INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 19, No. 5, p. 78-87, 2021
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Knowledge, attitudes and practices of water users that affect water resource use in lower thiba sub-catchment, Kenya

Wangechi Sarah Wagatwe*[1], Mutembei Henry M'Ikiugu[3], Kironchi Geofffrey[2]

[1]*Wangari Maathai Institute for Peace and Environmental Studies, University of Nairobi, Kenya*

[2]*Department of Land Resource Management and Technology, University of Nairobi, Kenya*

[3]*Department of Clinical Studies, University of Nairobi, Kenya*

Article published on November 26, 2021

Key words: Knowledge, Attitudes, Practices, Sub-catchment, Lower-Thiba

Abstract

Water resource in Lower Thiba Sub-catchment is important as over 70% of the population in the area rely on it for irrigation among other uses. This study was carried out to establish the knowledge, attitudes and practices of the community affecting its use. Data was collected from 361 households (n=361) within the sub-catchment. For ease of survey and for homogeneity, the sub-catchment was sub-divided into three zones namely; upper, mid and lower zones, from each a sample of 120 respondents was randomly sampled (n=120) using a transect line survey of every 5th household. Data was analysed using Social Science Statistical Package version 20 and presented using descriptive statistics. The results showed that 83% ($P \leq 0.01$) of the respondents practiced good water use practices with water recycling at (69%). Though 93% of the respondents used agrochemicals, (81%($P \leq 0.01$) of them applied agronomic practices that are meant to conserve soil water as follows; mulching (41%), mixed cropping (18%) and reduced frequencies of irrigation (16%). Respondents (57%($P \leq 0.01$) felt the main threat to water resource is degradation of the water source areas, with 22% feeling pollution of water is a major threat, while (12%) felt that climate change is a major threat. From the findings of this research, it is recommended that policy on water resource management and use should not only be based on the need to improve quantity and quality of water, but also the need to address the challenges arising from lack of awareness and negative community attitudes and practices.

***Corresponding Author:** Wangechi Sarah Wagatwe ✉ sarawa7hope@gmail.com

Introduction

Water is not an infinite resource and its highly climate sensitive (Millenium Ecosystem Assessment, 2005; IPCC, 2007a; IPCC, 2007b; Li *et al.,* 2008; Lanari *et al.,* 2016). Currently, up-to 1 billion (16%) of the global population lack acess to clean and safe water (WHO, 2010). Africa is the second driest continent with only 40% of its population accessing the climate sensitive, clean and safe water resource (UNEP, 2010).

Kenya is classified as a water scarce nation with renewable fresh water resources of 647m^3 per capita in relation to the United Nations recommended 1000m^3 (FAO, 2003; WRI, 2003). Kenya's water resources have continued to decline at the rate of 200m^3 per capita per annum, partly due to climate change but also due to poor governance and management (MoE,W & NR, 2014; World Bank, 2007); making her per capita availability of water to be projected to fall to 250m^3 by the year 2025 (WRI, 2003; UN-Water, 2006).

Increasing food demand and preferences, as well as the changes in global climate are exerting great pressure on existing water resources (IPCC, 2014). This calls for a more integrated water management approaches and policies, which must be understood and accepted by the users. This involves integrating knowledge and awareness of water issues by the users, integrating their attitudes, perceptions and practices in water management policies. Studies have shown that there are various conditions influencing knowledge, attitudes and practices in relation to water management (Oremo *et al.,* 2019; Dean *et al.,* 2016; Rolston *et al.*, 2017). These conditions include geographical experiences such as changing river regimes, farm characteristics such as distance from water source, acess to extension services, social experiences such as membership to social networks, and residency status, among others. Studies have shown that there are motivational factors explaining environmentally destructive behavior (De Young, 1996). It is necessary to make sacrifices for saving natural resources and the effort for conserving those resources ought to be shared by all the members of a community. If some of those members perceive that others waste the resource, they may not feel motivated to preserve it (Mundt, 1993). Previous studies have focused on analyzing the relationship between knowledge and support for sustainability of water resources. Very little has been done in regard to how knowledge, attitudes and practices of water users affect sustainability of the resource; and how policies can address existing gaps in knowledge, attitudes and practices.

