used as an indicator of the degree of integrity of the ecosystem. The indicator is calculated as:

$$E2 = \left(\frac{Xi}{X}\right) X100 \quad \text{...(3.8)}$$

Where X_i is the total forested area in the county and X is the total land area of the county.

(vi) Component weighting

When calculating the final WPI, different weights can be assigned to the different indicators to compensate for different priorities and situations in the region under study. Sullivan *et al.* (2002) compiled weighting groups as shown in Table 3.2 to include the hydrological and economic conditions, as well as the priorities of the area to be studied. The first and fourth combinations of weightings match most closely to the study area. However, the fourth combination of weightings is used since the hydrological condition in the study area is not known, and the priorities match those of Kenya's Vision 2030.

(vii) Final index calculation

The calculation of the final WPI including weightings of the individual components was as follows:

$$WPI = \frac{w_r R + w_u U + w_c C + W_a A + W_e E}{w_r + w_u + w_c + w_a + w_e} \qquad \text{.........................(3.9)}$$

Table 3.2: Weighting options for the WPI

Description of the local condition			**Component weights**				
Hydrological condition	Economic condition	National/ regional priorities	Resources	Use	Access	Capacity	Environment
Very good	Unknown	Agriculture, Industry and Social	1	3	2	2	1
Average	Average	Social	1	1	2	2	1
Very good	Good	Environment and Social	1	1	2	2	2
Unknown	Unknown	Agriculture and Industry	1	2	2	2	1

Source: Sullivan et al. (2002)

4. Results and Discussion

4.1 Water Availability (R)

For the resources component, per capita water availability in the five basins was calculated according to the total water available at basin level and the populations of all the counties found within each basin. From the results, the Lake Victoria basin has the highest per capita water availability, while the Athi River basin has the lowest. The counties in the study fall within two basins. Nairobi and Kiambu counties fall within the Athi River basin (which has a per capita water availability of 133m^3/c/year), while Murang'a and Nyandarua fall within the Tana River basin which has a per capita water availability of 481.9m^3/c/yr. The component scores are shown in Table 4.1. Kiambu and Nairobi counties both score zero due to being in the basin with the lowest water availability per capita of all the five basins. Murang'a and Nyandarua both score 48.2.

Table 4.1: Resource component calculation

County	Water availability (m^3/c/yr)	Score
Kiambu	133	0
Murang'a	481.9	48.2
Nairobi	133	0
Nyandarua	481.9	48.2

4.2 Use (U)

Table 4.2 shows the component scores for water use in the four counties. Nairobi County scores the highest due to having the highest domestic water use and the highest proportion of land under irrigation. Kiambu and Murang'a both have relatively high scores for domestic use and proportion of land under irrigation, while Nyandarua scores much lower on both indicators, giving it the lowest overall score on the component.

Table 4.2: Use component calculation

County	Domestic water use (l/c/d)	Score	Proportion of land under irrigation (%)	Score	Use component score
Nairobi	108.5	100	17.1	17.1	58.6
Kiambu	76.6	70.9	9.7	9.7	40.3
Murang'a	73.0	66.3	12.5	12.5	39.4
Nyandarua	21.0	1.3	1.4	1.4	1.35

4.3 Capacity (C)

According to Table 4.3, Nairobi scores the highest on the capacity component, followed by Kiambu, then Murang'a then Nyandarua. Although Nairobi County scores the lowest of the four counties in terms of CDF spending on water projects, the county's high score on the education indicator gives it the highest overall score. Nyandarua scores low on both indicators, and the lowest overall on the component.

4.4 Access (A)

Table 4.4 shows results for the access component calculation. For the access component, Nairobi has the highest scores due to the high levels of access to both water and sanitation in the county. Murang'a scores the lowest on both indicators and on the overall access component. The National Water Services Strategy seeks to provide safe drinking water to 80 per cent of the urban population and 75 per cent of the rural population, and access to basic sanitation to 77.5 per cent of the urban population and 72.5 per cent of the rural population by 2015. In this regard, only Nairobi county is within the goals for the provision of safe drinking water to 80 per cent of the population by 2015, although it is still below the targets for provision of basic sanitation. The other

Table 4.3: Capacity component calculation

County	CDF spending on water projects (% of total CDF spending)	Score	Population with secondary education or higher	Score	Capacity component score
Nairobi	0.4	0.4	33.1	33.1	16.5
Kiambu	5.8	5.8	25.0	25.0	15.4
Murang'a	3.2	3.2	20.2	20.2	11.7
Nyandarua	0.6	0.6	15.9	15.9	8.3

Table 4.4: Access component calculation

County	Population with access to an improved water source (%)	Score	Population with access to an improved sanitation facility (%)	Score	Access component
Nairobi	83.1	83.1	61.1	61.1	72.1
Kiambu	78.1	78.1	23.9	23.9	51
Nyandarua	67.9	67.9	6.8	6.8	37.4
Murang'a	51	51	10.4	10.4	30.7

Table 4.5: Environment component calculation

County	Proportion of parcels not using chemical fertilizer (%)	Score	Vegetation cover (%)	Score	Environmental component score
Kiambu	14.7	14.7	56.3	56.3	35.5
Nairobi	45.2	45.2	19.2	19.2	32.2
Nyandarua	30.5	30.5	15.1	15.1	22.8
Murang'a	17.1	17.1	11.9	11.9	14.5

counties are still in need of resources to help them reach these goals.

