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Adoption of Rainwater Harvesting Technologies as an Adaptation Strategy to Climate Variability in Baringo County, Kenya

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Abstract: The study sought to investigate the adoption of rainwater harvesting technologies (RWHT) as an adaptation strategy to climate variability in Baringo County, Kenya. The study employed a descriptive survey design. Purposeful sampling and stratified proportionate random sampling procedures were used to obtain the sample. The respondents comprised of 376 households. Questionnaire, key informant interview schedule and observations were the main instruments of data collection. Analysis of data was done using the SPSS. Adoption was measured by calculating percentage of adopters. The results showed, about half (50 %) of the households in Baringo County adopted rainwater harvesting technologies in their households with storage tanks being the most widely practiced technique. However, many households use tanks with a capacity of between 200 and 500 liters which cannot hold enough water throughout the year. There is slow adoption of RWHT in Baringo County irrespective of their potential to improve household access to water. Half of the households do not use the technology due to lack of adequate rainwater harvesting structures and interest. Therefore, improvement of the existing rain water harvesting techniques which are already practiced will be of great advantage to the residents and can also promote wide adaptability. To promote interest in RWHT, residents should be sensitized on the potential socioeconomic benefits of adopting them.
Keywords: Adoption, rainwater harvesting technologies, adaptation, Climate variability.

INTRODUCTION

Water is life and is an essential component for the proper functioning of human settlements. However, the population at risk of increased water stress in Africa is projected to be between 75-250 million and 350-600 million people by the 2020's and 2050's respectively [1]. Despite considerable improvements in access to freshwater in the 1990s, only about 62% of the African population had access to improved water supplies in 2000 [2,3]. People living in rural areas are the worst affected, with only 41% of the rural population of Sub-Saharan Africa having access to clean water [4]. The food and Agriculture Organization reported that 48 countries in Africa, including Kenya, would face water shortage by 2025. About seventeen million (about 43%) Kenyans currently lack access to improved water supply [5]. Climate change is an additional threat that puts increased pressure on already stressed hydrological systems and water resources in Kenya [6]. Water resources such as streams, rivers, lakes and groundwater that are mainly rain-fed are adversely affected by climate change [7]. In Kenya, climate change has had far reaching effects since majority of the population depend on rain-fed water sources.

Climate change and climate variability are already taking place in Kenya and their effects are being felt [8]. Arid and Semi-Arid Lands (ASALs) and the poor in society are the most vulnerable and likely to be hit hardest by climate change due to their low adaptive capacity [9]. The climatic factors of greatest economic and social significance are temperature and rainfall with the latter, eliciting more concern than the former. Rainfall in Kenya is variable, especially in ASALs [10]. Climatic variations in Kenya have been associated with global climatic systems such as the El-Niño/South Oscillation (ENSO) phenomenon and Quasi-Biennial Oscillation (QBO) [11, 10]. They have also been associated with shifts in dry land or desert margins and the rise or fall of water levels in lakes and rivers. For instance, lakes Turkana, Baringo, Bogoria, Elementaita, Nakuru, Naivasha and Magadi are estimated to have occupied much larger area in the Holocene period [8]. As in the rest of the tropical regions, droughts and floods are common phenomena in Kenya. The two are triggered by the same factors and can be either mild or disastrous. They are more common in the arid and semi-arid regions. The main causes/sources of floods are storm surges, El niño/La niña events, and other extremes of climate variability, land terrain, poor drainage systems and regulation of dams [12]. The intensity of drought also seems to be increasing over the years as a result of the changing climate [13]. Notable ones are the 2000/2001 and 2006 droughts which were the worst in at least 60 years (since 1940's) [13].