In Lower Thiba sub-catchment where this study was done, the dry season which occurs twice a year, generates conflicts between upstream and downstream water users, which can lead to loss of life and livelihoods of the people involved (LTSCMP, 2012; KCIDP, 2013/2017). Water resource in the sub-catchment is under pressure to supply growing irrigation demand occasioned by mushrooming unregulated smallholder irrigation systems, as well as from a growing horticultural production economy in the area (KCIDP, 2013/2017). This has led to increased abstraction of surface water and deteriorated some important ecosystems such as wetlands and riparian areas that have been encroached on.

This study therefore analyses how water resource users in the sub-catchment are engaged in water management, in special focus to what they know and belief, their perception, attitude and practices; and explores how this can inform water resource planning in the area. The study also identifies existing gaps in knowledge, attitudes and practices of water users and suggests necessary interventions to improve support for sustainable water use.

Materials and methods

Theoretical and Conceptual framework

Water management for irrigation purposes such as in Mwea Irrigation Scheme, (located within Lower Thiba sub-catchment) requires utmost sustainability governance and management consideration as the water resource is dwindling due to a myriad of factors such as catchment degradation, poor farming practices in the watershed, excessive and illegal water abstraction, and negative effects from climate change

(Notter *et al.,* 2007). This study was based on institutional theory which posits that institutions operating in the same field (in this case water users/actors) tend to adopt similar norms and practices overtime (Di Maggio and Powell, 1983). Institutions do this by either copying practices/strategies from similar successful institutions; or by induction from existing institutional values and expectations. These values and expectation can be compulsory (legally mandated) or voluntary (imposed by users or society) (Delmas and Toffel, 2008). The actors anticipate and observe what the other is doing and respond appropriately. If the action is perceived as negative, then it triggers a negative action and eventually it leads to the tragedy of the commons (Hardin, 1968). The key outcome in this study was sustainable and efficient water use, which could be affected either positively (sustainable water resource use) or negatively (tragedy of the commons) by the attitudes and practices of the water users, as well as their knowledge or perception regarding the water resource. There are other factors that could affect sustainable water use in the area, such as the political forces, cultural elements, policy environment as well as regime changes that could disrupt water resource access and use. The theory has been used to argue the KAP elements of this case study by testing how actors' requisite skills (knowledge, attitudes and practices) interphase and interact with existing frameworks to achieve or not achieve sustainability in institutionalized behavior for effective water resource management and use in the study area (Fig. 1).

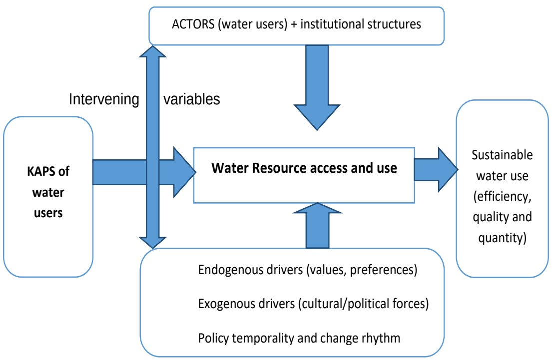

Fig. 1. Conceptual framework.

Study Design

The study used a descriptive survey design (Kombo and Tromp, 2006) where quantitative and qualitative data was collected. The key sampling parameter used in this study was household, since each household uses water for various purposes, and the target person in each household was the head of the household.

Sampling

The study sampled water users within the lower, mid and upper areas of Lower Thiba sub-catchment and those surrounding the sub-catchment up to a 5km radius, since the greatest interaction of the community with the resource is by those living within the radius of 5km from the resource (Muchapondwa and Okumu, 2017). Members and officials of the local water user association (RWATHIBAWRUA) and members / officials of Irrigation Water Users Association (IWUA) within Mwea Irrigation Scheme also gave their views through focus group discussions. The sub-catchment was sub-divided into 3 sections for purposes of sampling; upper, mid, and lower zones comprising (Kutus/Kimbimbi area, Ngurubani/ Karira area and Ndindiruku/Makima area respectively). All households were randomly selected using the transect line survey of every fifth household for each of the three zones. Yamane (1967) provides a simplified formula to calculate sample sizes, which was used;

$n = N/ (1+N (e)^2$

Where n is the sample size, N is the population size, and e is the level of precision (0.05), A 99% confidence level and P (variability level) = 0.01 are assumed; a population of 33,875 households was used (data on the number of households was gotten from the Water Resource Management offices and Lower Thiba WRUA sub-catchment management plan, 2012) and an average of six members per household (provided by the Census survey report KNBS, (2009).

