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Understanding Ecosystem-Based Adaptation to Climate in Kenya's Mt Elgon Forest Ecosystem: Definitions, Opportunities and Constraints

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Abstract

A number of approaches have been employed across the world to address adaptation to climate change impacts. The role of ecosystems in adaptation to climate change impacts has been recognized at the international level more so upon the realization that conservation, sustainable management and the restoration of ecosystems can help people adapt to the impacts of climate change. This concept of using ecosystems for climate change adaptation otherwise known as Ecosystem based Adaptation (EbA) utilizes the premise that healthy, well managed ecosystems have climate change mitigation potential. The approach is gaining increasing attention as it is accessible to the rural poor in developing countries due to its cost-effectiveness and due to the fact that it uses infrastructure that is already established by nature. Research has it that the Mount Elgon ecosystem in the south-rift part of Kenya has EbA characteristics which can offer longer term solutions to adaptation to climate change impacts while providing a range of other benefits in terms of ecosystem goods and services. This paper seeks to profile Mt. Elgon ecosystem's natural infrastructure in improving resilience of the forest adjacent community to the impacts of climate change. This was achieved by carrying out, a descriptive survey that involved 405 household and 51 civil servant and civil society respondent drawn from Saboti, Kiminini, Endebess, and Kwanza sub- counties, Transnzoia County in Kenya. Results show that residents of the study area grow maize (90.6%) being their staple food as compared with other crops such as beans (3.7%), vegetables (2.7%) and millet (1.5%).The household incomes centre around crop farming (47.4%) followed by formal employment (21.5%),family business (12.9%), casual employment in the agricultural sector (10.9%), while other sources accounted for 0.5%. This specialty economy exposes residents to the effects of climate. A major conclusion in this study is that beneficiary decentralized governance systems must seize opportunities presented by the Mt Elgon ecosystem to develop initiatives that improve the resilience of ecosystems and people to climate change impacts.

Keywords: *Ecosystem based adaptation, opportunities, challenges, Mt. Elgon*

1. Introduction

Ecosystem based adaptation is a nature-based approach, has the potential to increase adaptive capacity and social and ecological resilience to climate change in both developed and developing countries [1]. It provides a cost effective, economically beneficial, as well as longer term solutions, with a range of co-benefits in terms of the goods and services provided by ecosystems

Mount Elgon Forest Ecosystem is one of Kenya's five major water towers and the second highest mountain in the country. It doubles up as an important biodiversity hotspot of global significance, supporting several endemic plant and animal species (CIFOR, 2017). This gazetted montane forest reserve was recognized as a Biosphere Reserve by UNESCO in 2003 due to its significance as a water tower and biodiversity reservoir [2]. The key values of Mt Elgon are presented in the form of natural heritage, biodiversity, water catchments, agricultural base, and tourism that support a poor human population in its landscape. This ecosystem is characterized by peasant farmers whose population density average at 600 people per km^2 near forest. This community depends on the forest for most of their subsistence needs. The bimodal pattern of rainfall with annual rainfall of 1,400 – 1,800 mm comes in March to May and September to November. The dry seasons run from June to August and from December to March. The reliable climatic conditions, coupled with other ecological services of this ecosystem supports the adjoining human population of about 2 million people, a majority of whose livelihoods and economic activities depend solely on the goods and services that they derive from this forest ecosystem.

As a key afro-montane ecosystem, the effectiveness of management policies and institutional arrangement has direct impacts on the livelihoods of the surrounding community and other support sectors across large watersheds in Kenya and Uganda (CIFOR, 2017). Improved understanding of the ecosystem health of this ecosystem, biodiversity status and its contribution to provision of ecosystem goods and services is a key step in developing a cost effective and economically viable policy strategy to increase community resilience to climate change impacts. In view of the foregoing, this paper seeks to profile Mt. Elgon ecosystem's natural infrastructure in improving

resilience of the forest adjacent community to the impacts of climate change.

1.1. Study area

The study area covers four sub-counties whose residents directly or indirectly interact and depend on the Mt. Elgon forest for their livelihoods **(Figure 1)**.