Approximately 80% of Kenya's land mass is arid and semi Arid (ASAL) characterized by average annual rainfall of between, 200mm to 500mm per year, and is prone to harsh weather conditions according to [14]. Some areas in the northwest and east receive only 200 mm per year [10]. Kenya has a population estimated at 38.6 million. 80% of Kenya is classed as ASALs, and these areas are home to approximately 30% (~12 million) of Kenya's people [15]. The principal climatic hazard in the ASALs is drought. Most of the droughts exhibit such characteristics as false and late onset of the rains, pronounced breaks during the rainy season, and early cessation of the rains, leading to drastic alterations in the pattern of seasonal rainfall distribution [16-18]. Many areas in Baringo County in mid-west Kenya are in the ASAL's region. While Kenya, like countries in other parts of the world, have considerable experience in dealing with climate variability, climate change is likely to present them with new and tougher challenges. Consequently, the country needs to adopt new strategies to cope with new situations. The current technologies and approach especially in water are unlikely to be adequate to meet projected demands, and increased climate variability will be an additional stress [9]. Innovations that may help to increase the availability of water are of major importance. Effective rainwater harvesting systems can decrease the risk of flooding during extreme rainfall events while providing access to clean water during the expected prolonged dry seasons expected because of climate change.

Rainwater harvesting refers to all technologies where rainwater is collected to make it available for domestic purposes and agricultural production [19]. By convention, Rainwater Harvesting Technology (RWHT) is a technique used for collecting and storing rainwater from rooftops, the land surface or rock catchments using simple techniques such as jars and pots as well as more complex techniques such as underground check dams. It is considered as the single most important means to increase agricultural productivity and provide a source for domestic supply in drought prone areas [20]. Various rainwater harvesting technologies have been in use for millennia and new ones are being developed all the time [21]. These can be classified as: rooftop water harvesting and surface runoff water harvesting. Many communities and countries facing water shortages because of climate change could significantly boost supplies by collecting and storing rain falling freely from the clouds [22]. Throughout the ages, this has been a traditional way of enhancing domestic water supply [23]. Effective RWH systems can decrease the risk of flooding during extreme rainfall events while providing access to clean water during the expected prolonged dry seasons expected because of climate change.

Rainwater harvesting is a very old practice and has been in parts of the world for more than 4000 years [24]. The technology is popular in rural Australia, parts of India, Africa and parts of the United States [25]. The importance of traditional, small scale systems of rainwater harvesting in sub-Sahara Africa has recently been recognized [26] and is gradually being adopted with high degree of success in the four Great Horn of African countries (Ethiopia, Kenya, Tanzania and Uganda) [27]. The technology has been exploited in Kenya for many years with most focus on the arid and semi-arid areas (ASALs) and rural areas [28]. Rainwater harvesting (RWH) has been proposed as one of the options to improve water supply especially in rural and peri-urban areas of low-income countries [29-30] as well as in all agro climatic zones [31]. However, the technology is more suitable in arid and semiarid areas (ASALs) [32-33] to ensure water availability especially during prolonged dry season and drought [34]; [35] and [36]. Improving domestic water supply by rainwater harvesting saves ASALs women and children more time who spend 3-5 hours per day collecting water and more in periods of drought [10].

Baringo County suffers from intensive floods, severe droughts combined with short rainy seasons and drought related losses like any other County situated in the northern regions of Kenya. Given that many households in Baringo County are poor, they are vulnerable to rainfall variability. Household water needs in the County are met from nearby surface water sources or withdrawn from traditional wells [37]. However, in the dry season, wells, streams and rivers dry up forcing women and children who do the considerable labor involved in water collection to travel longer distances in search of water for domestic use from unprotected sources. High rainfall variability negatively impacted on household access to improved water sources. Many households find it difficult to store quantities of rain falling in very short periods so that it can be used over the entire year. This study therefore seeks to determine adoption of rainwater harvesting technologies (RWHT) as an adaptation strategy to climate variability in Baringo County in order to provide them with relevant and appropriate information that can inform their adaptation appropriately and reduce vulnerability to rainfall variability. Domestic Rainwater Harvesting, which provides water directly to households, would enable a number of households in rural areas to access water that conventional technologies cannot supply.