Data collection tools

Data was collected using semi-structured questionnairesFocus Group Discussions (FGDs) comprising members of the community, members of WRUA, IWUAs and NGOs, was conducted to get views on existing community practices and attitudes towards water use and management. Information from focus group discussion was used to corroborate information from the questionnaires. Secondary data was collected from government documents/archives; literature from both physical and electronic materials.

Data analysis

Data was then analyzed using Statistical Package for Social Sciences (SPSS), and presented using descriptive statistical tools that include; percentages, means, standard deviation, frequency distribution tables, graphs, and charts. The test for significance was done using Pearsons' chi-square test.

Results and discussion

Community knowledge, attitude and practices in relation to water resource use and conservation

The results showed that 87% (n=361, P= ≤0.01) of respondents had a good understanding of what water resource conservation is all about, with 81% (n=361, P= ≤0.01) of the respondents admitting that they engage in good water use practices (Table 1). This is expected as water resource was the economic lifeline of the area, and the fact that there were water user associations across the sub-catchment.

Table 1. Community knowledge attitudes and practices: Positive; Respondents who understood and practiced water conservation. Negative; those who were of a contrary opinion.

Parameter	Yes (positive) %	No (negative) %
Understanding of water resource conservation	87	13
Engage in good water use practices	81	19
Community attitude to water conservation positive	42	56
Benefits in conserving water resource	90	10

Chi-square value significant at 99% confidence level, P≤ 0.01

Water users who are members of WRUAs and IWUAs easily access information and extension services in regard to water resource use and management as opposed to those who are not members (Krell *et al.,* 2020). Other studies have also indicated that community awareness increases water conservation habits (Oremo *et al.,* 2019; Hohenthal, 2018; Cole *et al.,* 2017; Lee and Paik., 2011). The most common practice was water recycling and reduced irrigation times, especially during the dry season.

Slightly more than half (56%) of the respondents' attitude towards water conservation was negative mainly because river water is easily accessible throughout the year and hence believe there is excess water with no need to conserve. This is despite an overwhelming proportion of respondents (90%) who said they believed that there is a benefit in conserving water resource, with the most cited benefit being access to adequate water volumes at 59%. This agrees with Roseth (2006), who observed that community conservation behavior was driven by the desire not to run out of water. However, the community's perception regarding water resource in the area largely determines their conservation behavior (Fan *et al.,* 2014). The community believes there is enough water most of the times during the year, hence no need to conserve it. Behavior change has been known to occur only when actors feel that such a change maximizes their utility (Alley, 2001). Community water users' association in the area need to be supported by both levels of government, as well as by the private sector as they have proved to be key in ensuring effective water use practices hence sustainability of the finite resource.

Community practices affecting water use and conservation

In regard to water conserving agronomic practices, the most common practice was mulching with 34% (P≤0.01) across the sub-catchment out of which 52% were in the upper zone; other practices were mixed cropping (14%) and reduced irrigation frequencies (14%) (Table 2). The upper zone of the sub-catchment grows a variety of horticultural crops, hence the reason they can afford to do mulching and mixed cropping as a way to conserve soil water. Mulching was found to be one of the agronomic practices that has high soil water retention (Moradi *et al.,* 2011). The mid zone of the sub-catchment is mainly dominated by the production of paddy rice, which may not allow other soil water conservation measures done, save for reducing irrigation frequencies. Paddy rice crop that is grown in the middle zone of the study area was found to be a heavy water user (McIntosh, 2001). Further, the results showed that 57% of the respondents did not practice any water conservation method. This could be as a result of low awareness and also the perception that there is always enough water from the river. This can be mitigated through public awareness/extension and involvement of community members in water management activities, as water is a finite resource, despite the illusion of plenty, and needs to be conserved (Chepyegon and Kamiya, 2018).

