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Agricultural Water Technologies Adopted by Smallholder Farmers in Lare Division, Nakuru County Kenya

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Authors' contributions

This work was carried out by all the authors. Author FNB conceptualized the study, designed protocols, collected and analyzed data under the supervision of authors MMM and RB. All the authors read and approved the final manuscript.

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ABSTRACT

This study aimed at investigating agricultural water use technologies adoption by smallholder farmers in Lare Division Nakuru County Kenya. The study adopted a descriptive research design and was carried out between February and March 2014. It involved smallholder farmers who had adopted agricultural water technologies namely; water harvesting, water storage and irrigation to mitigate effect of climate change induced agricultural water scarcity. Data was collected by use of face-to-face administered interview schedule and analyzed using descriptive statistics such as percentages and

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means. Out of 115 household heads interviewed, 53.9% were male, 46.1% were female and 75.6% had primary level education and below. The main source of income was farming (70.4%). Water harvesting, storage and irrigation technologies were adopted by 98.3%, 93.9% and 37.4% of the farmers respectively. Common water harvesting structures were gutters and runoff drains (59.1%) and tanks (plastic and concrete) for storage (98.30%). Out of those that have adopted irrigating technology, 86.1% and 9.3% used buckets and drip respectively. However, the farmers face challenges in technologies adoption in terms of inadequacy of water harvesting (74%) and storage (81%) structures' capacities and use of efficient irrigation facilities (78%). Farmers' adult education, improvement of technologies structures' capacities and usage of efficient irrigation facilities are recommended. Formulation and implementation of policies that would facilitate Lare farmers' accessibility and usage of efficient irrigation technologies are advised.

Keywords: Agricultural water use; technologies adoption; climate change; food and economic security.

1. INTRODUCTION

In sub-Saharan Africa, climate change-induced rainfall scarcity has led to increased incidences of extreme droughts resulting in food insecurity at household, regional and national levels [1]. This has prompted affected governments and development partners to get actively involved in sensitizing rural resource scarce smallholder farmers, in water constrained Arid and Semi-Arid Legions (ASALs), to adopt appropriate agricultural water technologies. This approach is aimed at empowering the farmers in mitigating effects of climate change induced agricultural water scarcity and vulnerability. This effort aims at ensuring both food and economic securities at household levels hence stimulate rural development.

Water scarcity is a rural developmental challenge facing Kenya [2]. This is because close to 80% of Kenya's population is rural and dependent on agriculture for basic livelihoods. This makes the country highly vulnerable to rainfall variability since 98% of the country's agriculture is rain-fed [3]. The water scarcity problems in Kenya have been exuberated by decreased rainfall amount and frequency of occurrence due to climate change, high population which leads to high water demand, vulnerability of water resources and human encroachment of marginal areas among others [4]. One way of addressing this challenge is through rural farmers' empowerment in adopting agricultural water technologies. Agricultural water technologies are easily acceptable and replicable across many cultural and economic settings [5]. However, the technologies' adoption depends on socio-economic status of the adopting farmers such as age, education level, family size, perception of farming and land tenure among others [5].

In Kenya rainfall scarcity is a major challenge facing rural communities in farming activities from which they derive both households' foodstuffs and economic returns. Therefore, adoption of water harvesting, water storage and irrigation application technologies may be one approach of increasing smallholder farmers' access and efficient use of agriculture water. This would enable the farmers to engage their farms all year round including off seasons, as natural rainfall would now not be a limiting factor in agricultural production. This paper focuses on agricultural water technologies adoption namely water harvesting, storage and irrigation, by smallholder farmers in Lare Division, Nakuru County Kenya in the face of climate change induced agricultural water vulnerability.

1.1 Agricultural Water Technologies

Three agricultural water technologies of interest are water harvesting, water storage and irrigation. They are ancient practices and still form an integral part of many farming systems worldwide. They were first used in Iraq over 5000 years ago, in the Fertile Crescent [6]. In sub-Saharan Africa, over 90% of farmers depend on rain-fed agriculture. However, agricultural activities face many constraints due to erratic and unreliable rainfall in quantity and distribution patterns. Therefore adoption of agricultural water technologies use in sustainable and integrated production systems can assist smallholder farmers in boosting agricultural output by supplementing the rain-fed agriculture production [7].