MATERIALS AND METHODS

A descriptive survey was carried out on the sample of Baringo households to explore and describe use of rainwater harvesting technologies as at the time of study. The study used purposeful sampling and stratified proportionate random sampling procedures to obtain the sample. Within Baringo County, the locations were stratified according to the agro-ecological zones. These are LM 5 (lower Midland), LH 2 (Lower Highland) and IL 6 (Inner Lowland). Lembus Central, Salabani and Ribkwo locations was purposefully selected for the study. They were selected because of having Agro-ecological zones LH2, LM5 and IL6 respectively to ensure that the researcher picks extreme climates only and ensure proper representation of the respondents within the whole Baringo County area coverage. Lastly, random selection of the respondents within locations was made proportionate to the population of each location as per the household census report of 2009 [38]. The study targeted 376 households which constituted 7.9 % of the total number of households in the three agro ecological zones. The selection of respondents was informed by household population by location level. This information was acquired from the County Development Officer at Kabarnet, the County headquarters. Lembus Central location has a population of 2,668 households while Salabani has a population of 963 households and Ribkwo 1128 households. These were the three strata where proportional representation was obtained. 211 households in Lembus Central, 76 in Salabani and 89 in Ribkwo location was selected. A total of 376 respondents were selected for the study. Their participation during the interviews was however based on random sampling.

As for the key informants, purposive sampling was used to select those to be interviewed. These were selected from among meteorologists, NGO officers, chiefs, NDMA officers and water officers based on their positions of authority. These key informants were selected for the interview in consideration that they have insights on the subject of climate and water and use of RWHT by the households in the County.

The data were obtained from households and key informants through personal interviews by use of structured questionnaire, key Informant interview schedule and observations. The study focused mainly on household heads for interviewing to ensure uniformity of data collection process. The questionnaire was used to collect data from households on use of RWHT and levels of adoption of RWHT. The questionnaire was administered to all the 376 households in the study area. Key Informant Interview Schedule was used to collect in-depth data on use of RWHT.It was used to collect valuable data that was used to check the validity of responses obtained through use of questionnaires. Observations were made of the various water sources, water harvesting structures and the nature of their construction. Information obtained through observation enabled comparing of the reported information with the actual occurrences in the study area. Additionally, photographs in the study area were taken by researcher. The photographs have helped to illustrate the various water sources and RWH technologies that were used by the households. The use of photographs augmented findings from other data collection procedures.

The data collected was analyzed using descriptive statistics. Adoption was measured using one of the procedures mentioned by Agbamu [39]; calculating percentage of adopters. The use of percentage involved asking respondents to respond yes (1) or No (0) to the technologies they have adopted. Five stage processes of adoption were used to develop a framework for measurement of adoption. The five stages are: awareness, trial, evaluation, interest and usage. The respondents were asked to tick yes or no against stages of adoption of rainwater harvesting technologies. The percentage yes or no were calculated. The adoption level was the summation of the numerical values of the Yes responses. This appears to be the commonest approach to the measurement of adoption [40-43]. Adopters were further asked to indicate the number of years they have made use of the technology. A five-year period was considered long enough for households to have fully adopted the technology.

RESULTS AND DISCUSSION

In this study, the adoption scale to measure the adoption of Rainwater Harvesting Technologies (RWHT) was constructed using percentage of adopters. Adoption of innovations followed hierarchical stages namely: awareness, interest, evaluation, trial and usage. These five stage processes of adoption were used to develop a framework for measurement of adoption in the present study. Respondents were asked to tick yes or no against stages of adoption of rainwater harvesting technologies. The percentage yes or no were calculated. Adopters were further asked to indicate the number of years they have made use of the technology. A five-year period was considered long enough for households to have fully adopted the technology.

The findings (Table 1) revealed that most of the households in Baringo County had awareness (90 %), interest (96 %), evaluated (92 %), tried (79 %) and used (91%) the technology. However, most of them had made use of the technology for few years (less than five years). From Table 1, about 68 % of the households sampled had used RWH technologies for five years or more. About 32 % had practiced the technology for only few years; 4 years (13 %), 3 years (9 %), 2 years (6 %) and 1year (4 %).

