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Factors Influencing Smallholder Farmers' Adoption of Agricultural Water Technologies and Innovations in Lare and Elementaita Divisions of Nakuru County, Kenya

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ABSTRACT: Water for agricultural use has been adversary affected by climate change in Arid and Semi-Arid Legions. Water inadequacy and un-reliability can be addressed by farmers' adoption of agricultural water technologies and innovations of water harvesting, storage and application. Adoption of these technologies is low in developing countries. This study aimed at investigating factors influencing smallholder farmers' adoption of agricultural water technologies and innovations Lare and Elementaita Divisions, Nakuru County Kenya. These areas were selected as they are water constrained and inhabited by smallholder farmers some having while others having not adopted these technologies. Study objectives were: to document the socio-economic status of the farmers and ecological characteristics' influence on technologies' adoption. Descriptive research design was used with a sample size of 114 and 76 farmers who had, and not adopted the technologies respectively and selected using purposive and proportionate sampling techniques. Data was collected by use of face-to-face administered structured questionnaire and analyzed using descriptive and inferential statistics. Findings indicate that the farmers had low education level by Kenya's standard. Chi-square analysis indicated existence of statistically significant relationship between land topography, affordability of irrigation facilities and availability of technical and financial support and adoption of the technologies. No statistically significant relationship exists between soil types and water harvesting, storage structures and adoption of technologies. Financial constraints and lack of skills in management of these technologies were challenges. Technical, financial and supportive policy focusing the farmers' technologies' adoptive capacities is advised.

KEYWORDS: Agricultural water inadequacy, Climate change, Water technologies, Innovations Adoption, Smallholder farmers.

1 BACKGROUND OF STUDY

Climate change has become a major threat to food security in many regions of the world especially those that depend on rain-fed agricultural production [1]. Although Africa is a continent that is least responsible for climate change, it is the most vulnerable to the negative effects of the change. According to reference [2], projected climatic changes for Africa suggest a future of increasingly scarce water, collapsing agriculture yields and encroaching deserts. Unexpected prolonged droughts, food insecurity, water stress-related crop failure, livestock deaths and community conflict over scarce water resources are now frequent in marginal areas in Kenya [3], [4], [5]. Other disasters include infrastructures' destructive flooding, receding lake levels and drying rivers [6]. Agriculture is the backbone of the Kenyan economy and the major share of agricultural activities is carried out by smallholder farmers. These agricultural activities, that drive rural communities' development, are rain-fed. Therefore, climate change, leading to agricultural water scarcity majorly impedes rural community development. Water variability poses a challenge for Kenya in her determination to become a food secure country by the year 2030.

The chronic water problems experienced in Kenya may be attributed to climate change and destruction of water catchment areas among others. According to reference [7], deforestation, forest fires, overgrazing and agricultural activities within the Mau-Complex, has led to reduced rivers' discharge, drying up of water sources and receding of ground water table among others. Therefore, in the wake of water scarcity occasioned by climate change, appropriate agricultural water technologies and innovations needs be well understood and agricultural water adoptive capacities up-scaled at smallholder farmers' level. To mitigate water scarcity threat requires application of innovations based on integrated technologies both indigenous and modern, stakeholders' involvements and policy intervention.

Due to agricultural water inadequacy, some farmers in Lare and Elementaita Divisions of Nakuru County have been involved in agricultural water technologies and innovations that include water harvesting, storage and application. Lare and Elementaita Divisions differ in terms of ecological characteristics such as topography and soil types. Individual smallholder farmers in these areas also differ in terms of socio-economic status. Since majority of farmers in Lare and Elementaita Divisions are resource scare and their livelihoods hinge on agriculture. Adoption of agricultural water technologies and innovations would be one approach of empowering these farmers to mitigate the effects of water vulnerability and uncertainty due to climate change and sustainably enhance food and economic security of smallholder farmers. This is because, harvested water can be used for many interrelated agricultural activities such as kitchen gardening, poultry keeping; zero grazing, biogas digester installations, drip irrigation, fish farming and apiculture among others. All these farming activities translates into increased income generation, improved household food and economic security, creation of on-farm employment, decreased rural urban migration, poverty reduction and conservation of environment, among others (Kenya Rainwater harvesting Association [8]. In addition, harvested water can serve as an artificial recharge to groundwater [9].

