African Journal of Climate Change and Resource Sustainability
ajccrs.eanso.org
Volume 1, Issue 1, 2022
Print ISSN: 790-962X | Online ISSN: 790-9638
Title DOI: https://doi.org/10.37284/2790-9638

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment

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Article DOI: https://doi.org/10.37284/ajccrs.1.1.952

Date Published:

10 November 2022

Keywords:

Ecosystem-Based Adaptation (EbA), Floods Mitigation, Afforestation, Soil Conservation.

ABSTRACT

Flood is a natural disaster that occurs due to the sudden onset of rainfall that causes runoff waters from high altitude areas to low altitude areas. The purpose of the study was to assess ecosystem-based adaptation in flood risk management in the upper Suswa- Magadi catchment. The study used a descriptive research design. Purposive sampling and stratified random sampling methods were used to select three locations of the Upper Suswa-Magadi catchment. These included Suswa, Keekonyokie and Mosiro. The locations had a population of 8,094 households, from which a sample size of 370 was obtained. The study relied on both primary and secondary data. The questionnaires, key informant interviews, and observations were used to collect data. The study concluded that; Community participation in EbA could increase the soil texture, and increased afforestation could help in the absorption of runoff water increasing the infiltration rates of water and causing flash floods. The study recommended the creation of awareness on the EbA measures to curb flash floods which could help the community members to avert the effect of flash floods and encourage the community to participate in the application of EbA measures in order to increase the soil texture, increase afforestation could help in the absorption of runoff water increasing the infiltration rates of water causing a flash flood. This can be done through community-based organizations that easily understands their problems and supports project that will assist them.

APA CITATION

Njeru, M. L., Mabwoga, S., & Konana, C. (2022). An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment. *African Journal of Climate Change and Resource Sustainability*, *1*(1), 26-36. https://doi.org/10.37284/ajccrs.1.1.952.

Article DOI: https://doi.org/10.37284/ajccrs.1.1.952

CHICAGO CITATION

Nashipay, Moshira Lydia, Samson Mabwoga and Charity Konana. 2022. "An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment". *African Journal of Climate Change and Resource Sustainability* 1 (1), 26-36. https://doi.org/10.37284/ajccrs.1.1.952.

HARVARD CITATION

Njeru, M. L., Mabwoga, S., & Konana, C. (2022) "An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment", *African Journal of Climate Change and Resource Sustainability*, 1(1), pp. 26-36. doi: 10.37284/ajccrs.1.1.952.

IEEE CITATION

M. L. Nashipay, S. Mabwoga, & C. Konana. "An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment", AJCCRS, vol. 1, no. 1, pp. 26-36, Nov. 2022.

MLA CITATION

Nashipay, Moshira Lydia, Samson Mabwoga & Charity Konana. "An Assessment of the Ecosystem-Based Adaptation Approach for Flood Risk Management in the Upper Suswa-Magadi Catchment". *African Journal of Climate Change and Resource Sustainability*, Vol. 1, no. 1, Nov. 2022, pp. 26-36, doi:10.37284/ajccrs.1.1.952.

INTRODUCTION

Flooding is by large a state of complete or halfway immersion of typically dry regions because of the flood of flowing or inland waters or from the unusual and quick collection of spillover (Jeb & Aggarwal, 2008). "Floods are the most recurring, widespread, disastrous, and frequent natural hazards of the world" (Adedeji et al., 2012). Floods are grouped by the United Nations International Strategy for Disaster Reduction (UNISDR) as hydro-meteorological perils and have been viewed as the most often happening cataclysmic event that outcomes in broad fatalities universally (Doocey et al., 2013). In Kenya, the earliest reported flooding occasions were the Uhuru surges of 1961 (Opere, 2013), which set off the requirement for research on the degree and size of flooding. All the more as of late, nonetheless, is the El Nino surges of 1997 and 1998 that caused the deficiency of many lives and enormous harm to private property and public foundations.

In the Suswa upper catchment, flooding issues can be connected to the unfortunate floor of the board nearby. This is confirmed by the accessible end-all strategies, which have not been completely executed, generally because of insufficient capital expense prompting spontaneous urbanization and settlement designs (Elmqvist et al., 2018). In the background of flooding as a serious worldwide, local, and public peculiarity, the general point of this examination, subsequently, is to consider and propose an environment-based approach in flood risk maintainable administration, Upper Suswa-Magadi Catchment that would be founded to relieve against and fabricate the versatility of this region with the impacts of flooding.