1.2 Agricultural Water Harvesting Technology

In Kenya, runoff harvesting from roads, footpaths and compounds is a practice that is currently not so widely used considering its potential replicability. Road runoff harvesting systems vary from simple diversion structures that direct surface water into agricultural fields or water pans, to deep trenches with check-dams in to trap eroded soil [8]. The rainwater harvesting potential in Kenya is estimated at over 12,300m^3 per person per year compared with the current annual renewable water availability of just over 600m^3 per person per year, indicating a significant gap [9].

1.3 Agricultural Water Storage

Agricultural water can be harvested and stored in situ or transported and stored away from the point of harvesting. Water storage systems can be cistern or pond. In the former, water is stored in underground or above ground tanks while in the latter, in dams, ponds, pans and trenches. Where soil type permits, pond system can be cost-effective [10]. In the Tigray region of Ethiopia, small earth KRA 2006). -dams harvesting stream-flow diverted from small gullies are used for storing water [9]. In the semi-arid parts of Laikipia District, in central Kenya, underground water tanks have been constructed for agricultural water storage [5]. The largest concentration of rock catchment, water storage dams in East Africa, is found in the semi-arid parts of Kitui District in Eastern Kenya (8).

1.4 Irrigation Application

Traditional agricultural water application technologies include farming using irrigation, kitchen gardening, poultry keeping; zero grazing, biogas making, fish and apiculture farming among others. Modern agricultural water applications technologies encompass efficient use of agricultural water such as drip and sub-surface irrigation, among others. Harvested water application is seen as a major component in curbing the rural-urban migration by ensuring farmers economic stability, enhanced living standards and jobs' creation at rural farm levels. Agricultural water application technology has been used to stabilize farm yields hence enhancing food security in rural India [11]. Studies done in Zibambwe, Tanzania and Niger on irrigation using harvested agricultural water showed increased sustained agricultural yields for local rural communities involved [12].

2. RESEARCH METHODOLOGY

Descriptive survey design was deemed suitable as it provided information about subjects under study on the past and current situation [13]. Lare Division was purposively selected for this study because the area is water constrained and is inhabited by resource scarce-smallholder farmers. The division had a human population of 36,924 and 6008 households in 2009 [14], 60% of who use agricultural water technologies. The study targeted 115 household heads and employed purposive sampling in selecting four out of eight study locations with high concentration of farmers who use the water technologies. Proportionate sampling technique was then employed to assign a representative sample from each selected location. Simple random sampling was finally applied, at 95% confidence interval, in picking study sample size for each location, [15] as shown in Table 1.

Table 1. Farmers that have used the technologies in Lare division

Location	Households	Sample size
Kabati	1,552	30
Bagaria	762	14
Kiriri	3,156	61
Ngano-in	538	10
Total	6,008	115

The study used face to face administered semi-structured interview guide to collect data from the respondents. The data was analysed with statistical package for social sciences (spss) using descriptive statistic involving frequencies, percentages and means.

3. RESULTS

3.1 Demography of Farmers in Lare Division

Out of 115 household heads interviewed, 53.9% were male while 46.1% were female. According to [16] Women contribute 66% of all the hours worked throughout the world. In Lare Division, some female are also household heads hence decision makers on agricultural water technologies' adoption. Therefore, views of both genders have been captured in this study as both are involved in agricultural water technologies adoption. Respondents aged 51 years and above constituted 51.7%. This age category consists of those farmers that first acquired and settled in Lare Division. They regard themselves as original land owners, hence the ultimate decision makers on issues touching use of land. Their rather advanced age may have bearing on adoption of agricultural water technologies in their own farm and even in those pieces of land in the hands of their off springs.A study by [16] found that age influences a farmer's adoption of technologies, but direction of the influence is in contention. Some researchers find it positively influencing adoption and others find a negative correlation or no significant influence at all.

