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Established Water Conservation Projects in Kitui County, Kenya

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Abstract: **As human population grows coupled with completion and among water users and climate change, there is need for the ASALs to conserve for agricultural use and nonfarm use. This study examines the type of established Water Conservation Projects (WCPs) in Kitui County, which is one of Kenya's ASALs. This provide ground to analyze the water uses from the WCPs. The study statistically and thematically analyzed responses randomly selected 400 household heads of Kitui County and purposively selected key informants. The study was done in between November 2014 and April 2015. The tools of data collection included: questionnaires, Interview Guide, Focus Group Discussions Guide and Field Observation Guide. Cross-sectional Survey Research Design was used depicting the current state of the established WCPs, the humanitarian organizations behind their establishments and the rationale for their establishments. Results reveal that the established WCPs include earth dams, sand dams, subsurface dams, farm ponds, rock catchment dams and soil moisture conservation trenches.**

Keywords: **Household involvement; Water conservation and Water Conservation Projects.**

I. INTRODUCTION

According to Grey and Sadoff (2007), water security is the availability of the satisfactory quantity of water. It is estimated that by 2050, 40% of the world's population will experience diminished access to water facilitated by, among other things, growing water shortage, population expansion and contending water use (Ward, 2007). The projected climate changes will further worsen the state of water and food security, and this will especially affect poor people who rely on the environment for survival (Oluoko-Odingo, 2011).

Water scarcity, amid climate change, calls for water conservation for use by humans, animals, crops and for income generation (Jewitt *et al* 2004; FAO, 2014). Birnie *et al* (2002) note that the conservation of natural resources among them soil, water, plants and forests are a necessary guarantee for the subsistence of humanity. FAO, (2013b), estimates that two thirds of the World's population is likely to experience water scarcity by the year 2025 owing to the increasing droughts, overuse of water, misuse of water and pollution. The situation is likely to worsen if there is unregulated forest use because they play a significant role of regulating the flow of surface and ground water (FAO, 2013b).

Although water is beneficial, it can be destructive by either its presence or absence: water's destructive nature can be through floods, landslides, soil erosion, contamination and conflicting uses among others (Grey and Sadoff, 2007). This calls for strategies to diminish the negative potential of water while increase the fruitful potential of water (Grey and Sadoff, 2007). Increased stream flows during precipitation should be harvested and conserved for use during the dry season (Ward, 2007). Experiences from the study done on rainwater harvesting at Mahasarakham University indicated that water resource conservation can be in the form of harvesting rain water from the roof and have it stored in a tank or in a pond for household or outdoor uses (Chaimoon, 2009). Investing in rainwater harvesting can conserve water supply or supplement scarce water in the dry areas (Chaimoon, 2009).

Kenya is a water scarce country with 647 cubic meters of renewable fresh water per capita and with extremes of droughts (KWR 2005; Monteiro *et al* 2010), besides, Kenya's investment in water resource management declined in the 1990s (RoK, 2005). Between 2003 and 2006, many parts of Kenya's ASALs received insufficient rainfall, which ushered in food insecurity, with the number of affected people rising from 1 million in 2003 to 3.5 million in 2005/2006 (Shanguhyia, 2008). Due to climate change, the Kitui County has experienced water shortage and altered rainfall patterns (RoK, 2012). Based on this background, the study sought to determine the established WCPs in Kitui County.

2. MATERIALS AND METHODS

2.1. Study Area

This study was conducted in between November 2014 and April 2015 in Kitui County, Kenya. According to the 2009 Census Report, the Kitui County has a total population of 1,012,709, composed of an estimated 205,491 households (KNBS, 2009). The County lies on the Eastern Part of Kenya (Kavoi *et al* 2013), and occupies an area of 30,570.30 km^2 some of which (6,369 km^2) are occupied by Tsavo East National Park. Kitui County borders Tana River to East and South East; Taita Taveta to the South, Makueni to the West; Machakos to North West, Embu to the North West, and finally Tharaka and Meru to the North (KC, 2013). Kitui County is one of the drought-vulnerable, water scarce and food insecure parts of Kenya (RoK, 2010; Mbii, 2011; Kaveva, 2011). The annual rainfall ranges between 500-1,050 and the county's high temperatures facilitate high evapo-transpiration of the built dams (RoK, 2010). The long rains in Kitui County are estimated to constitute 30% to crop production (KC, 2013).