Ecosystem-based Adaptation (EbA) is an emerging perspective for supervising typical resources under logical factors and irritated climatic conditions (Pérez et al., 2010). As a strategy, it consolidates 'fragile' and 'hard' responses as assigned natural framework conservation, the board, and revamping exercises. The focus of this paper is to study the utility of EbA as a framework for controlling the flood. To identify the environmental impacts of floods and assess the effectiveness of an ecosystem-based adaptation approach for flood risk management in the upper Suswa-Magadi catchment.

The findings of this study will significantly contribute to the identification of ecosystem-based adaptation approaches, which will help reduce surface runoff, increase food production, increase vegetation cover and biodiversity, soil and water conservation, and recharge aquifers.

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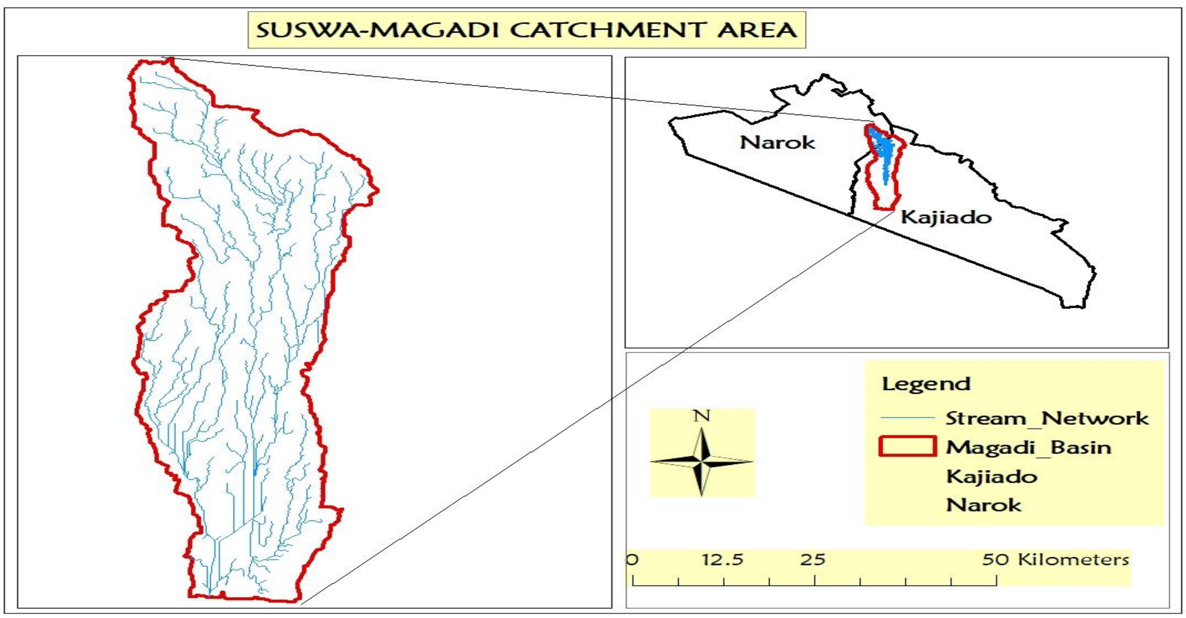
MATERIALS AND METHODS

The geographical focus of this study is Upper Suswa- Magadi Catchment, located in Narok County. It is located in southern Nairobi and East of Narok County and *Muhoho – Mai Mahiu* Road to the north. It covers an approximate area of 4.84 square kilometres.

According to the Upper Suswa- Magadi Catchment Development Ordinances and Zones regulations, Suswa-Magadi catchment has allowed ground inclusion (GC) of 35% and least plot proportion percentages of 75%. The Catchment further allows for comprehensive subdivisions with smaller sizes on type plan and development density at 35 units per hectare. The area is zoned as a medium to high-density mixed-use development and is therefore characterized by residential developments comprising semi-permanent huts and permanent bungalows with accompanying commercial and institutional developments.