Table 2. Water conservation agronomic practices by the community (n=313).

Water conservation agronomic practice	Location within the study area.			Total
	Upper	Mid	Lower	
Mulching	55	22	29	106
Reduced tillage	10	9	8	27
Mixed cropping	2	20	21	43
Agro-forestry	1	27	6	34
Reduced irrigation frequencies & times	6	32	7	45
Other (specify)	1	0	0	1
None	4	28	25	57
Total	79	138	96	313

Chi-square value significant at 99% confidence level

Community perception on water quality, water distribution and water charges

The results showed 87% (P≤ 0.01) of the water users felt the general water quality was good (table 3), which is contrary to the fact that water pollution was cited as the second-most serious threat to water resource in the area. A previous survey conducted by Rural Focus Survey, (2012), indicated that Thiba River, the main source of water in this sub-catchment, was highly polluted. The report recommended that river water should not be used for drinking. On observation, it was noted that within the major urban centres, there were so many health centres, which could indicate demand, and in essence water-borne diseases could be some of the reasons for the demand. Further study should be done to establish the connection between water quality and the users' health. Majority of the community members drink water from the river and only 66% treat the river water before drinking. Treating river water before drinking should be a practice encouraged by public health authorities and more affordable means of treating the drinking water introduced.

Table 3. Community perception on water distribution, quality, amount, use and conservation.

Parameter	Agree (positive) %	Disagree (negative) %
Water quality is good	87	13

Chi-square value significant at 99% confidence level

Causes of water pollution

Majority of the respondents who felt water quality was poor were from the mid and lower zones of the sub-catchment with only 7% from the upper zone feeling there was water pollution. This is expected as much of agriculture is done in the upper and middle zones of the sub-catchment where a lot of agrochemicals are used and this through run-off flows into the river. Though the area does not have many industries, 40% of the respondents felt the major cause of water pollution is from industries (Fig. 2). This can be explained by the fact that the whole of Kirinyaga County doesn't have a sewerage system, which means raw sewer disposal is done in rivers (Rural Focus Survey, 2012). Agricultural chemicals came in second with 27% from the rice fields, with only respondents from the mid and lower zones responding in the affirmative. Domestic waste was cited at 27%, with siltation at 3%, and plastics were cited at 1%.

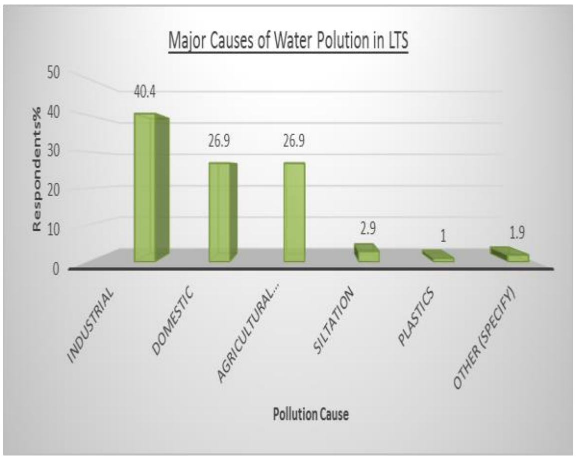

Fig. 2. Community perception on the potential causes of water pollution across the sub-catchment.

The findings agree with similar findings that shows agricultural pollution (agro-chemicals and siltation) is common in the area (Lanari *et al.,* 2016; MoE,W & NR, 2014; Rural Focus Survey, 2012). More recent studies have indicated excessive use of inorganic chemicals during rice and horticultural production as the main cause of pollution to adjacent water bodies (Kumunga *et al.,* 2020). Domestic waste is directed to the rivers due to a lack of sewerage line in the area. Therefore there is an urgent need for a sewerage and disposal system within the area by the water service providers, specifically Kirinyaga Water & Sewerage Company (KIRIWASCO). Similarly, the National Irrigation Board (NIB) needs to come up with a way of treating waste water from the rice farms before releasing it back into the river. The public should be trained in better farming practices with minimal use of agro-chemicals and with more soil water conservation practices. Though use of plastics is banned in the country, the results indicate that they are still being illegally accessed and used.