In the survey locations, about 50 % of the respondents have adopted RWH techniques in their households and equally 50 % have not adopted (Figure 1). Adoption of rainwater harvesting technologies in this case meant that the household had gone through the adoption process that is awareness, trial, evaluation, interest stage and had finally accepted to practice the rainwater harvesting technologies for five years or more. The survey established that even non-adopters utilized RWHT to some extent. Some of them had some knowledge or awareness while others had tried, assessed or used the technology for a short period (less than five years) of time. Those non adopters were asked as to why they are not adopting RWHT and most of them responded that they lacked adequate rainwater harvesting structures. Some of the respondents also reported that they are not interested with the technology. Respondent households practicing this technique reported improved access to water in their households.

Table-1: Percentage and frequency distribution for stages of adoption (N=376)

Adoption stages	Response categories	Frequency	Percentage
Awareness	Yes	342	91
	No	34	9
Interest	Yes	362	96
	No	14	4
Evaluation	Yes	347	92
	No	29	8
Trial	Yes	298	79
	No	78	21
Usage	Yes	342	91
	No	34	9
Duration of use Freq. Percent.			
1 year	14	4	
2 years	19	6	
3 years	32	9	
4 years	43	13	
5 years or more	235	68	
Non -users of RWHT	33	9	
Total	376	100	

Source: Field data, August 2015

Table 1 shows the adoption process (awareness, trial, evaluation, interest and use) that households undergo before they finally accept to practice the technology in their households and that number of years they have practiced the technology.

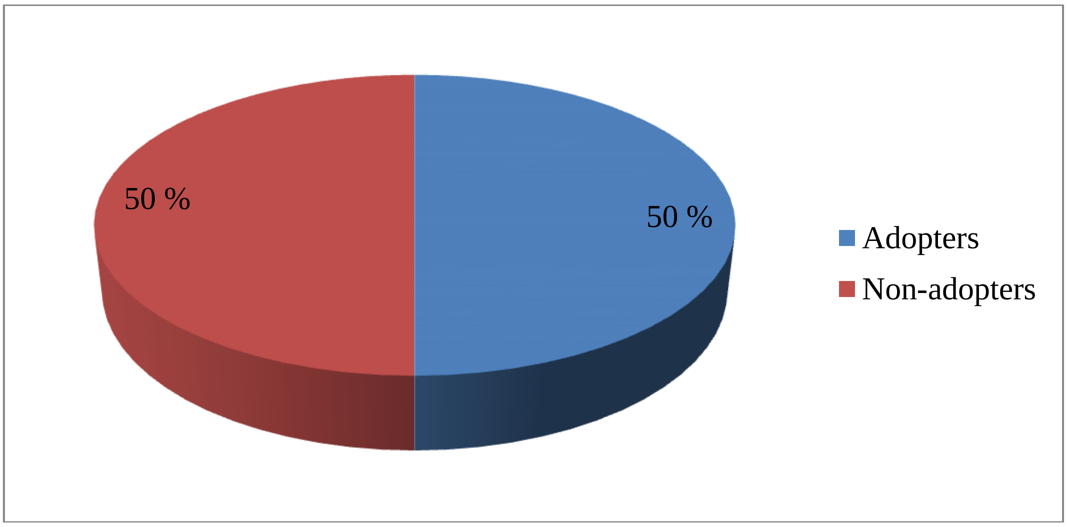

Fig-1: Adoption of rainwater harvesting technologies

Source: Field data, August 2015

Figure 1 shows percentage of adopters and non-adopters of rainwater harvesting technologies. Adopters are aware, interested and have evaluated, tried and used the technology in their households for five years or more.

Households in Baringo County were engaging in various rainwater harvesting techniques to adapt to climate variability. From the total sample households (Table 2), 2 %, 65 % and 33 % percents of the respondents were using rain water only during rainy season, full rainy season and partial dry seasons, full rainy and dry seasons respectively. Full rainy & full dry season, and full rainy & partial dry season was mainly indicated by the adopters of the technology. Only few adopters of the technology indicated only rainy season consumption of rain water.