Figure 1: Suswa-Magadi catchment area



Source: Researcher, 2022

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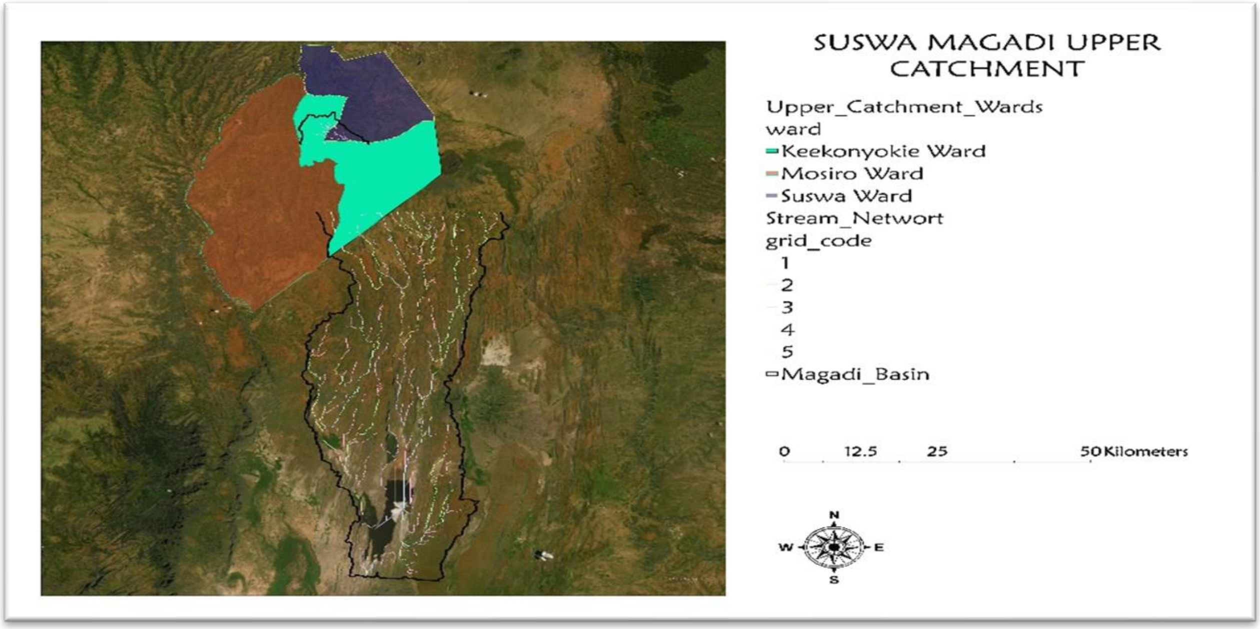
Figure 2: Upper Suswa-Magadi Catchment Drainage Map



Source: Researcher, 2022

Target Population

The target population refers to all the households that are found within the upper Suswa-Magadi Catchment. This included Suswa, Keekonyokie, and Mosiro. According to KNBS (2019) national census: Suswa has a population of 14,302; Keekonyokie has a population of 17,026, while Mosiro has a population of 6,264. Therefore, the total population of this study was 37,592. The three locations have 2,680, 4118 and 1296 households, respectively

Table 1: Population of Upper Suswa-Magadi Catchment in 2019

Location	Population	Households
Suswa	14,302	2,680
Keekonyokie	17,026	4,118
Mosiro	6,264	1,296
TOTAL	37,592	8,094

Source: (KNBS, 2019)

Sampling Procedure

Purposive and proportionate sampling methods were used to obtain the sample. Three locations were purposively selected based on agroecological zone. Suswa, Keekonyokie, and Mosiro locations were selected because they are lowland zones in the Upper Suswa-Magadi Catchment.

Sample Size

Since the target population was less than 10,000, the sample size was calculated using the sample size formula, which had been advanced by various scholars such as Kothari (2004) and Mugenda and Mugenda (2003).

$$nf = \frac{n}{1+\frac{n}{N}}$$

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Where: -*n* = 384, which is a constant sample used as a minimum sample for any population that is below 10,000; *nf* = Desired sample size when the population is less than 10,000; N = Population size

$$nf = \frac{384}{1 + \frac{384}{8094}} = 366\, respondents$$

Therefore, the sample size from the target population of 8094 members needed for this study is 366.