3.2 Lare Farmers' Education Levels

Generally, respondents had low levels of education by Kenyan standards with more than 76% having primary or no formal education, as indicated in Fig. 1.

3.3 Lare Farmers' Family Sizes

On family sizes, 60.9% of the respondents are in the range of 6 -10 members. This is in line with rural African communities that tend to have large families or live with extended families. Having a large family to house, feed, pay school fees and medical bills among others, may encourage or discourage a household head in adopting farming related technologies. Technologies may be adopted if they are perceived as having the potential to boost farm production so that there would be enough food for household consumption. However, the technologies may not be adopted if they are perceived as having inherent potential risks of underperforming. This would translate to inability of household heads to meet household's dependents' basic needs.

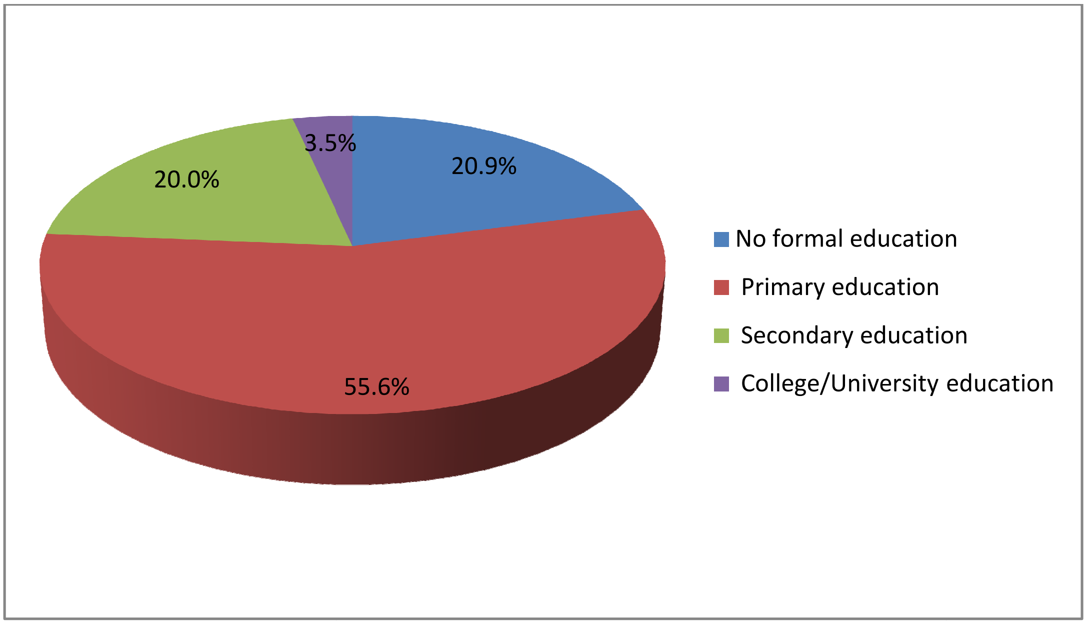

Fig. 1. Farmers' education levels in Lare division

3.4 Socio-economic Characteristics of The Farmers In Lere Division

The main source of income (70.4%) is farming, the rest (29.6%) indicating business and employment as their other income sources. On community interaction, only 20.0% of the respondents belonged to farmers' groups. 75.7% of the respondents indicated that the foodstuffs consumed in their households were obtained from their farms. The rest (24.3%) supplemented by buying from markets.

3.5 Adoption of Agricultural Water Technologies in Lare Division

Water harvesting technology was adopted by 98.3% with 67.8% of them indicating a period between 5 -10 years of this technology adoption using water harvesting structures such as gutters (93.9%) and runoff channels (63.5%). However, (59.1%) of the farmers use both gutters and runoff channels. The farmers, (74%) felt water harvesting structures capacities were inadequate leading to a lot of rain water going to waste in rainy seasons.