Other practices by the community

Only 69% ($P \leq 0.01$) of the respondents said they re-use water with the percentage of those recycling water increasing downstream (Table 4). The most common practice of re-use cited was using same water after cleaning clothes to wash the house. However, majority of the respondents (96%) felt that water recycling would minimize water-wastage, in cases where water was scarce. However, community awareness campaigns should be done to outline the benefits of re-using waste water and affordable ways of recycling, in order to change public perception on waste water recycling. According to Miller (2006), public perception and low awareness on the ways and benefits of recycling waste water are major challenges that hinder waste water recycling.

Rain-water harvesting was low at 22% ($P \leq 0.01$) though a majority of respondents (72%) owned water harvesting facilities (Table 4). More effort needs to be put in ensuring more people harvest rain water and re-use waste water. Though rainwater harvesting may have hydrological impacts on downstream catchment water availability on-farm (Ngigi *et al.,* 2008; Makurira *et al.,* 2009); rainwater harvesting for domestic and drinking purposes should be encouraged in this sub-catchment.

Table 4. Community perception on water conservation as applied on good water use practices.

Parameter	Yes (positive) %	No (negative) %
Experience irrigation problems	93	7
Use of agro-chemicals in farm	93	7
Recycle water	69	31
Rain-water harvesting	22	78

Chi-square value significant at 99% confidence level

The study showed 93% ($P \leq 0.01$) of the respondents used agro-chemicals on their farms (Table 4); and 44% of them said they burn used agrochemical containers, 33% of them buried them and 23% littered them anywhere (Fig. 3). These agro-chemicals and used containers eventually drain into the river, and river water users downstream could be facing serious pollution problems. Horticulture in the area has increased use of pesticides and inorganic fertilizers which have been found to leach into the rivers caused major pollution (Lanari *et al.,* 2016; CDE Policy Brief, 2016).

Small holder irrigation farmers engage in inefficient use of irrigation water and agrochemicals thus resulting to water and environmental pollution (Aregay and Minjuan, 2012). In addition, irrigated farming uses 42% more inorganic fertilizers than rain fed farming. It was noted from observation that agricultural waste water from the paddy areas was channeled back to the river laden with fertilizers and agro-chemicals. Authorities must come up with a way to ensure waste water from the farms is treated before it can be released back into the river. Public awareness on negative effect of using agro-chemicals and disposal of chemical containers needs to be encouraged. Low awareness by farmers on agrochemical handling results to mishandling and either over-use or under-use of the same (Gesesew *et al.,* 2016). This could be the case with the farmers within the sub-catchment.

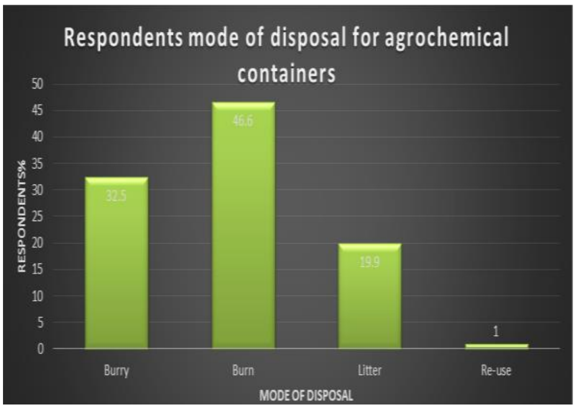

Fig. 3. Respondents mode of disposal for agrochemical containers in LTS.

Irrigation methods used

A majority of respondents 93% (P≤0.01) said they experience problems when irrigating (Table 4), with the most common problem being inadequate water amounts and water pollution coming in second. Studies have shown major problems associated with smallholder irrigation systems include loss of water due to inefficient irrigation systems, water pollution due to silting and agrochemical use and land degradation due to water logging and salts build-up (Bjornlund *et al.,* 2020; Yihdego *et al.,* 2015; Ulsido *et al.,* 2013; Asayehegn, 2012).