2.2. Research Design

According to Kothari (2004), a research design is the conceptual structure within which research is conducted. In line with the objective examining the types of established WCPs, Cross-sectional Survey Research Design was used. This research design was found helpful in depicting the current state of the established WCPs, the humanitarian organizations behind their establishments and the rationale for their establishments.

2.3. Study Population

The targeted study population comprised household heads of Kitui County, Kenya. According to the 2009 Census Report, Kitui County has a total population of 1,012,709 (KNBS, 2009). The sampled study population included both household heads who have benefitted from the WCPs and those who have not benefitted from the WCPs. Whereas households who have benefitted from the WCPs were helpful in giving an insider's perspective on water uses and its bearing on food security, households who have not benefitted from the projects gave the outsider's perspective on water uses and its bearing on food security. The study as well targeted the group members of WCPs; group leaders of water-user projects; opinion leaders like retired teachers, retired civil servants, religious leaders and women leaders; officers from the ministry of water, nutrition department and County Agricultural Extension Officers.

2.4. Sampling Strategy

The study randomly selected 400 household heads of Kitui County to represent the entire county population of 1, 012, 709 (KNBS, 2009). The stratified random sample size was determined using a web-based calculator of Survey Systems (Zar, 1984).

$$SS = \frac{Z^2 * (p) * (1-p)}{C^2}$$

Where:

SS = Sample Size

Z = Z value (e.g. 1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal (.5 used for sample size needed)

c = confidence interval, expressed as decimal (e.g., .05 = ±5)

A sample size of 384 with a confidence interval of 95% and a margin error of 5% was arrived at. However the sample size was rounded up to the nearest hundred to come up with a sample size of 400. The study further made use of quota sampling to select FGD participants while key informants were purposively selected.

2.5. Data Collection

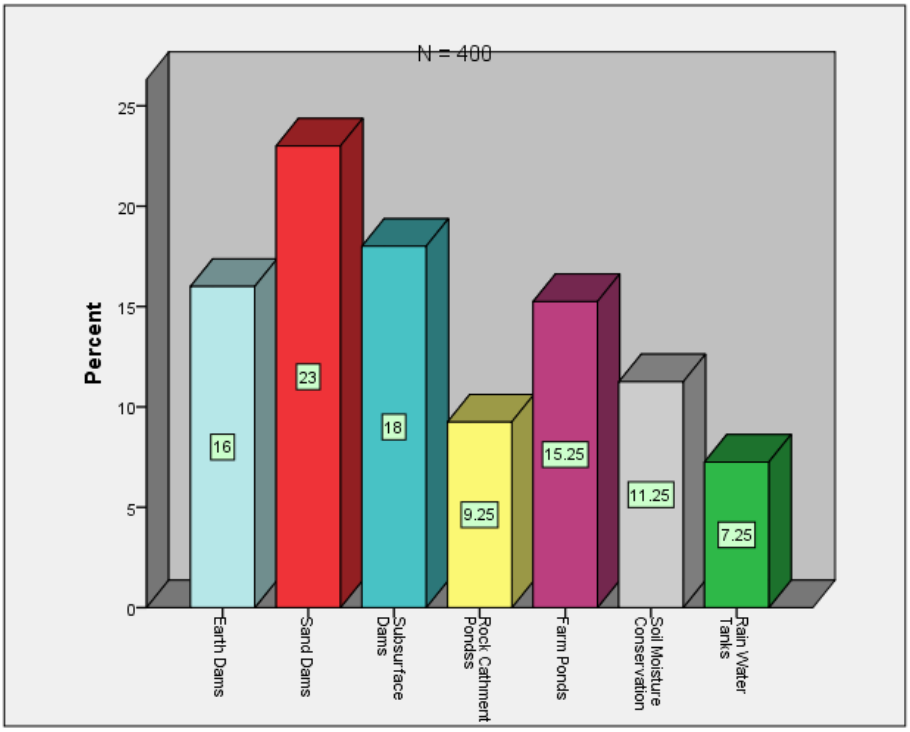
The researcher, assisted by two research assistants collected data in between November 2014 and April 2015. Whereas quantitative primary data were collected using questionnaires, qualitative primary data were collected through using Interviews Guides. Data collection through both questionnaires and key informant interviews was done by the researcher, interpreter and two Research Assistants. The study made use of questionnaires with both closed-ended and open-ended questions to source data from household heads. This was followed by face to face interviews, FGDs and field Observations were made through the entire field work. Field observations were helpful in noting the established WCPs to minimize discrepancy between what the informants noted in the questionnaires or said and what is actually on the ground. The following libraries were helpful in sourcing theoretical data: MMUST Library, Mary Immaculate Library of Tangaza University College and the National Library.