Water storage technology was adopted by 93.9% of the smallholder farmers with commonly used water storage structures being plastic and concrete tanks (98.30%). Plastic tanks are popular as are affordable, maintainable and water stored in them is hygienically clean hence suitable for domestic use. These tanks are also locally available in various capacities to suit households' water requirements. 49.3% of the farmers use water pans for water storage. Water storage technology has been adopted for over 10 years by over half of the respondents (54.8%). A few farmers have designed innovative way of conserving and cleaning the stored water in pans. Azolla plants have been introduced to cover the stored water surfaces thereby minimizing water loss through evaporation. Suspended plant roots physically clean water stored in water pans. Out of 115 farmers investigated, only 37.4% have adopted irrigation application technology. Out of these 37.4% that have adopted irrigation technology, 42% of them irrigate crops, 93% water livestock while 35% use the water for both purposes as shown in Fig. 3. Bucket, drip and sprinkler irrigation facilities have been adopted by 86.1%, 9.3% and 2.3% of Lare farmers respectively.

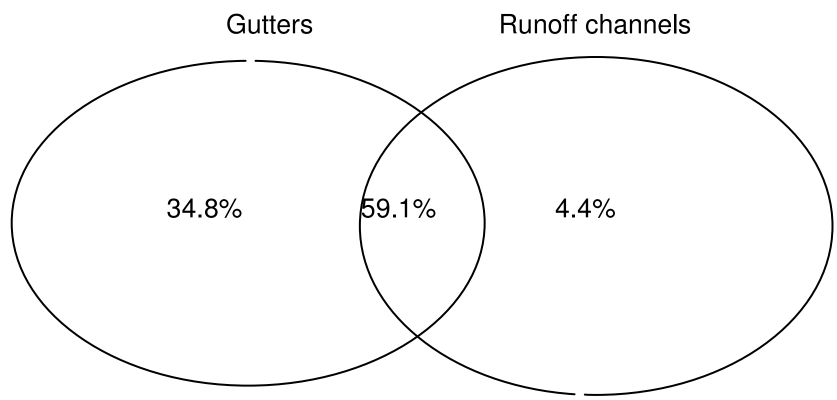

Fig. 2. Water harvesting structures in Lare division

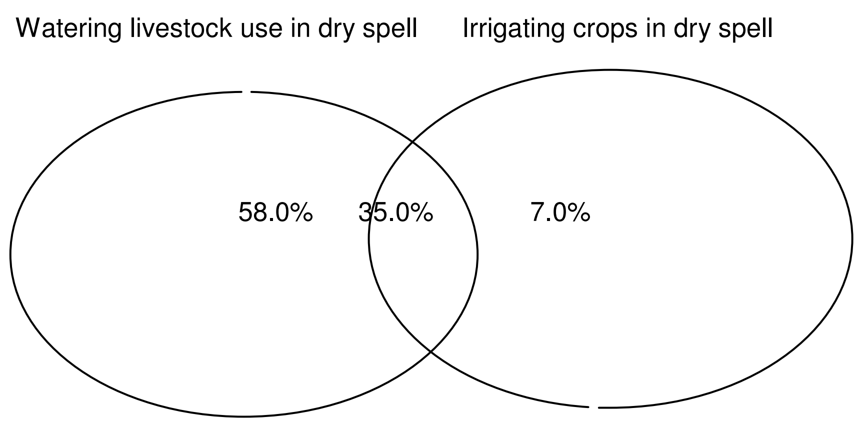

Fig. 3. Applications of stored water in dry spell by Lare farmers

4. DISCUSSION

Out of 115 household heads interviewed, 53.9% were male while 46.1% were female. Therefore, there was gender streaming on issues of agricultural water adoption by Lare farmers. Women contribute 66% of all the hours worked throughout the world [16]. Besides, men and women do not benefit equally from agricultural water technologies adoption. Respondents aged 51 years and above constituted 51.7%. This rather advanced age may have had bearing on adoption of agricultural water technologies. A farmer's age influences technologies adoption. However the direction of the influence is in contention. Some researchers have found positive and negative correlation or no significant influence at all [16]. Generally, Lare farmers had low levels of education by Kenyan standards with more than 76% having primary or no formal education. Education is believed to create a favourable mental attitude for the uptake of new practices [16]. Since educated farmers are expected to embrace new farming related technologies, it would appear that the low level of education among Lare farmers could have led to low adoption of irrigation technology as it requires some knowledge which these farmers may not adequately have. The main source of income (70.4%) is farming, the rest (29.6%) indicating, business and employment as their other income sources. Relying on farming alone or partly for source of income may have bearing on a farmer's effort in adopting agricultural water technologies. Resources farmers commit to these technologies such time, labour and finance may determine amount of benefits accrued from technologies' adopting. Therefore, fulltime farmers are expected to be highly involved in adoption of agricultural water technologies given that farming is the only source of their households' income [17]. However, an extra occupation may mean an extra source of finance that could possibly be ploughed into agricultural water technologies management [16]. In Lare Division, a few farmers were observed as having left other businesses to fully concentrate on farming but not the other way round. On community interaction, only 20.0% of the respondents belonged to farmers groups. Farmers groups are effective avenues for passing farming technologies to farmers. According to [18], new ideas' such as adoption of agricultural water technologies, spread effectively through groups found in communities. A study done in India found that smallholder farmers active in farmers groups had adopted farming related technologies twice as much compared to their counterparts who did not [19]. The low level of community interaction