According to reference [10], climate change is both a global environment and a local development challenge, as it could jeopardize the livelihoods of millions. This is particularly so where poor rural communities are already vulnerable to water scarcity and have limited coping capacity. Africa is experiencing increased incidences of prolonged droughts, extreme floods and reduced or failed agricultural production. All these lead to both food and economic insecurity and also increased risk of communities' conflict over scarce water resources. In Kenya, human-wildlife conflict, arising from human encroachment of marginal areas, in search of water resources, is on the rise [6]. Frequent and prolonged droughts have made communities that were one time food and economic secure to be destitute relying on relief food and water supply for their survival. Therefore water variability, particularly water scarcity, poses one of the greatest challenges for Kenya in her determination to become a food and economic secure country, according to her Vision 2030. However, the adverse effects of water scarcity can be ameliorated at household levels by adoption of agricultural water technologies and innovations. In rainfall seasons, rainwater, in form of runoff, wastes away. It is possible to harvest this runoff, store and use it in dry seasons [11]. Uncontrolled runoff causes destruction in the form of farm flooding, landslides, soil erosion, infrastructure destruction and community displacement among others. According to reference [12], one way of reducing incidents of communities' water related conflicts and infrastructure destruction is through water harvesting and storage in rainy seasons and efficient application of stored water in dry seasons. This may be achieved through the farmers' adoption of agricultural water technology and innovations.

According to reference [10], close to 80% of Kenya's population is rural and dependent on agriculture for basic livelihoods. The makes the country highly vulnerable to rainfall variability since 98% of the country's agriculture is rain-fed, hence sensitive to rainfall scarcity [3] and [13]. Therefore adoption of agricultural water technologies and innovations may be one approach of mitigating climate change adverse effects on agriculture.

A report by reference [14] showed that Kenya with a population of about 40 million is capable of meeting the water needs of six to seven times of its current population. Rainwater harvesting can yield numerous social and economic benefits, and therefore contribute to poverty alleviation and sustainable development [15]. According to reference [11], rainwater harvesting technologies are acceptable and replicable across many cultural and economic settings. However, it is puzzling to observe a farmer who has adopted these technologies, with easily observable positive outcomes bordering fellow farmers ignorant of these technologies in Lare and Elementaita Divisions. It is envisaged that the adoption of a technology does not only depend on its potential outcome, but also on the socio-economic situation of adopting farmer, among others. The study therefore focused on how these technologies' characteristics and the smallholder farmers' socio-economic situations influenced adoption of agricultural water technologies and innovations in Lare and Elementaita Divisions in Nakuru County.

Characteristics of technologies as perceived by individual adopters include relative advantage, compatibility, past skills, needs of potential adopters, complexity and observability. Ecological factors include individual farm topography and soil types. The study therefore focused on how these technologies' characteristics and topography influence smallholder farmers' adoption of agricultural water technologies and innovations.

2 Research Methodology

The study used descriptive survey to collect data from Lare and Elementaita Divisions in Nakuru County. The design was deemed suitable because it provided information about subjects under study on the past and current situation [16]. Lare and Elementaita Divisions were purposively selected as these areas are water constrained and inhabited by smallholder farmers, majority of whom have adopted agricultural water technologies and innovations. Purposive sampling was used to select study locations with high concentration of farmers who have adopted the technologies under the study. Proportionate sampling technique was used to assign a proportionate representative sample for each selected location. Simple random sampling was then used to pick the sample size for the study in each location [17]. The study used a researcher-administered semi-structured interview guide to collect data. Statistical package for social sciences (SPSS) was used for data analysis. Descriptive statistics was used whereby frequencies percentages and means were generated from the various data categories were computed and represented in different tables and figures. Chi-square was used for inferential statistics analysis.

3 FINDINGS AND DISCUSSIONS

3.1 FARMERS' GENDER PARTICIPATION

The study established that household heads are male at 55.2% and female at 44.8% as shown in Table 1. Therefore views of both genders have been captured in this study as both are involved in agricultural water technologies' adoption**.** Though women contribute 66% of all the hours worked throughout the world [18], they do not benefit as men do from technologies' adoption.

Table 1. Gender of Respondents

Gender		Percent
Male	63	55.2
Female	48	44.8
Total	115	100

3.2 FARMERS' AGE

Based on age, majority of the respondents (51.7%) were 51yrs and above. This consist of a generation of farmers that first acquired and settled in Lare Division hence commonly referred to as the original land owners. They believe they have final say on agricultural water technologies' adoption on their farms even in instances where some parts of their farms have been inherited by their off springs. A study by [18] 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.

3.3 FARMERS' EDUCATION LEVELS

Majority of the respondents (70%) had primary or no formal education, while 23.4% and 5.2% had secondary and college/university education respectively. Generally, respondents had a low level of education by Kenyan standards. According to reference [18], education has been found to influence adoption of agricultural related technologies such as agricultural water technologies. This is because education is believed to create a favorable mental attitude for the uptake of new practices. Therefore, educated farmers would be expected to embrace new technologies in order to experience the benefits that come with new practices. Education level correlates significantly with adoption of Harvesting and abstracting water technology as shown in Table 2.

Table 2 Education Level Correlation with Agricultural Water Technologies Adoption by Lare Farmers

	Education level	Harvesting and abstracting water	Storing harvested water?	Have been applying irrigation
Education levelPearson Correlation	1	-.191*	-.120	-.156
Sig. (2-tailed)		.041	.203	.097
N	115	115	115	115
Pearson Correlation	-.191*	1	-.034	.103

*. Correlation is significant at the 0.05 level (2-tailed).