4.5 Environment (E)

Table 4.5 shows the environment component score. Kiambu County scored the highest due to its high proportion of forest cover, while Murang'a scored the lowest.

4.6. Water Poverty Index for Kiambu, Murang'a, Nairobi and Nyandarua

Overall values for the WPI are shown in Table 4.6, while the pentagram plot (Figure 4.1) allows for easy visualization and comparison of WPI values among the four counties. Overall, three out of the four counties in the study score higher than the water poverty index score for Kenya, which is 47.3 according to the international comparison of countries in terms of WPI carried out by Lawrence *et al.* (2003). Nairobi scores 60.9, Kiambu (50.5), and Murang'a (49.5). The WPI component scores show the underlying reasons for water poverty and their variation within the counties in the study.

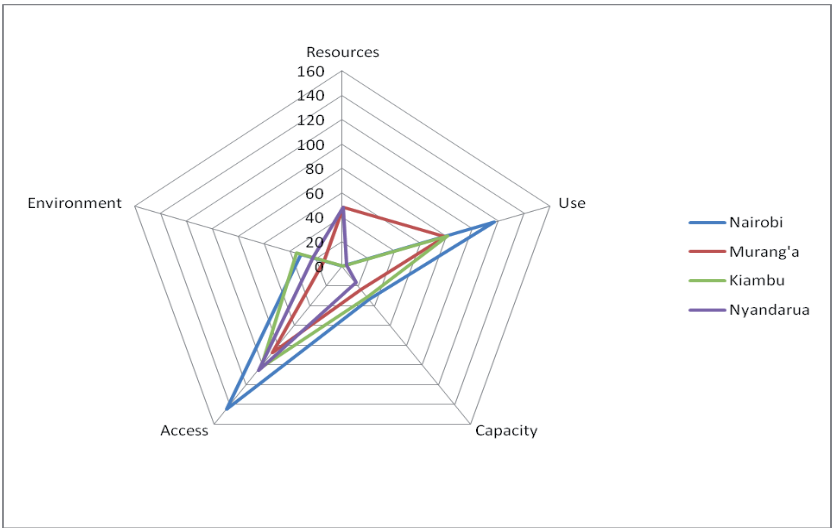
Nairobi county scores poorly in the resources component, being in the basin with the lowest amount of water resources available per capita in the country (Athi River Basin). However, the county scores the highest on the use, access, and capacity components; and second highest on the environment component, giving it a high score on the index. Kiambu County also scores low on resources as a result of being in Athi River Basin. However, like Nairobi, the county scores well on the use, capacity, access and environment components of the index.

Murang'a and Nyandarua both score well on the resources component due to their location in the Tana River Basin. Murang'a

Table 4.6: Overall water poverty index calculation

	Resources (Weighting =1)	Use (Weighting =2)	Capacity (Weighting =2)	Access (Weighting = 2)	Environment (Weighting =1)	Overall WPI
Nairobi	0	47.50	16.50	72.1	32.2	60.98
Kiambu	0	42.00	15.4	51	35.5	50.46
Murang'a	48	36.50	11.7	52.7	14.5	49.5
Nyandarua	48	1.35	8.25	43.9	22.8	39.08

Figure 4.1: Pentagram plot of WPI component values in the four counties



scores relatively well on use and capacity, but has the lowest scores in terms of access and environment. The low score in the environment component is due to its high use of artificial fertilizers and low amount of vegetation cover. Nyandarua scores the lowest on use and capacity, despite the county's Sasumua Dam providing 20 per cent of Nairobi's water. This low score is mainly due to low investment in CDF spending on water projects, and the low domestic consumption from the WSP in the area.

5. Conclusion and Policy Recommendations

5.1 Conclusion

The Water Poverty Index is a useful tool for policy makers and managers in the water sector to determine where priorities need to be placed in ensuring sustainable and equitable development of water resources for the benefit of all. This study used a water poverty index to compare the situation between Nairobi, Kiambu, Murang'a and Nyandarua counties.

The study shows that while Nairobi county is water poor in terms of per capita resource availability, it has been able to provide access to water to a good proportion of its population. However, sanitation access still needs to be improved to attain the targets of the NWSS. For Kiambu County, which is also resource poor, environmental integrity, capacity and use are relatively high. However, the county still faces challenges in improving access to sanitation in particular. Murang'a and Nyandarua counties both have an abundance of water resources compared to Nairobi and Kiambu. However, Murang'a County faces challenges of improving access to water and sanitation and improving environmental integrity by increasing the amount of vegetation cover. For Nyandarua, low figures for capacity, use and access to sanitation give it the lowest overall WPI score. The county's main challenges are in improving use of water, spending on water and education projects, and access to sanitation. The low scores on access and use in Murang'a and Nyandarua point to a need to develop the capacity for local water provision in the two counties, which have an abundance of water resources.