2.6. Data Analysis

The study made use of continuous data processing so as to minimize the time interval between the completion of data collection and data entry. The responses given by various respondents were categorized into specific themes and subthemes. Qualitative data was descriptively analyzed and presented in discussion form while quantitative data was analyzed using the Statistical Package for the Social Science (SPSS), and presented in the form of numbers, figures and charts. The information given by the respondents was subjected to descriptive statistical and inferential analysis, and given frequencies and proportions.

3. RESULTS AND DISCUSSIONS ON THE ESTABLISHED WATER CONSERVATION PROJECTS

The study sought to determine the types of established WCPs and the results are as shown in Figure 1.



Source: Field Data (2015)

Figure 1: The Established WCPs in Kitui County, Kenya

The results in Figure 1 show that 16% (64) of household head respondents indicated earth dams; 23% (92) sand dams; 18% (72) subsurface dams; 9% (37) rock catchment ponds; 15% (61) farm ponds; 11% (45) soil moisture conservation, and 7% (29) rain water tanks. The results on the established WCPs have a close bearing on literature by OECD-FAO (2012), which states that farmers should be involved in harvesting and storing rainwater runoff in ponds, tanks and small dams, and then make use of such water to irrigate crops (OECD-FAO, 2012). It also coincides with findings by Africa

Harvest Biotech Foundation International which states that in terms of knowledge dissemination, IFAD has sensitized people in Ukambani on water conservation (AHBFI, 2011).

3.1. Earth Dams

The results in Figure 4.7 indicate that 16% (64) of household head respondents noted earth dams as one of the established WCPs in Kitui County. From key informant interviews, it emerged that the oldest earth dams were built in Kitui region as early as 1970s by the GoK influenced by the politics of the day; others were built after the 2002 Kenya's national elections. Their construction involves GoK, politicians, humanitarian organizations, household heads in the form of self-help groups, tractors, rollers and manual laborers. The FGDs conducted at Kairungu and Mutindi concurred with field observations that some earth dams dry up in the event of prolonged drought. Field observations noted that most areas where earth dams easily dry up neither have access to piped nor have reliable bore holes. However, van Loon and Droogers (2006) indicates that in terms of water infrastructure, almost 500 dams have been constructed in Kitui Central while Mbii (2011) notes that water tanks have been constructed in some schools to facilitate water conservation.

3.2. Sand Dams

Results in Figure 1 show that 23% (92), constituting majority of the respondents, indicated that one of the established WCPs in Kitui County are sand dams. The study established through Key Informant Interviews and FGDs of household heads that the technology of storing water in the sand is used in harvesting surface runoffs or rain floods along seasonal river beds. Field observations noted that sand dams are constructed perpendicular to the direction of water flow on a riverbed, necessitating the piling of sand and stones, thus forming an aquifer. According to a chairperson of a self-help group, the heaped sand not only acts as an aquifer but also prevents the water's exposure to the sun, thus reduced evaporation. The water stored in the sand is fetched through constructed shallow wells or scoop-holes long after households have exhausted their roof water.

It emerged from field interviews and observations that some sand dams are built on road crossing, in which case the river acts a stop of the flow of sand, pebbles and flood water. Plate 1 shows a road, which the researcher observed, acting as sand interceptor, thus creating an aquifer at Mutindi in Kitui County.

Plate 1: Sand dam at intersection of a road and river at Mutende, Kitui County, Kenya

It emerged from the face to face interviews, and precisely from, Field Water Officers, there is increased effort of utilizing an intersection between a river and a road. In this case, a road acts as an opportunity to construct a sand dam where the road acts as a stopper of sand that store water to be used long after the rains have stopped. Data on rain water harvesting is related to a study on rainwater harvesting potential in Mahasarakham University which asserts that investing in rainwater harvesting can conserve water and in turn supplement scarce water in the dry areas (Chaimoon 2009).