This study showed that 93% (P≤0.01) of the respondents used inefficient irrigation methods; with 45% of them using furrow irrigation, 27% basin irrigation, 21% surface irrigation, with only 5% using sprinkler irrigation (Fig. 4). Less than 1% used drip irrigation. Majority of the respondents in the upper zone use furrow irrigation at 45%, while majority of the respondents within the mid zone used basin irrigation and furrow irrigation at 70% and 33% respectively. Respondents from the lower zone were more versatile preferring to use surface irrigation as the main method at 53%, as well as sprinkler, drip and other irrigation methods not common in other zones of the sub-catchment. This can be explained by the fact that water flows through natural drainage in the lower zone hence no need to pump it. The type of crops grown, (the region is known for producing aromatic pishori rice variety, which is water intensive), also dictate the kind of irrigation method used. The high cost of installing the more efficient irrigation methods like drip, is limiting to a majority of existing small holder irrigation farmers within the sub-catchment. However, use of more efficient irrigation methods does not necessarily equal to water conservation (Ward and Pulido-Velazquez, 2008), mainly due to the interference with the hydrological flows. The government should encourage other practices to conserve water or minimize wastage, such as lining of canals (all of which were not lined), use of efficient irrigation methods, and use of crop varieties that are of low water use, such as SRI for rice production. SRI was found to use up-to 50% less irrigation water and have yield increases of up-to 30% (Ndiiri *et al.,* 2012).

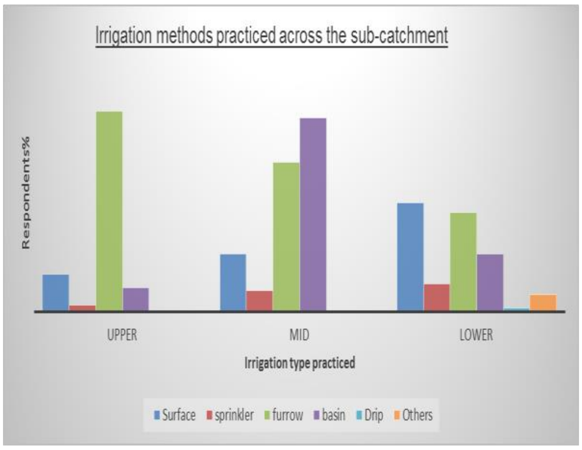

Fig. 4. Irrigation methods practiced across the sub-catchment (P≤0.01).

Further, it was noted from observation that there was no waste water treatment options especially within the rice irrigation scheme, with polluted water from the farms being released directly into the river (with pollution being cited as the second major irrigation problem experienced by farmers downstream). NIB should come up with a waste water treatment plant within the irrigation scheme in-order to ensure only treated water is released back to the river for downstream use.

Conclusion and recommendations

These findings indicate that community awareness, practices and perceptions can either positively or negatively affect water resource.

Policy makers therefore need to consider these practices and perceptions as affecting water resource in the area and address them appropriately. Community awareness campaigns should be done to inform the community of the effects of some of the negative practices and perceptions, and agree on how they can be changed or turned around to protect the water resource in the area. Farmer training would be key in ensuring sustainable agronomic practices. Further studies need to be done to establish the health impacts to the existing community as a result of consuming river water directly. Further, research should be done to establish the long term effect of irrigation on the soil and ground water within the Mwea Irrigation Scheme.

Acknowledgement

The authors are grateful to institutions and individuals who provided data and information towards this research. These include Kirinyaga County WRMA office, Rwathiba WRUA committee members, and the members of the community in the area.

References

Alley B. 2001. New institutionalist explanations for institutional change: A note of caution. Politics **21(2),** 137-145.

Aregay FA, Minjuan Z. 2012. Impact of irrigation on fertilizer use decision of farmers in

Asayehegn K. 2012. Negative impact of small scale irrigation schemes: A case study of central Tigray region State, Ethiopia. Agricultural Research and Reviews Vol **1(3),** pp. 80-85.