This landscape which consist of a forest reserve and a national park extend and border with the local communities who live adjacent to the forest and depend on its forest for their livelihood. The forest provides most of the goods and services, which form the basis of their subsistence. The rivers and many rivulets which emanate from this forest have for a long time influenced greatly the livelihoods of the immediate and downstream communities.

The rich agro-ecosystem that is supported by this afro-montane forest has recently experienced the impacts of climate change. This has manifested itself through increasing mean annual temperatures and shifting of precipitation means of the crucial agricultural calendar **(figures 2 & 3)**

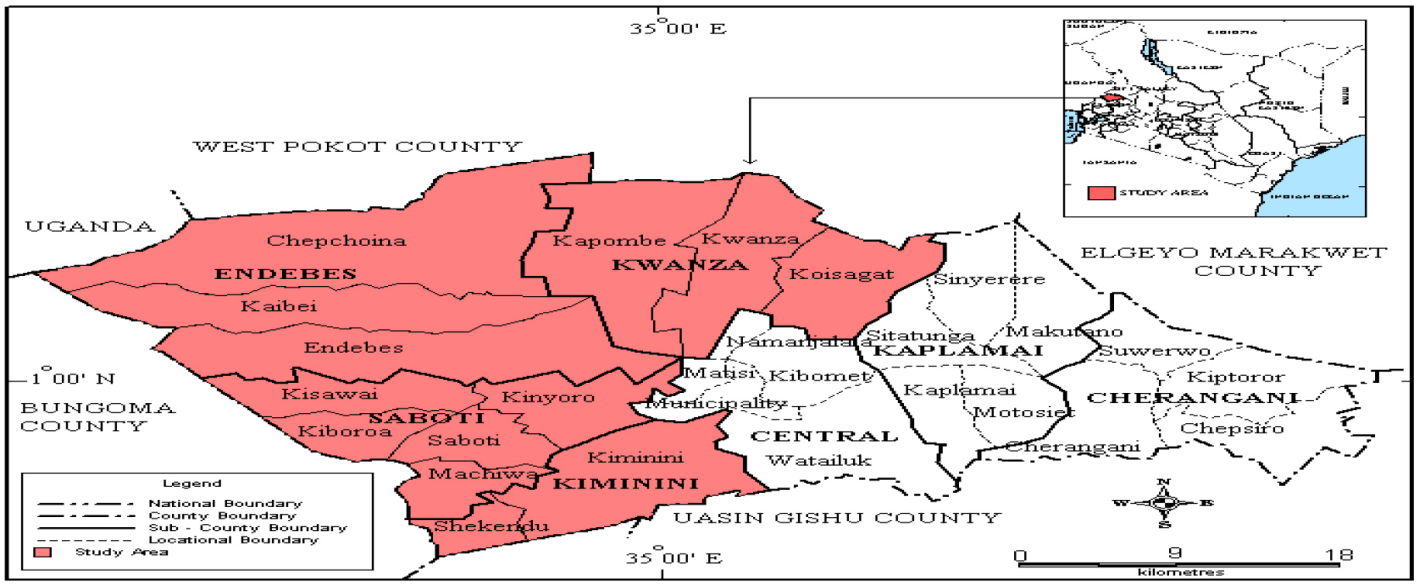


Figure 1. Study area.
(*Source: Moi University Geography Department GIS Lab, 2013.*)