The sample size derived from the above formula was proportionately distributed to the three locations using the proportion allocation to size formula by Salkind (2010).

The following formula was used to get the household proportion required for each of the three locations.

$$n_h = n\frac{Nh}{N}$$

Where; *nh*, is the sample size per location; *n*, is the total sample size of the study; *Nh* is the total households per location*;* *N* is the total households.

Table 2: Sample size per location.

Category	Households	Sample Size
Suswa	2680	366 x 2680/8094 = 121
Keekonyokie	4118	366 x 4118/8094= 186
Mosiro	1296	366 x 1296/8094= 59
Chiefs of the locations	3	3
Sub-County Disaster Management Officer	1	1
Total	8094	370

Source: Researcher, 2022

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Table 3: Summary of data matrix (sources, collection methods, analysis, and presentation) for each objective.

Research objectives	Data needs (Variables)	Data sources	Data collection methods	Data analysis methods	Data presentation methods	Expected outcomes
1. To determine the environmental impacts of floods in the upper Suswa-Magadi Catchment.	Loss of biodiversity Destruction of roads and other infrastructure Soil erosion Damage to vegetation Deterioration of landscape	Field survey Key informants FGDs Household heads, community leaders, and ministry of environment officers.	Observation Interviews Photography Questionnaires	Descriptive analysis (SPSS & MS Excel)	Descriptive report Photographs Reports Tables	A descriptive report on environmental impacts of floods in the upper Suswa-Magadi Catchment.
2. To assess the effectiveness of ecosystem-based adaptation approaches in flood management in the upper Suswa-Magadi Catchment.	Livelihood improvement, provisioning water for domestic use, regulating invasive species and soil erosion, cultural conserving and recharging groundwater and improving soil quality.	Household heads, community leaders, ministry of environment officers and county disaster management officers.	Literature review Interviews Questionnaire	Descriptive analysis (SPSS & MS Excel)	Reports Charts Tables	Comprehensive descriptive report assessment on the effectiveness of ecosystem-based adaptation approaches in flood management.

Source: Research, 2022

Article DOI: https://doi.org/10.37284/ajccrs.1.1.952

RESULTS AND DISCUSSION

Environmental Impacts of Floods in the Study Area

From *Table 4*, the majority of the respondents agreed that flash floods cause the destruction of roads and other infrastructure. The impact of floods however is less on biodiversity.

Table 4: Environmental Impacts of Floods

	N	Mean	Std. Dev.
Effect of flash floods on siltation of water storage	310	2.1355	.58655
Effect of flash floods on the loss of biodiversity	310	2.1806	.54531
Effect of flash floods on change of nutrients cycle and loss of topsoil	310	2.0032	.32678
Effect of flash floods on the loss of vegetation	310	1.8161	.44256
Effect of flash floods on the destruction of roads and other infrastructures	310	1.8129	.41473
Effect of flash floods on soil erosion	310	2.0097	.27265

Source: Research, 2022

Based on the study findings in *Table 4* above, the respondents agreed that the following is the extent of environmental impacts as a result of flash floods in the study area; siltation of water storage (M = 2.1355, SD = 0.58655), loss of biodiversity (M = 2.1806, SD = .54531), change of nutrients cycle and loss of topsoil (M = 2.0032, SD = 32678), loss of vegetation (M = 1.8161, SD = .44256), destruction of roads and other infrastructures (M = 1.8129, SD = .41473), soil erosion (M = 2.0097, SD = .27265).

Flash floods highly impacted the destruction of roads and other infrastructure. The impact of floods however, is less on biodiversity.

Table 5: Ecosystem-Based Adaption Measures of Flood Control

	Frequency	Percent
Planting of soil conservation grass	3	1.0
Contour farming	250	80.6
Terrace farming	14	4.5
Smart agriculture	43	13.9
Total	310	100.0

Table 5 shows that the respondents were aware of ecosystem-based measures of flood control in their area. The study found that there is significant knowledge of the Ecosystem-based measures of flood control in their area. The majority, 80.6% indicated contour farming as the common Ecosystem Based measure of flood control in their area. The use of smart agriculture was indicated by 13.9% of the respondents, while 4.5% indicated terrace farming. Planting of soil conservation grass was indicated by 1% of respondents. According to Nyakundi et al. (2010), traditional mitigation measures assist in the management of flash floods in the world. It has been practised by communities to address gap problems associated with flash floods.