Bjornlund V, Bjornlund H, Rooyen AF. 2020. Exploring the factors causing the poor performance of most irrigation schemes in post-independence Sub-Saharan Africa. International Journal of Water Resources Development 2020, **36(5),** 554-5101.

Chepyegon C, Kamiya D. 2018. Challenges Faced by the Kenya Water Sector Management in Improving Water Supply Coverage. Journal of Water Resource and Protection **10,** 85-105.

China. 2002. A case study in Weihe River Basin. Journal of Sustainable Development **5(4),** 74-82.

De Young R. 1996. Some psychological aspects of a reduced consumption lifestyle: the role of intrinsic satisfaction and competence motivation. Environment & Behavior **28,** 358-409.

Dean A, Fielding K, Newton F. 2016. Community knowledge about water: Who has better knowledge and is this associated with water-related behaviours and support for water-related policies? PLoS ONE 2016 **11,** 159063.

Delmas M, Toffel M. 2008. Organizational responses to environmental demands: opening the black box. Journal of Strategic Management **29,** 1027-1055.

DiMaggio P, Powell W. 1983. The iron cage revisited: Institutional isomorphism and collective rationality in organizational fields. Sociological Journal review **48(2),** 147-160.

Fan L, Wang F, Liu G, Yang X, Qin W. 2014. Public perception of water consumption and its effects on water conservation behavior. Water 2014, **6,** 1771-1784.

Food and Agricultural Organization (FAO). 2003. Review of World Water Resources by Country, edited by A. P. o. F. s. L. a. W. D. Division, United Nations, Rome.

Gesesew HA, Woldemichael K, Massa D, Mwanri L. 2016. Farmers' knowledge, attitudes, practices and health problems associated with pesticide use in rural irrigation villages, Southwest Ethiopia. PLOS ONE / SRPT **13(2006),** pp. 1-13.

Hardin G. 1968. The tragedy of the commons. Science **162,** 1243-1248.

Hohenthal J. 2018. Local ecological knowledge in deteriorating water catchments: reconsidering environmental histories and inclusive governance in the Taita hills, Kenya pp. 56.

Intergovernmental Panel on Climate Change (IPCC). 2007a. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Solomon S, Qin D, Manning M, Chen Z, Marquis M, Averyt KB, Tignor M, Miller HL. Eds. Cambridge University Press, Cambridge 996 pp.

Intergovernmental Panel on Climate Change (IPCC). 2007b. Climate Change 2007, Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Metz B, Davidson O, Bosch P, Dave R, Meyer L. Eds. Cambridge University Press, Cambridge, UK

Intergovernmental Panel on Climate Change (IPCC). 2014. Synthesis Report. Geneva, Switzerland 2015.

Kenya National Bureau of Statistics (KNBS). 2009. Kenya Demographic and Health Survey 2009. Kenya National Bureau of Statistics, Nairobi.

Kirinyaga County. 2012. First County Integrated Development Plan Draft **2013-2017,** 22-23.

Kombo DK, Tromp DL. 2006. Proposal and Thesis Writing: An Introduction; Nairobi: Paulines Publications Africa.

Krell NT, Giroux SA, Guido Z, Hannah C, Lopus SE, Caylor KK, Evans TP. 2020. Smallholder farmers' use of mobile phone services in central Kenya. Climate and Development pp. 1-14.

Kumunga EM, Ndiwa TC, Muthama JN. 2020. Towards a framework for monitoring and communicating water resources sustainability: A case study of Rwamuthambi Sub Catchment, Kenya. Journal of sustainability environment and peace **3(1),** 21-33.

Lanari N, Liniger HP, Kiteme BP. 2016. Commercial Horticulture in Kenya: Adapting to Water Scarcity. CDE Policy Brief No. **8**. Bern, Switzerland: Centre for Development and Environment.

Lee S, Paik HS. 2011. Korean household waste management and recycling behavior. Building and Environment **46(5),** 1159-1166.

Lower Thiba Water Resource Users Association (LTWRUA). 2012. Sub-catchment management plan pp. 1-60.