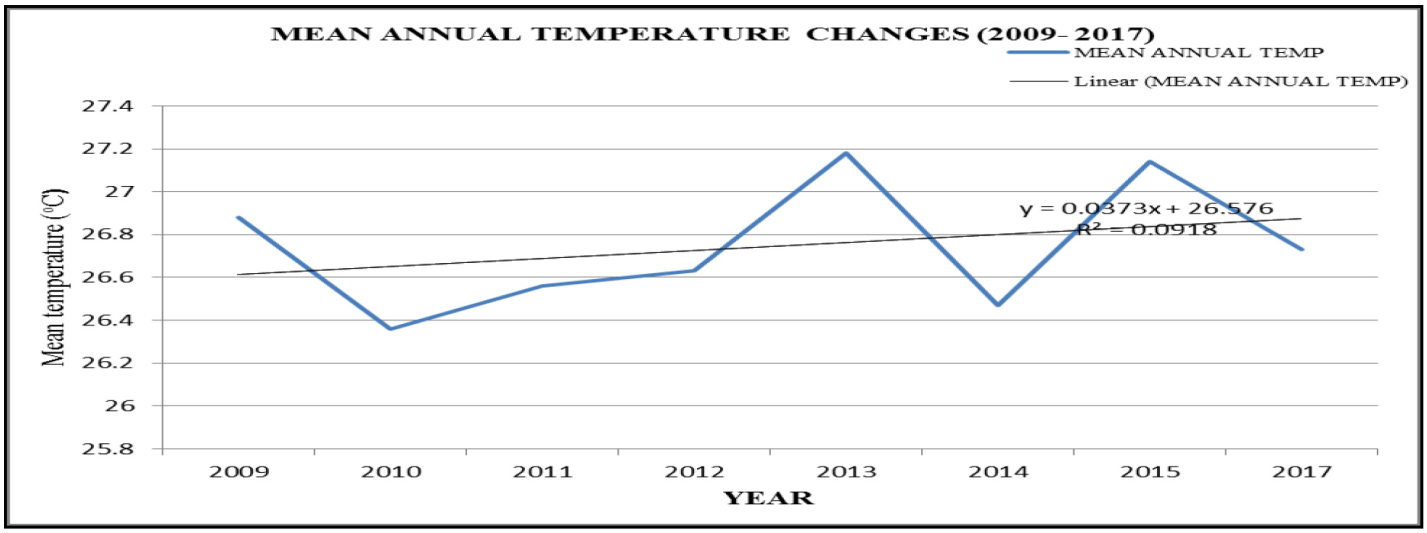
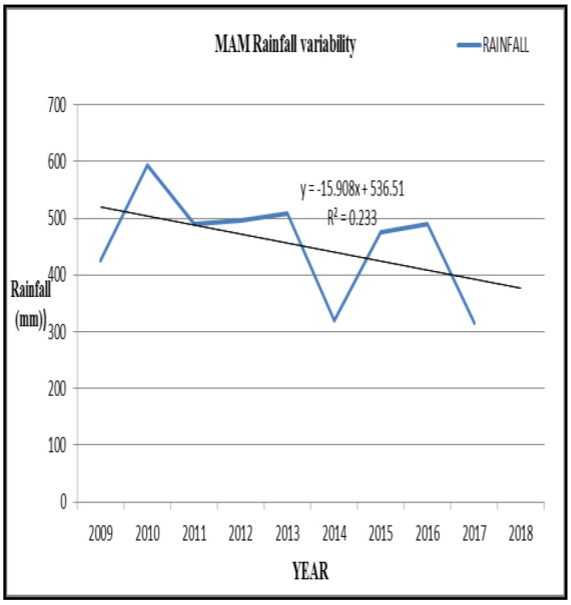


Figure 2. Mean annual temperature changes in the Mt. Elgon ecosystem.