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Plate 1: Making of Terraces

Source: Research, 2022

Effectiveness of Ecosystem-Based Adaptation Approaches in flood Floods Management

The study sought to find out from the respondents how they rate the effectiveness of ecosystem-based adaptation approaches in flood management.

Table 6: Effectiveness of Ecosystem-Based Adaptation Approaches in flood Floods Management

	N	Mean	Std. Dev.
Effect of EBA on reduced runoff	310	2.3645	.50822
Effect of EBA on soil and water conservation	310	1.6968	.77061
Effect of EBA on increased vegetation growth	310	2.1710	.65344
Effect of EBA on recharging of aquifers	310	2.2968	.52355
Effect of EBA on increased food production	310	2.0032	.78620
Effect of EBA on increased biodiversity	310	2.4419	.54700
Effect of EBA on the nutrient cycle	310	2.0645	.80192

Source: Research, 2022

From the results presented in *Table 6*, different indicators were used to show the extent to which EbA was effective in the study area. The results indicated; Reduced run-off (M=2.3645, SD=.50822), Soil and water conservation (M=1.6968, SD=.77061), Increased vegetation growth, (M=2.1710, SD=.65344), Recharging of aquifers (M=2.2968, SD=.52355), Increased food production (M=2.0032, SD=.78620), Increased biodiversity (M=2.4419, SD=.54700) and nutrient cycle improvement (M=2.0645, SD=.52355). The findings show that EbA is highly effective in soil and water conservation.

Article DOI: https://doi.org/10.37284/ajccrs.1.1.952

Plate 2: Increased food production due to terrace farming.

Source: Research, 2022

Table 7: The relationship between the applications of Ecosystem-based measures and their effectiveness

Correlations			
		Ecosystem-based measures	**Effectiveness of EBA**
Ecosystem-based measures	Spearman's Correlation Coefficient	1.000	.684**
	Sig. (2-tailed)	.	.000
	N	310	310
Effectiveness of EBA	Spearman's Correlation Coefficient	.684**	1.000
	Sig. (2-tailed)	.000	.
	N	310	310
***. Correlation is significant at the 0.01 level (2-tailed).*			

From Spearman's correlation results, it is clear that there is a positive correlation between the application of EbA measures and their effectiveness in flood risk management. This means that whenever there is a positive change in the application of EbA measures, there is a positive increase in flood risk control.

CONCLUSION AND RECOMMENDATIONS

The study concluded that; the respondents in the study area are knowledgeable about the causes of flash floods and the timing of the flash floods within their area. However, they do not have enough resilience skills to predict and avoid flash floods in their areas during heavy rainy seasons. Further, community participation in EbA could increase the soil texture; increased afforestation could help in the absorption of runoff water increasing the infiltration rates of water and causing flash floods.

The findings showed that the application of Eba measures is indeed effective in flood management and leads to reduced runoff, increased soil and water

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Article DOI: https://doi.org/10.37284/ajccrs.1.1.952

conservation, increased vegetation growth, recharging of aquifers, and increased food production. It was also found to increase biodiversity and the nutrient cycle.

Recommendations

The following are the recommendation made according to the study objectives;

- The creation of awareness on the EBA measures to curb flash floods could help the community members to avert the effect of flash floods.
- Community participation in EBA could increase the soil texture; increased afforestation could help in the absorption of runoff water increasing the infiltration rates of water and causing flash floods.
- Further, non-governmental organizations are key stakeholders that can assist this community address their persistent environmental concern of flash floods.
- Implementation of early warning systems and mapping of flash floods in the study area could enhance resilience to early prediction and avoidance of flash flood effects. This is possible when all the community members are informed of what is likely to happen in rainy seasons that preparedness by having lively hood alternatives.

Recommendation for Further Research

- Geospatial mapping and analysis of the flash flood trends in the study area should be conducted to help in understanding future flash floods.
- Adaptation measures in response to climate change effects such as flash floods include reforestation programmes established avoidance of the use of herbicides that destroys vegetation covers.
- Alternative livelihood and economic projects are developed instead of charcoal burning, which makes the land vulnerable to flash floods when all the vegetation is cleared.

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