3.3. Subsurface Dams

As per the results in Figure 1, 18% (72) of household head respondents indicated that subsurface dams were one of the established WCPs, second to sand dams. It was established during field interviews and through FGDs that the flow of rainwater floods in seasonal rivers are checked and stored in the constructed subsurface weir across the river bed and then covered by a heap of sand, soil and hard cores. Plate 2 Ilalambyu Subsurface Dam with a gravity-pipe system.

Plate 2: Subsurface Dam with gravity-pipe at Ilalambyu, Kitui County, Kenya

The study sought to know from the Field Development Officer on how safe the water from a subsurface dam is for animal and human consumption, who argued that the harvested water from the subsurface dam has improved quality due to the filtration of water in the sand as it moves to the constructed gravity-pipe system that drains it out for use.

Part of the literature reviewed indicates that water conservation like harvesting runoff water should be accompanied with recycling water and desalination (Pamukcu, 2003; Mires, 2000; Federbush, 2009). In line with this, the study sought to know from a Water Project Officer if the subsurface dams have a desalination mechanism. He indicated that they can place a discharge pipe at the base of a subsurface dam to drain out dissolved salts should the region in question has saline river floor. Findings on the usefulness of Subsurface Dams in rain water harvesting concurs with findings from a case study of the Swarnamukhi River basin in Southern India (Raju *et al* 2006)

3.4. Rock Catchment Dams

According to the results in Figure 1, 9% (37) of household heads pointed out rock catchment ponds as one of the established WCPs. It emerged from field visits and interviews that the community was empowered with the idea of using vast bare rock outcrop to harvest rainwater. This was done by a combination of NGOs involved in water resource development. A Chairperson of a rock catchment project at Kathoo (Nzambani) explained that,

The harvested rainwater is channeled by the gutters into a rock catchment pond that is deep to minimizing the surface exposure of the water to the sun.

According to the members of self-help group interviewed in Kathoo, rock surfaces acts as a roof of harvesting huge volumes of water to be used once the rains have disappeared. It however emerged from a farmer who participated in an FGD conducted in Nzambani that land subdivisions and use occasionally tampers with the earthen gutters that are meant to deliver waters from the rock outcrop into a storage pond. The findings on the rationale of rain water harvesting using rock outcrop are in line with literature on water resource management through rain water harvesting in Ukambani, designs, constructions and maintenance of rock catchment tanks and dams (Nissen–Petersen 2006).

3.5. Farm Ponds

The results in Figure 1 shows that 15% (61) of household heads noted farm ponds to one of the established WCPs. According to an NGO worker involved in sensitising farmers in agricultural water uses, Farm Ponds are the easiest to make and cheap to construct for they only require household's labour force and nylon around the walls and floor of the pond facilitate water retention. Plate 3 shows a Nonporous Farm Pond in a household's farm used in supplement irrigation for sweet potatoes, maize, kales and water melons at Athi.

Plate 3: Farm Pond at Athi in Kitui County, Kenya

According to a household head farmer, Farm Pond can be as small as six 6 by 4 metres and as deep as three or more metres. Although it was observed that household heads use nylon to prevent water loss through the walls and floor of the Farm Pond, there is another category of farm ponds that are supposed to be porous, thus qualify as a Porous Farm Pond. The rationale of Porous Farm Ponds is to allow water to ooze into the soil thus support the growth of agricultural plants. As the case of Nonporous Farm Ponds, once constructed, rainwater is channels into them and used much later for both open and green house irrigation once the rains stopped. Findings in rain water harvesting in Kitui County concurs with Recha *et al* (2012) who note that various water harvesting and water management techniques in relation to agricultural practices have been put in place. Such include harvesting runoffs from either short or long slopes by the use of contour bands, ridges and terrace (Recha *et al* 2012).

3.6. Soil Moisture Conservation

The results in Figure 1 show that 11% (45) of household heads noted Soil Moisture Conservation as one of the WCPs. It was observed that unlike Sand Dams where water is stored in the sand and then later fetched through constructed shallow wells or scoop-holes, the water stored in the soil is only meant to support plant growth. Field observations established the presence of farms soil moisture conservation either in the form of Porous Farm Dams or Porous Farm Trenches. The two prevent rainwater runoff from being swept downstream but instead have it trapped in the farm ponds or trenches and ooze into the soil gradually for the purpose of supporting crops long after the rains have gone.