Table-2: Use of rainwater technology by seasons

Category	% Technology users
Rainy season only	2
Full rainy & partial dry	65
Full rainy & full dry seasons	33
Total	100

Source: Field survey, 2015

During the study, respondents were asked to name/list the rainwater harvesting technology (RHT) they know. From Table 3, Most of the respondents (42 %) knew a variety of both Roof top RWHT (such as storage tanks and wells) and Surface runoff RWHT (such as water pans, ponds and dams). About 35 % of the respondents knew only Roof top RWHT while 17 % knew Surface runoff RWHT only. The remaining 6% knew none of the technologies. Roof water harvesting is a system of collecting rainfall water from the roof of a building and storing it in some storage facilities for future use when there is shortage of water [44]. Surface run-off harvesting - is a system of collecting run-off from a catchment using channels or diversion systems and storing it in a surface reservoir [45].

Adopters have good knowledge about roof top rainwater harvesting technologies because many roof water tanks have been implemented by NGOs in rural areas of Kenya. These tanks were regarded to be of the best quality and increasing water quantity and availability at the implemented site [46]. The technology has been exploited in Kenya for many years with most focus on the arid and semi-arid areas (ASALs) and rural areas [28]. The technology is also flexible and adaptable to a very wide variety of conditions [24]. It is used in the richest and the poorest societies, as well as in the wettest and the driest regions in the world.

Table-3: Rainwater harvesting technologies known

Type of RWHT	Frequency	Percentage
Surface runoff RWHT (water pans, dams)	65	17
Roof top RWHT (storage tanks, wells)	130	35
All of the above	159	42
None of the above	22	6
Total	376	100

Source: Field data, August 2015

About 90 % of the households in Baringo County were aware of water harvesting techniques that existed within their local context. A small proportion of households (10%) were not aware of the rain water harvesting techniques and this may be attributable to inadequate dissemination of information and skills with regard to rain water harvesting techniques. The distance to be covered and time spend collecting water in the event of water scarcity further amplified the awareness of and the need for water harvesting technologies. The distance covered in search of water is relatively far during water scarcity. This makes people, especially women and children whose work is to ensure that there is water in the household, spend a lot of energies and time as well as travel longer distances in search of water during this period. Collecting and storing water close to households improves the accessibility and convenience of water supplies and has a positive impact on health [24].

The research sought to find out how awareness was created. Figure 2 illustrates four major channels used to sensitize households on rainwater harvesting technology and practices. Majority of the governmental and non – governmental officers said that they created awareness through group meetings. This can be the very reason why majority of the households (71 %) revealed that such awareness is created by fellow villagers. In addition, school training and other sources such as radio, television and own initiatives were also mentioned. However, the finding that even non-adopters have some knowledge of RHT implies that some of the technologies are not new in the sampled locations. The NGOs, and to a limited extent government extension staff, are just trying to revitalize utilization of RWHT and training residents in better ways of constructing rainwater harvesting structures . NGOs with few private sectors played an important role in implementing and adopting water harvesting techniques all over Kenya [47]. These organizations were well appreciated by the community and were considered to be most efficient compared to government driven programs. Awareness exposes someone to information and therefore creates knowledge which is a very important stage in the adoption of rain water harvesting technologies [48].