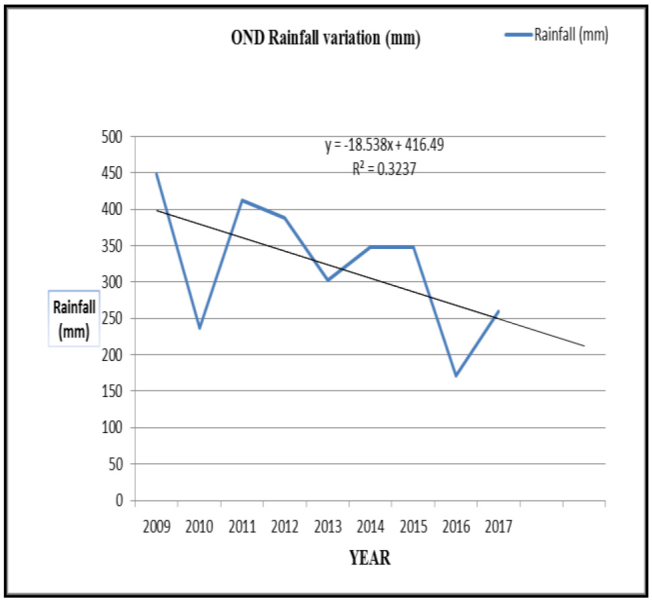


Figure 3. Rainfall variability in MAM and OND over the years (2009 -2018).

1.2. Methodology

A descriptive survey was used to collect data from fro 405 households who are residents of Saboti, Kiminini, Endebess, and Kwanza sub- counties (table 1).

Table 1. Sample size of households.

Sub-county	No of households	Number in sample
Kwanza	139,708	$\frac{139,708}{393,531} \times 405 = 144$
Endebess	53,811	$\frac{53,811}{393,531} \times 405 = 55$
Saboti	141,575	$\frac{141,575}{393,531} \times 405 = 146$
Kiminini	58,437	$\frac{58,437}{393,531} \times 405 = 60$
Total	393,531	405

Another set of 51 responds drawn from the civil servants and civil society organizations was selected using purposive sampling. The selection was based on their knowledge on Mt. Elgon ecosystem and climate change adaptation matters. The civil servant respondents were drawn from the County Government of Transnzoia, the national government ministries, departments and agencies. Civil society respondents were drawn from the private sector, local NGOs and CBOs. Information obtained from this category of respondents was correlated with existing secondary information.

2. Results and Discussion

2.1. Opportunities for Ecosystem based management in Mt. Elgon ecosystem

2.1.1. Ecosystem goods and services in enhancing resilience to climate change

There is a wide range of ecosystem goods and services that are obtained from the Mt. Elgon forest ecosystem (table 2). The community regards these as important in both directly and indirectly supporting their livelihoods.

Explanation

Goods such as food, fiber, fuel wood, freshwater and medicinal plants are obtained from this forest ecosystem besides offering diverse ecosystem services. Generally, the benefits obtained from Mt. Elgon ecosystem can be grouped into four main categories. These are provisioning, regulating, supporting, cultural, and recreational services. They are all relevant in contributing to the reduction of vulnerability of the community to the effects of climate change.

A healthy, fully functioning Mt. Elgon ecosystem can enhance the provision of these much needed ecosystem goods and services. Further, a healthy ecosystem can be more resilient to stressors and thus better able to support adaptation to climate change impacts. Further, a healthy ecosystem implies a greater element of flexibility in adaptation response options. Strengthening and protecting this ecosystem is a sustainable investment that ensures an array of environmental, social and financial benefits especially under adverse climatic situations.

2.1.2. Eba in improving food security in Mt. Elgon Ecosystem

Table 3 shows the main crops grown by most households in the study area. They include maize (90.6%), beans (3.7%), vegetables

(2.7%), millet (1.5%) and sugarcane (1.5%). The physiographic and edaphic factors are suitable for growing other crops such as millet, sunflower and sorghum (GoK, 2013) [2] but this opportunity has not been exploited.

Maize farming is widely adopted in the study area with the size of land owned not being an obstacle to people growing maize ($\alpha = 0.05$, $p = 0.207$). It is the most preferred irrespective of the size of land owned by a household (table 4).

Table 2. Goods and services obtained from the Mt. Elgon forest ecosystem.