According to one of the participants in an FGD carried out at Athi, soil moisture conservation is an alternative water conservation project in the sense that,

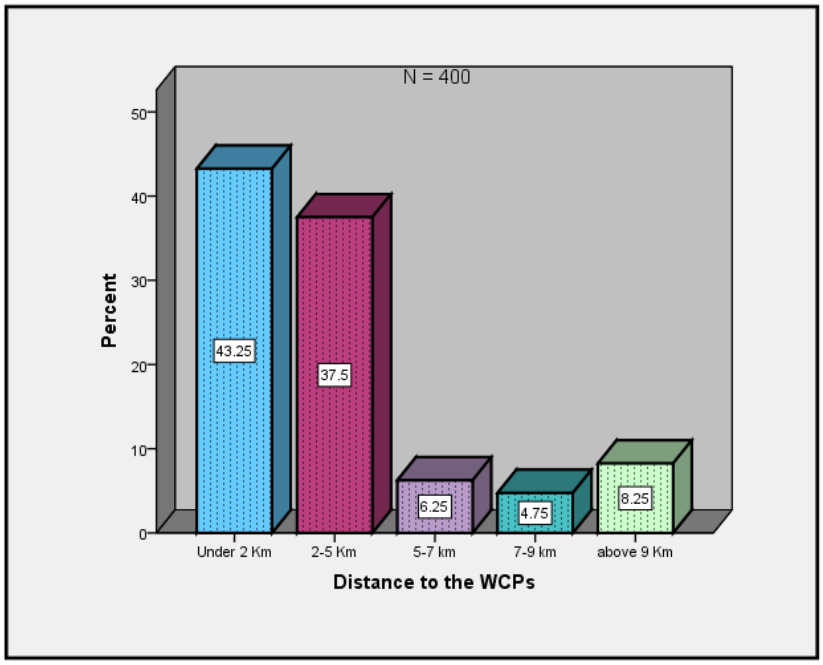
Besides harvesting rain water and storing it in water tanks, earth dams and in subsurface dams, rain water can be stored right inside the soil. The stored soil moisture will facilitate the growth of crops up to a period of three months after the rains have gone.

Wasula *et al* (2012) observe that irrigation is a recommended strategy of increasing agricultural production in the ASAL but its implementation is burdensome to households who are already impoverished. Having this in mind, it was observed that the alternative to irrigation in Kitui County for poor households is farming through Soil Moisture Conservation using either Porous Farm Trenches or Porous Farm Sinkholes. The findings on the importance of soil moisture conservation through Porous Farm Ponds and Porous Trenches in Kitui County resonates with findings of the report by Africa Harvest Biotech Foundation International which notes that IFAD has sensitized people in Ukambani on the techniques of increasing soil moisture (AHBFI, 2011) for agricultural productivity. Lessons from India shows that farmers use what they call bench trenching to either slow or stop the running rain floods. This facilitates the infiltration of the rain floods into the underground (Raju *et al* 2006).

According to Faurès (2013) one of the actions that build household resilience to climate change with regard to farming is embracing is conserving soil moisture. A study done on best practices of soil and water conservation in the highlands of Ethiopia indicates the use of drainage ditches whose construction is executed in every planting season to as both soil erosion control mechanism and as well assist in draining off excess water (Taye, 2006). The other Water Conservation Projects done by individuals, schools and churches in Kitui County is in the form of Rain Water Tanks.

4. DISTANCE TO WATER CONSERVATION PROJECTS IN KITUI COUNTY

Owing to the fact that water is part of the food that humans consume, it was necessary to establish the distance to water projects as a way of determining water availability for drinking. The results are as tabulated in Figure 2.