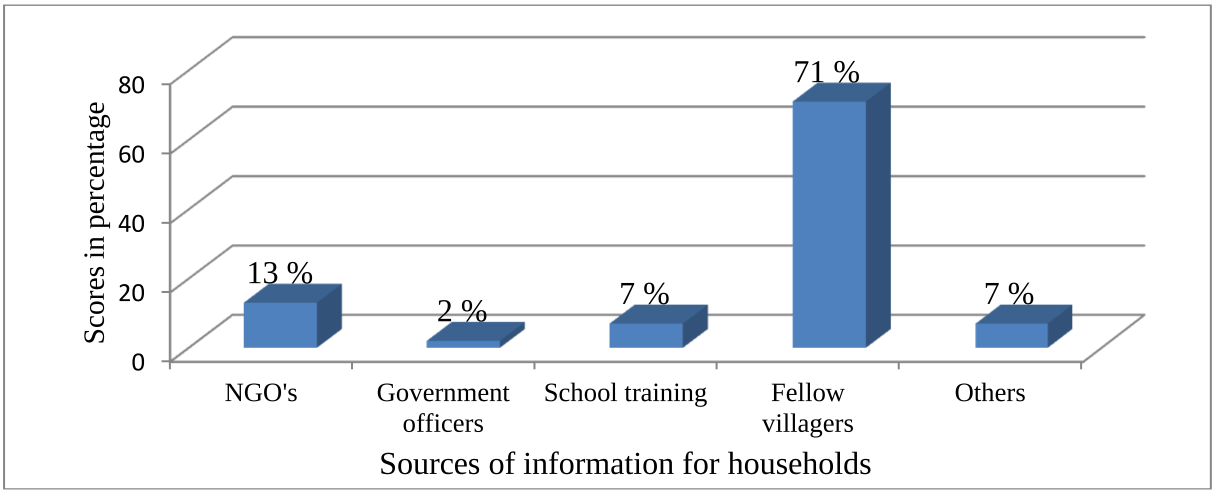

Fig-2: Sources of information and knowledge on RWHT

Source: Field data, August 2015

About (57 %) of the households in Baringo County practiced rooftop water harvesting techniques (storage tanks) followed by dams (18 %,) and wells (12 %) with minority of the households using water pans (1%). (Table 4). Most of the households practiced rooftop water harvesting techniques -with rooftop catchment (storage tanks) being the most commonly used technique where communities use gutter-to-tank technology. All those who harvest water at their homesteads use gutter-to-tank technology. The findings concur with those of Makueni County, Kenya where various rainwater harvesting technologies were used including rooftop harvesting techniques with rooftop catchment being the most commonly used technique [49]. Rooftop water harvesting techniques was also the most adopted technology in Yatta, Kenya [50]. The ease of implementation of the said technique may have made it popular to the communities. Rooftop harvesting technologies have the advantage to collect relatively clean water [20]. Rooftop rainwater harvesting has also shown a high degree of reliability especially to the households who have invested in substantial rainwater harvesting systems [49].

The second most widely practiced water harvesting technique was the dam. This is the case in other places of Kenya such as Yatta Sub-County of Machakos County [50], Makueni County [49] and Kitui West, Lower Yatta and Matinyani sub-Counties of Kitui County [51] where adoption of dams technique is pronounced. Despite its poor quality, water collected from earth dams is used to cater for livestock and domestic purposes [49]. Adoption of other techniques such as water pans (1 %) and wells (12 %) were found to be low in this area. This however is not the case in other places of Kenya such as Lare Sub-County of Nakuru County, where adoption of water pans technique is pronounced [52].

Table-4: Type of water harvesting techniques practiced by household

	Frequency	Percent
Water pans	5	1
dams	69	18
storage tanks	216	57
Wells	44	12
storage tanks & wells	20	1
All of the above	17	6
None of the above	5	5
Total	376	100

Source: Field data, August 2015

Table 4 shows the type of rainwater harvesting technologies practiced by households in Baringo County. These include Roof top RWHT such as storage tanks and wells and Surface runoff RWHT such as water pans and dams.

Majority of the households (85 %) in Baringo County lack adequate rainwater harvesting structures (Figure 3). Only few households (15 %) have adequate structures. The study established that most (over 70%) of the respondents especially those using rooftop RWH systems have storage facilities of less than 150 litres capacity which cannot hold enough water throughout the year. Households that have invested in sizable rainwater harvesting systems ranging from 1 to 10 m^3 capacity hardly experience water shortage problems and waterborne diseases [49]. Several studies have been done on different issues pertaining to rainwater harvesting. For example, with respect to storage 4,000 L concrete tank installed with a roof area of 40 m^2 is adequate to take care of water demands of four-member household for five-month dry period [53]. An optimum tank size of 0.5 m^3 is recommended to achieve water savings of 10-40% [54]. In order to achieve a good water-saving efficiency and limit financial losses, a storage tank size limit of 1.2-1.5 m^3 is recommended [55]. Pictures of some of the rooftop rainwater storage facilities used in Baringo County are shown in plate 1 below.