HOUSEHOLD RESPONSES (N=405)				GOVERNMENT/CIVIL SOCIETY RESPONSE (N=41)			
Goods/service	**Trend**	**Freq**	**Percent**	**Goods/service**	**Trend**	**Freq**	**Percent**
Food	Increase	111	27.4	**Food**	Increase	5	12.2
	Decrease	289	71.4		Decrease	36	87.8
Fuel wood	Increasing	100	24.7	**Fuel wood**	Increasing	7	17.1
	Decreasing	304	75.1		Decreasing	34	82.9
Fresh water	Increasing	78	19.3	**Fresh water**	Increasing	7	17.1
	Decreasing	321	79.3		Decreasing	34	82.9
Medicinal plants	Increasing	65	16.0	**Medicinal plants**	Increasing	7	17.1
	Decreasing	339	83.7		Decreasing	34	82.9
Air quality	Increasing	81	20.0	**Air quality**	Increasing	8	19.5
	Decreasing	321	79.3		Decreasing	33	80.5
Natural hazard regulation	Increasing	142	35.1	**Natural hazard regulation**	Increasing	16	39.0
	Decreasing	259	64.0		Decreasing	25	61.0
Water flow regulation	Increasing	127	31.4	**Water flow regulation**	Increasing	8	19.5
	Decreasing	275	67.9		Decreasing	33	80.5
Cultural and spiritual	Increasing	99	24.4	**Cultural and spiritual**	Increasing	6	14.6
	Decreasing	304	75.1		Decreasing	35	85.4
Biodiversity regulation	Increasing	118	29.1	**Biodiversity regulation**	Increasing	7	17.1
	Decreasing	284	70.1		Decreasing	34	82.9

Table 3. Main crops grown by respondents.

Crop type		Frequency	Percent	Valid Percent	Cumulative Percent
	Beans	15	3.7	3.7	3.7
	Vegetable	11	2.7	2.7	6.4
	Maize	367	90.6	90.6	97.0
	Millet	6	1.5	1.5	98.5
	Sugarcane	6	1.5	1.5	100.0
	Total	405	100.0	100.0	

Source: (*Author, 2015*)

Explanation

Owing to the food preferences, maize is a staple food in both the study area and in Kenya as a nation. The adequacy of this preferred crop determines how food secure the Mt. Elgon community is at any one given moment. In the event of a short supply occasioned by the effects of climate change, most households will have limited choices of other food stuffs and will be considered to be food insecure. This causes maize to be widely grown as compared to other crops. Its production is relies mainly on rain-fed agriculture, which is in turn influenced by the prevailing climatic conditions in the Mt. Elgon forest ecosystem. This climatic fluctuations that are characteristic of the area exposes Maize production to climate related uncertainties

and may in turn affect the production pattern of this staple food. The major climatic uncertainties include precipitation variability, seasonal temperature change, extreme weather events such as; drought, floods, emergence of new crop pests and diseases, which may in turn increase the community's vulnerability to climate change impacts.

Herrero [4] observes that overreliance on one staple food crop by a society may expose them to the impacts of climate change. This is especially so when the production systems rely on the prevailing climatic patterns of the area. The uncertainties associated with natural climatic patterns may strongly affect the stability of food supplies. This results to multiple effects that include the reduction of the society's ability to access food at affordable prices besides leading to critical effects on food security. Seizing ecological opportunities that come with the Mt. Elgon's ecosystem can diversify crop farming and thus broaden the variety of agricultural activities in the area. These favorable conditions can positively be used to increase resilience to impacts of climate change.

Table 4. Relationship between sizes of land owned by respondent and the main crop grown.

Size of Land Owned by Respondent	Main crop					
	Beans	Vegetable	Maize	Millet	Sugarcane	Total
< 0.5 Acre	3	4	126	2	3	
0.5 - 1 Acre	6	4	47	0	0	
2 - 4Acres	5	2	106	4	3	
5 - 10 Acres	1	1	55	0	0	
> 10 Acres	0	0	15	0	0	
None	0	0	18	0	0	
Total	15	11	367	6	6	

Source: (*Author, 2018*)

2.1.3. EbA in increasing income diversity in the Mt. Elgon ecosystem

Crop farming (47.4%) is the main source of family income followed by formal employment (21.5%). Other income sources include family business (12.9%), casual employment in the agricultural sector (10.9%), while other sources accounted for 0.5% (**table 5)**.