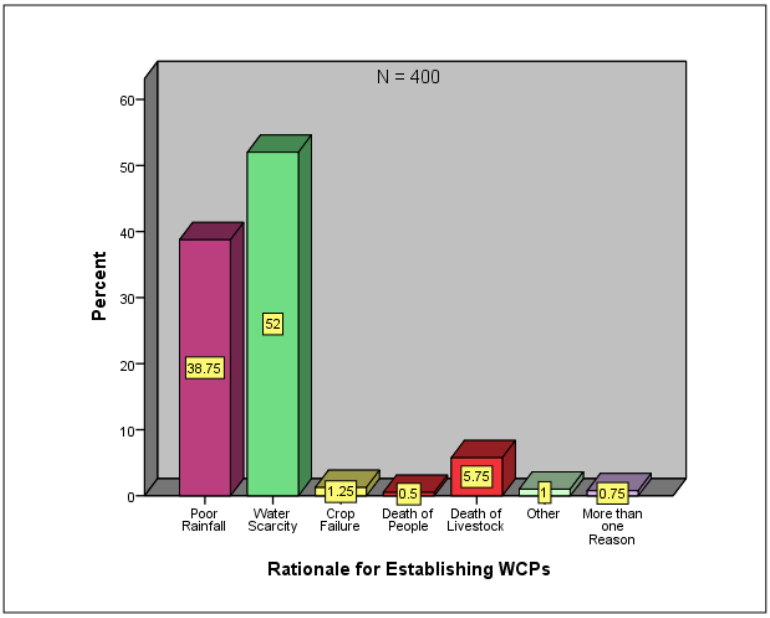
Source: Field Data (2015)

Figure 2: Distance to Water Conservation Projects in Kitui County, Kenya

As per Figure 5.11, 43% (173) of the respondents indicated that WCPs are below 2km from their homesteads; 38% (150) are at the range of 2-5km from their homesteads; 6% (25) are at the range of 5-7km away from their homesteads; 5% (19) are at the range of 7-9km and 8% (33) are at the range of above 9km.

5. RATIONALE FOR ESTABLISHING WATER CONSERVATION PROJECTS

The findings on the reasons behind the humanitarian establishment of WCPs in Kitui County are as shown in Figure 3.



Source: Field Data (2015)

Figure 3: Rationale for establishing Water Conservation Projects in Kitui County, Kenya

Results in Figure 3 show that 39% (155) of household respondents attributed the rationale for the establishment of WCPs to poor rainfall; 52% (208) attributed them to water scarcity; 1% (5) attributed them to crop failure; 0.5% (2) attributed them to death of humans; 6% (23) attributed them to the death of livestock; 1% (3) settled for more than one reason. The Chi Square value ($\chi^2_{3,\ 0.01}$ =351.176) on the variation the reasons behind the establishment of WCPs was significant at (P<01). According to an NGO worker, organizations behind the establishment of WCPs, the organizations involved do needs assessment, and priority need is identified for action. He further pointed out that

In most cases, "the priority need of most households among other needs is the combination of water and food due to erratic weather conditions of the county and largely the entire Ukambani region and low incomes.

The outcome of the FGD and Key Informant Interviews done at Mutindi indicated that the poor rains lead to water surface scarcity that does not favour crop growth and development, and it as well leads to the drying up of sand dams, subsurface dams and some bore boreholes. The researcher observed dry sand dams and boreholes at Kaikungu region of Nzauni. According to a pastor present in an FGD conducted at Mavulya, the conservation of rainwater from rooftops, rocks and ground runoffs is necessary for animal, human and plant consumption. The importance of availability of water augments with literature on the value of the right to water because water besides being useful for drinking is useful in food production (Gifra and Beltrán, 2013).

According to a local chief Informed by crop failure, some household heads organized themselves into groups and sought for help from NGOs to establish dams that can conserve huge volumes of rainwater so as to have water for domestic consumption, animal consumption, micro open drip irrigation and green house irrigation.

Face to face interviews done across the county indicated that there are instances where some household heads take the initiative of calling for the establishment of WCPs. This involves writing a project proposal and approaching concerned NGOs to come in and assist in conserving rain water as a preemptive measure to counter water scarcity during the dry season. These findings match the literature on the need to match water needs during precipitation and dry periods through harvesting and storing increased stream flows during the rainy season to be used during the dry season (Ward, 2007).