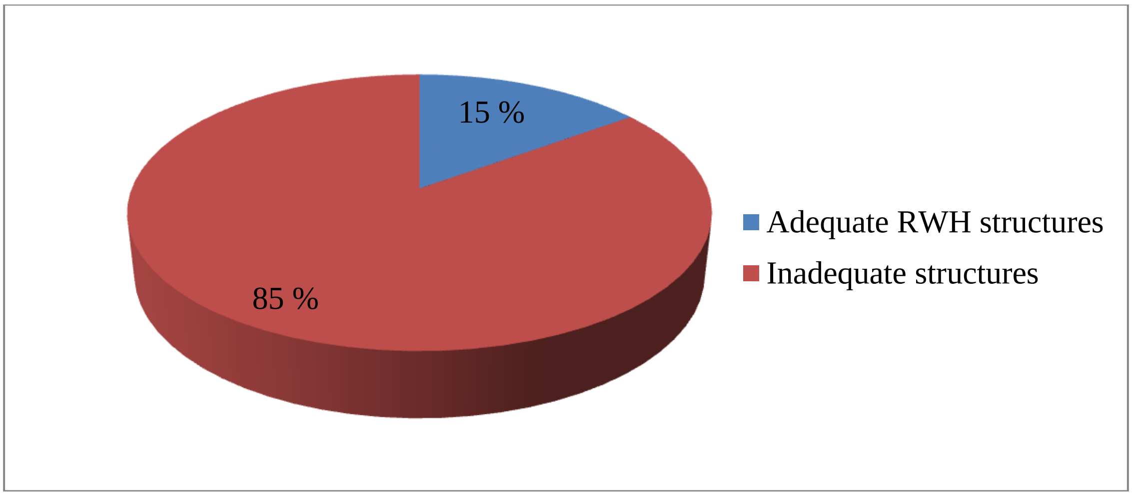

Fig-3: Adequacy of Rainwater harvesting structures
Source: Field data, August 2015

Figure 3 shows the percentage households with adequate structures of harvesting rainwater in their households and those with inadequate structures.

(a)Cement tank in Lembus Central

(b) Plastic tank in Salabani

(a) Jerry can storage facilities in Salabani (d) Dug well in Ribkwo
Plate 1: Various Rooftop Rainwater storage Facilities used in Baringo County.
Source: Field data, August 2015

CONCLUSION

About half (50 %) of the households in Baringo County have adopted Rainwater harvesting technologies in their households as an adaptation to rainfall variability. There is slow adoption of RWHT in Baringo County irrespective of their potential to improve household access to water. Half of the households do not use the technology due to lack of adequate rainwater harvesting structures and interest. Households in Baringo knew a variety of Rainwater harvesting technologies. They obtained such information from both governmental and non-governmental sources through fellow villagers. The households practiced both Roof top Rainwater harvesting technologies (such as storage tanks and wells) and Surface runoff RWHT (such as water pans and dams) in their homesteads. Storage tanks were found to be the most widely practiced technique. However, many households used tanks with a capacity of between 200 and 500 liters which cannot hold enough water throughout the year. It has been evident that where water harvesting has been adopted for household water, there has been increased access to water especially during the dry period. Hence, Baringo residents see water harvesting as part of the solution to enhancing their water security. It is therefore important that more trainings and support programmes be increased in Baringo County in order to combat rising water insecurity. Therefore, improvement of the existing rain water harvesting techniques which are already practiced will be of great advantages to the residents and can also promote wide adaptability. To promote interest in RWHT, residents should be sensitized on the potential socioeconomic benefits of adopting them.

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