4 ECOLOGICALCHARACTERISTICS

On ecological characteristics, Chi-square analysis revealed existence of statistically significant relationship between land topography and adoption of the technologies. Water pans/pods were observed to be concentrated more on lower gentle and flat rather than on the upper sloppy areas. However, no statistically significant relationship existed between soil type and adoption of the technologies as shown in Table 3.

Table 3. Relationship between Ecology's Characteristics and Technologies' Adoption.

Variable	P Value	Df	Chi-square Value
Land topography	13.948[a]	2	.001
Soil type	4.891[a]	2	.087

*Significant = p <0.05

5 TECHNOLOGIES' CHARACTERISTICS

On technologies' characteristics, results indicate no statistically significant relationship exists between affordability of harvesting and storage facilities and adoption of the technologies. However, there exists statistically significant relationship between affordability of irrigation facilities and their adoption. While the maintenance of harvesting facilities does not influence the technologies' adoption, the same is untrue with the maintenance of irrigation facilities. There also exists statistically significant relationship between availability of financial support and adoption of the technologies as shown in Table 4.

Table 4. Technologies' Characteristics and their Adoption

Variable	P Value	Df	Chi-square Value
Harvesting facilities (affordability)	3.830[a]	4	.429
Harvesting facilities (maintenance)	3.141[a]	3	.370
Harvesting facilities (easy to use)	2.429	4	.657
Storage facilities (affordability)	1.489	3	.685
Irrigation facilities (affordability)	9.531	3	.023
Irrigation skills	6.894	4	.142
Irrigation facilities(maintenance)	16.233	4	.003
Technologies fitting farm activities	6.121[a]	4	.190
Financial support	11.912	3	.008

*Significant = $p < 0.05$

6 INNOVATIONS

On innovations, it was found that a few farmers have designed and constructed house roofs that facilitate water harvesting. Some have landscaped their compounds in order to direct runoff to their farms. A few farmers have constructed road runoff diverting trenches that harvest both water and eroded soil. They maintain these trenches by regularly scooping deposited soils which they use as manure in their farms. Where land slope and soil type permits, these farmers have strategically designed and constructed water pans to harvest surface runoff and then use gravity to irrigate land down slope. Flood barriers in form of vegetative strips and trenches have been erected across farms to reduce runoff speed and its erositivity hence facilitate water infiltration thereby recharging ground water table. The farmers have also adopted innovative ways of cleaning and conserving the harvested water by use of greenish minute floating mass of a local azolla plant that has been introduced to cover the stored water surfaces thereby minimizing water loss through evaporation and physically cleaning the stored runoff. Suspended plant roots eventually turn brown runoff to sparkling clean water.

7 CONCLUSIONS

- Low literacy levels among household decision makers, inadequate follow-up by experts in provision of technical & financial support in management of agricultural water are some cited constraints in technologies' adoption.
- In citing, design & construction of water pans, it appears the following may not have been adequately considered hence not factored in :
  - Household agricultural water needs as majority of the farmers reported water inadequacy.
  - Siting of water pans to allow crop irrigation using water flow by gravity.
  - Safety of water pans' users; children & livestock have been reported to have drowned in water pans
  - Costs and maintenances skills were cited as significant constrains in adoption of these technologies. This would imply availability of financial and technical expert support would enhance farmers' adoption of these technologies.

The issue of water for agriculture is one that affects all families within the Lare and Elementaita communities. The effects of climate change have only exacerbated these problems. However, as seen through this study, simple solutions such as adoption of agricultural water technologies can help mitigate these issues. Also illustrated is the importance of the implementation process of these solutions. Although simple, if a farmer is not properly educated on how to properly execute and upkeep these processes, they will prove to be of no help and can end up having a negative impact. Furthermore, if the outreach and education about these solutions is not done properly, it can leave families unable to partake in these opportunities. A focus needs to be placed on availability of funding. Without proper funding opportunities, those most affected by poverty are not able to participate in the innovations to alleviate the adverse side effects of climate change. The smallholder farmers are in need of these innovations most, as they are the ones who have no resources to recover from the impacts. If these improvements are made and education is given a priority, members of the Lare and Elementaita communities will feel the positive effects of agricultural water technologies and inventions adoption. They will have a higher ability to successfully adapt to climate change induced water vulnerabilities, produce higher crops yields hence become water, food and economic secure.

Agricultural water technologies' and innovations' adaptation is not an issue for farmers alone. It is a social learning process expected to equip farmers, researchers, extension workers, local decision makers and other stake holders with information on how to respond to challenging circumstances brought about by climate change. For ownership and sustainability of intervention measures, agricultural water technologies and innovations should start off from farmers' indigenous technical knowledge, skills and experiences.

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