in Lare may explain low adoption of irrigation technology. Majority of the respondents indicated that the foodstuffs consumed in their households were obtained from their farms. The rest supplemented by buying from market implying that majority of the smallholder farmers in Lare Division are subsistence farmers [20]. They are therefore resource, knowledge and skills scarce hence would be expected to adopt simple farming technologies that would boost their farms' agricultural production. Lare Division has no single permanent river. Hence, roof and runoff are techniques adopted by Lare farmers for water harvesting during rainy season each year. Using simple channels with tree twigs placed at intervals inside the channels, to trap eroded soils, road runoff is diverted either directly into cropped land or into water pans. The trapped fertile soil is periodically scooped from the channels and spread on farms as manure. The farmers felt water harvesting structures' capacities were inadequate leading to a lot of rain water going to waste in rainy seasons. Water storage technology was adopted by 93.9% of the smallholder farmers with commonly used water storage structures being plastic and concrete tanks (98.30%). Plastic tanks are popular as are affordable, maintainable and water stored in them is hygienically clean hence suitable for domestic use. These tanks are also locally available in various capacities to suit households' water requirements. 49.3% of the farmers use water pans for water storage. Water storage technology has been adopted for over 10 years by over half of the respondents (54.8%). A few farmers have designed innovative way of conserving and cleaning the stored water in pans. Azolla plant has been introduced to cover the stored water surfaces thereby minimizing water loss through evaporation. Suspended plant roots physically clean water stored in water pans. Majority of Lare farmers use bucket while others use drip and sprinkler irrigation facilities. The low percentage of Lare farmers that use water efficient irrigation facilities was attributed to cost involved and skills needed acquisition and maintenance.

5. CONCLUSION

The low education level and rather advanced general age of majority of Lare farmers may have limited adoption of agricultural water technologies that would require relatively high knowledge and skills to effectively operate. The low level of community interaction in Lare, may explain low adoption of irrigation technology. Majority of the respondents are subsistence resource, knowledge and skills scarce farmers. Lare Division has no single permanent river. Hence, roof and runoff are techniques adopted by Lare farmers for water harvesting during rainy season each year. The commonly used water storage structures are plastic and concrete tanks. A few farmers have designed innovative way of conserving and cleaning the stored water in pans using azolla plant which covers the stored water surfaces in water pans thereby minimizing water loss through evaporation and suspended plant roots in the water physically clean stored water. However, water harvesting and storage structures' capacities are inadequate leading to a lot of rain water going to waste in rainy seasons. Low usage of water efficient drip and sprinkler irrigation facilities by Lare farmers may be attributed to cost involved and skills needed acquisition and maintenance.

6. RECOMMENDATIONS

Agricultural water technologies' adoption is an all-inclusive social learning process involving farmers, extension workers, researchers, decision makers and other stake holders on how to respond to farming challenges brought about by climate change. Intervention measures should include both technical and financial empowerment components. For ownership and sustainability, agricultural water technologies adoption process should start off from farmers' indigenous technical knowledge, skills and experiences.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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