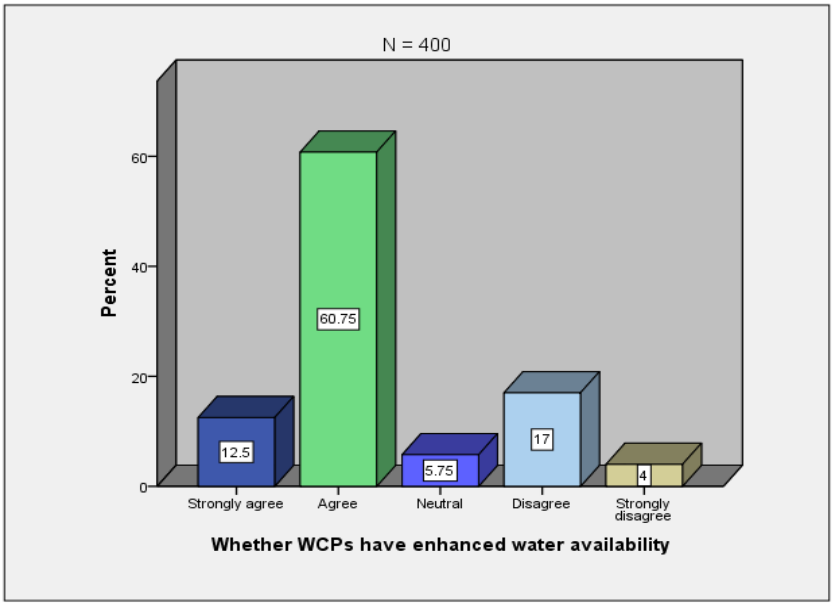
The FGD conducted at Ilalambyu, past Kyome Boys, had it that household reduction of the number of herds of cattle to match the harsh weather conditions, made households push for establishment of WCPs in the form of sand dams and subsurface dams for the purpose of encouraging more and more households to engage in cattle keeping. The contemplated utility result is to have locally available milk for children and sell surplus milk to supplement other household needs. These findings augment with literature on measures to curb climate change and water scarcity. Water scarcity, amid climate change, calls for water conservation for animals, crops and income generation (Jewitt *et al* 2004; FAO, 2014).

It further emerged from the FGDs of Ilalambyu, Mutindi, Mavulya and Athi that the other reasons that led to the establishment of WCPs are external in character. This is the case where there is external intervention to anchor human survival without necessarily having been called for by the community members. The above findings concur with literature by Verma *et al* (2008) who contends that water infrastructure development, in particular, is necessary to create access, store, regulate, move about and conserves water. Acevedo (2011), observes that there is need to expand enhance water productivity as a means of increasing food production, and in line with this, FGD informants were asked on they are equipped epistemologically to engage in water productivity. The FGD respondents cited that the establishment of WCPs is accompanied with workshops to push people towards embracing the ideas of minimal water use for maximum returns through greenhouse irrigation, increased Soil Moisture Conservation and establishing Porous Farm Ponds.

6. WATER CONSERVATION PROJECTS AND WATER AVAILABILITY

Findings on the extent to which the WCPs have enhanced water availability are as shown in Figure 4. Out of the total responses, as shown in Figure 3, 74% agreed that the establishment of Water Conservation Projects have enhanced water availability while 26% disagreed. Through direct observations, it was noted that some sand dams, subsurface dams and small earth dams dry up due to elongated drought and due to competing water uses that catalyses the depletion of water volumes. It however, emerged that there are some earth dams like the one at Kwa Ndonga and Kwa Nzuki that hardly dried up either through competitive domestic water uses or due to evaporation during drought. This may the case that