Makurira H, Savenije HHG, Uhlenbrook S, Rockström J, Senzanji A. 2009. Investigating the water balance of on-farm techniques for improved crop productivity in rainfed systems: a case study of Makanya catchment, Tanzania. Physics and Chemistry of the Earth **34,** 93-98.

McIntosh AC. 2001. A Guide and Sourcebook on Urban Water Supplies in Asia for Governments, Utilities,Consultants, Development Agencies, and Nongovernment Organizations pp. 1-137.

Millennium Ecosystem Assessment (MEA). 2005. Ecosystems and human well-being: current state and trends. Island Press, Washington DC.

Ministry of Environment, Water and Natural Resources (MoEWNR). 2014. Upper Tana Natural Resources Management Project (UTaNRMP). Baseline Survey Report, June 2014 pp. 1-270.

Moradi A, Sung CT, Goh KJ, Hanif AH, Ishak CF. 2014. Effect of four soil and water conservation practices on soil physical processes in a non-terraced oil palm plantation. Soil and Tillage Research **145(2014),** 62-71.

Mundt J. 1993. Externalities: uncalculated outcomes of exchange. Journal of Macro-marketing **13,** 46-53.

Ndiiri JA, Mati BM, Home PG, Odongo B, Uphoff N. 2012. Comparison of water savings of paddy rice Under System Of Rice Intensification (SRI) growing rice In Mwea, Kenya. International Journal of Current Research and Review **4(6),** 63-73.

Ngigi SN, Savenije HHG, Gichuki FN. 2008. Hydrological impacts of flood storage and management on irrigation water abstraction in upper Ewaso Ng'iro river basin, Kenya. Water Resources Management **22,** 1859-1879.

Notter B, Macmillan L, Viviroli D, Weingartner R, Liniger H. 2007. Impacts of environmental change on water resources in the Mt. Kenya region. Journal of Hydrology (2007) **343,** 266-278.

Okumu B, Muchapondwa E. 2017. Determinants of Successful Collective Management of Forest Resources: Evidence from Kenyan Community Forest Associations; ERSA working paper **698,** August 2017.

Oremo F, Mulwa R, Oguge N. 2019. Knowledge, Attitude and Practice in Water Resources Management among Smallholder Irrigators in the Tsavo Sub-Catchment, Kenya. Journal of Resources 2019 **8,** 130.

Rolston A, Jennings E, Linnane S. 2017. Water matters: An assessment of opinion on water Management and community engagement in the Republic of Ireland and the United Kingdom. PLoS ONE 2017 **12,**174957.

Roseth N. 2006. Community views on water shortages and conservation. Research Report **28**,Cooperative Research Centre for Water Quality and Treatment, Salisbury, South Australia.

Rural Focus Limited (RFL). 2012. Water abstraction and pollution survey for Thiba and Ragati Rivers. Final Report, 5th September (2012), 1-124.

Ulsido DM, Demisse EA, Gebul MA, Bekelle AE. 2013. Environmental impacts of small scale irrigation schemes: Evidence from Ethiopia Rift-Valley Lake Basins. Environmental Research, Engineering and Management, 2013, No. **1(63),** pp. 17-29.

United Nations Environmental Programme (UNEP). 2010. Africa Water Atlas, Volume **1**, pp.311.

UN-Water. 2006. The 2nd United Nations World Water Development Report: Water, a shared responsibility.

Ward FA, Pulido-Valesquez M. 2008. Water conservation in irrigation can increase water use. PNAS **105(47),** 18215-18220.

World Bank. 2007. Mainstreaming adaptation to climate change in agriculture and natural resources management projects: climate change team environment department. Guidance Notes **7**. Washington, DC: World Bank 18 pp

World Health Organization (WHO). 2010. Global Water: Issues and Insights pp. 249.

World Research Institute. 2003. International Water Management Institute 2003. Water Resources Atlas.

Yamane T. 1967. Statistics; an Introductory Analysis, 2nd Ed., New York: Harper and Row.

Yihdego GA, Gebru AA, Gelaye MT. 2015. The impact of small scale irrigation on income of rural farm households: Evidence from Ahterom Woreda in Tigray, Ethiopia. International Journal of Business and Economics Research 2015 **4(4),** 217-228.