Differences in the overall WPI value may be partly informed by the percentage rural population in the four counties. Percentage urban populations in the four counties are: Nairobi (100%), Kiambu (60.8%), Nyandarua (18.5%), and Murang'a (16.5%). The fact that rural areas are inadequately covered in terms of access to water and sanitation has been acknowledged in the WASREB Impact Report No. 4 of 2010 (WASREB, 2011). Peri-urban areas also pose a challenge in terms of access to water and sanitation.

5.2 Policy Recommendations

This study provides the following policy recommendations to improve the water poverty situation in Kiambu, Murang'a and Nyandarua.

Firstly, resource-endowed counties such as Nyandarua and Murang'a can trade water with counties such as Nairobi that currently rely on them for water. This would allow them to generate funding to build infrastructure for local water services provision within individual counties. The funding can also be used to fund water conservation and management to ensure that water resources are developed sustainably. Trading in water is in line with the National Water Resources Management Strategy goals, which seek to recognize water as an economic, rather than a social good, and thus put in place pricing mechanisms that promote efficient use of water and conservation of water resources. This is also in line with Article 209 (4) of the new constitution which states that national and county government may impose taxes on the services they provide. The buyers, in this case, would be the resource-poor counties such as Nairobi which have benefitted from external water resources in the past. Schemes for trade in environmental goods and services are already in place within the study area. For example, Nairobi Water and Sewerage Company pays farmers in Nyandarua's Sasumua catchment to engage in conservation activities, which maintain the integrity of water resources that the company uses[3] (Mafuta *et al.*, 2011). However, the scheme has the potential to be used at a county-wide level in providing funds for the individual counties to carry out sustainable development projects. Such monies can be put into the Water Services Trust Fund, which is used to develop access to water and sanitation in counties such as Nyandarua and Murang'a, as well as towards conservation activities such as those needed in Murang'a to ensure sustainability of these water resources. Currently, planned investment in rural areas falls over 50 per cent short of what is required to achieve the MDG related to water, while the same investment in urban areas exceeds what is required by 10-19 per cent (World Bank, 2010). Thus, providing funding to the WSTF would benefit the more rural counties.

Secondly, for counties to successfully trade in their natural resources, there is need for legislation and policy at the national level, which governs how counties can cooperate and consult in managing shared resources such as water, roads, forests and others. Such a mechanism

[3] (http://presa.worldagroforestry.org/where-we-work/kenya-sasumua/

is provided for in Article 6 (2) of the Constitution. Article 189 (2) of the constitution provides the legal framework for cooperation between counties. The article states that "different governments at the county level shall cooperate in the performance of functions and exercise of powers and, for that purpose, may set up joint committees and authorities".

Thirdly, the performance efficiency of WSPs should be improved. Nyandarua county's low water use score is in part caused by the performance of its local WSP. In fact, the Nyandarua North Water and Sewerage Company has been ranked the worst performing rural WSP in the country (WASREB, 2011). The performance of WSPs is now monitored through *Impact*, the annual performance report of Kenya's water services sector released by WASREB annually. Through this, WSPs should be provided with incentives to reduce the amount of unaccounted for water lost through leakages, inactive and illegal connections and corruption-fed supply distributions in areas connected to the formal water supply. In Nairobi, which has a huge population served by the Nairobi Water and Sewerage Company, improving the efficiency of this WSP would result in increased coverage as well as reduce the burden of Nairobi on water resources in Nyandarua, Murang'a and Kiambu. This increased efficiency in Nairobi would have positive impacts in the counties that provide its water resources.

5.3 Areas for Further Studies

The study has the potential to be expanded to other counties in the country, to be used to determine the water poverty situation in each individual county, where focus needs to be put in to improve the water poverty situation in the country, and how counties can effectively manage their shared water resources for the benefit of all.

5.4 Limitations of the Study

Different methodologies for determining access to water and sanitation can yield different results. For example, comparison figures obtained by the Commission on Revenue Allocation (CRA, 2011) in their county fact sheets show the same figures for access to water, but different figures for access to sanitation. This may be due to the CRAs definition of an improved sanitation source, which includes connection to a main sewer, septic tank and cesspool as well as ventilated improved pit (VIP) latrine and covered pit latrine. This study excludes access to a cesspool as an improved water source.

Table 5.1: Figures on percentage access to water and sanitation obtained from this study compared with figures provided by the Commission on Revenue Allocation county fact sheets

County	CRA figures for % households with access to improved sanitation	Figures from this study on % households with access to improved sanitation
Nairobi	93.7	61.0
Kiambu	99.6	24.0
Murang’a	237.9	10.4
Nyandarua	99.7	16.0

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