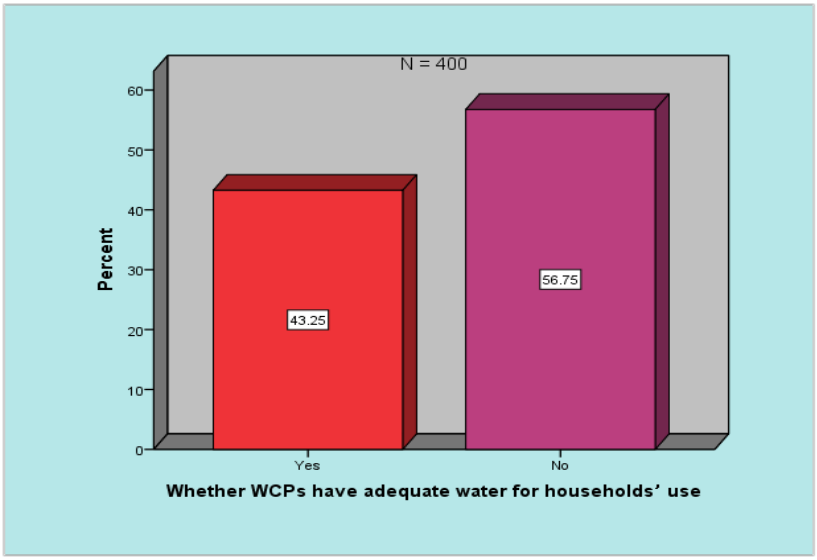
some households rely on water from the water kiosks that sell piped water. In other parts like Matinyani and Ilalbyu of Kitui West, water availability in the WCPs has been supplemented by perennial boreholes. The concern raised on the adequacy of available water augers with Thiengkamol (2011) who notes that the utilization indicator of food security is not only a function of the household's knowledge on nutritional and social value of food and food safety, but as well their knowledge on adequate water and sanitation.



(Source: Field Data (2015)

Figure 4: Whether WCPs have enhanced water availability in Kitui County, Kenya

Grey and Sadoff (2007) observe that water security is the availability of the acceptable quantity of water for consumption. This assertion prompted an inquiry as to whether the established Water Conservation Projects have adequate water. The results as to whether the established WCPs have adequate water for household use are as given in Figure 5.



Source: Field Data (2015)

Figure 5: Whether the WCPs have adequate water for household use, in Kitui County, Kenya

From the results in Figure 4, majority of the household heads comprising 57% (227) indicated that the established WCPs do not have adequate water for household use while 43% (173) indicated that the WCPs have adequate water for household use. Pearson Chi-Square value ($\chi^2_{2,\ 0.01}$ =36.758) of the variation in the respondent's yes and no responses was significant at (P<0.01). Field interrogations indicated that some WCPs dry up during elongated moments of drought and

in some cases huge volumes of water goes to waste during overhead crop irrigation as opposed to using drip irrigation. A key informant respondent observed that when there is a mismatch between the conserved water volumes and the demand, the WCPs will not be able to sustain the household water needs.

Some areas like Kitui West were observed to have water Kiosks selling piped water. This helps households to have access to water for domestic consumption in the event of prolonged drought. Akivaga *et al* (2010) observes that sustainable water management exists when water systems have enough water volume to sustain themselves together with their functions. This means that while using water, its source should not be depleted so that it continues to exist and regulate itself. The criteria for implementing sustainability of water resource include non-declining use per capita, sustenance of water production, water use and ecosystem reliability (Ward, 2007).

7. SUMMARY

The established WCPs in the Kitui are 16%(64) earth dams; 23%(92) sand dams; 18%(72) subsurface dams; 9%(37) rock catchment dams; 15%(61) farm ponds; 11%(45) soil moisture conservation, and 7%(29) rain water tanks. with regard to the rationale for the establishment of WCPs, 39% (155) of household respondents attributed the establishment of WCPs to poor rainfall; 52% (208) attributed them to water scarcity; 1% (5) attributed them to crop failure; 0.5% (2) attributed them to death of humans; 6% (23) attributed them to the death of livestock; 1% (3) settled for more than one reason. Out of the total responses, 74% of the informants agreed that WCPs have led increased water availability while 26% disagreed. Through direct observations, it was noted that some sand dams, subsurface dams and small earth dams dry up due to elongated drought and due to competing water uses that catalyses the depletion of water volumes. With regard to adequacy of water volumes in the WCPs, majority of the household heads comprising 57% (227) indicated that the established WCPs do not have adequate water for household use while 43% (173) indicated that the WCPs have adequate water for household use.

8. CONCLUSION

Although there is evidence of established WCPs in Kitui County, the study concludes that WCPs can be intensified in the County, if humanitarian organizations and the County Government of Kitui invest in water conservation in regions with neglected political good will. This has to be coupled with the good will of household heads to form self-help groups to serve as a ground to attract external intervention, which will in partnership with group members establish WCPs. The study recommends that humanitarian organisations and households actively involved in water conservation and use should take a lead role in helping youthful households to engage in best practices of farm water uses from the WCPs instead of over relying on the inspiration of traditional Akamba diviners.

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