Explanation

Agriculture, being the main economic activity has a strong ripple effect on the vibrancy of other sectors in the same region. This sector emerged as the single largest source of income supporting a majority of homesteads. It was established that even those in formal employment and are with a relatively stable income are actually working in agriculture-allied institutions. For instance, the Kenya Seed Company, Agricultural Development Corporation (ADC), Educational facilities, and flower farms in the study area have a workforce that receives a relatively regular income to supports their livelihoods. All these employees are categorized as working in the agriculture sector and its value chain facilities. This implies that the agricultural share of total labor force and associated income is big and largely influences the vulnerability to climate change narrative in the study area. This is largely due to the fact that agricultural activities practiced by the community in the area heavily rely on the natural climatic patterns.

Indeed the findings point out to lack of diversification in income sources in the study area. This narrow range of income streams is an important socio-economic exposure to the effects of climate change. Diversified income sources can help in cushioning households against the negative effects of climate change by providing alternatives should another fail. Herrero et al [4] observes that over-reliance on limited economic livelihood options is a strong predisposing factor to vulnerability to the effects of climate. Broadening of income-generating opportunities by vulnerable groups especially with the imminent threats of climate change and its impacts is urgent. This then calls for the need to avoid the overreliance on climate dependent agriculture and its income sources. Adger [5] too observes that dependency on income from agriculture is an important aspect of vulnerability and is caused by reliance on a narrow range of limited resources. Such dependency may often lead to social and economic stresses. He further points out that there are links between poverty and lack of diversification of livelihood activities by the farmers and thus leading to enhanced poverty.

The Mt. Elgon ecosystem which has diverse ecological niches can wistfully be utilized to broaden the economic base of the residents. This call on enhanced investment in research directed at birthing economic ventures that site match the different ecological niches presented by this ecosystem. Eco-tourism and commoditization guided by sustainable exploitation of some renewable natural resources such as water may provide additional avenues of income generation. Restoration of degraded ecosystems is an important aspect of EbA because it provides a mechanism for carbon sequestration and hence climate change mitigation, sources of employment and enhancement of resources to support livelihoods [6,7].

Payment for ecosystem services also known as payments for environmental services or benefits are other possible income streams

in the Mt. Elgon ecosystem. It implies that incentives can be offered to farmers, landowners and natural resource conservancies in exchange for managing their land to provide some sort of ecological service [8]. The programs are voluntary and mutually beneficial contracts between the riparian consumers of environmental services and the suppliers of these services.

3. Challenges to Ecosystem based adaptation

3.1. Biodiversity loss

The Mt. Elgon ecosystem has lately suffered from a shrinking biodiversity resource base, a situation that has been attributed to over-abstraction of some species. Diminished biodiversity is a pointer of poor ecosystem health and consequently, reduced ability to buffer the community against the effects of climate changes. A publication by IUCN [2] points out that there has been a marked reduction in forest cover due to clearing of land for agricultural production (**figure** 4).

The use of land and natural resources in and around the Mt Elgon ecosystem has resulted to significant alteration of ecosystem structure, function and processes, including connectivity within and between ecosystems, a case that has also been observed by Western [9]. Ongugo (op cit) [10] observes that water streams emanating from the Mt. Elgon have in the recent past reduced significantly in terms of volumes and annual discharge due to anthropogenic factors. The soils too have lost their fertility due to poor soil management practices. Deterioration of these resources has in turn impacted negatively on the community livelihood resources, whose existence is closely linked to the ecosystem health. Modification of the Mt. Elgon ecosystem may reduce its health, productivity and resilience, and must be managed to ensure sustainable supply of ecosystem goods and services.

Table 5. Common source of household income.

Family business		Common income Household income source						Total
		Crop farming	Livestock farming	Formal employment	Casual employment	Other		
Age of the Respondent	Below 18	0	6	0	0	0	0	6
	18-25	7	17	3	7	7	0	41
	26-32	7	28	2	14	10	0	61
	33-38	24	49	4	26	14	1	118
	39 and Above	14	92	19	40	13	1	179
Total		52	192	28	87	44	2	405

Source: (*Author, 2018*)

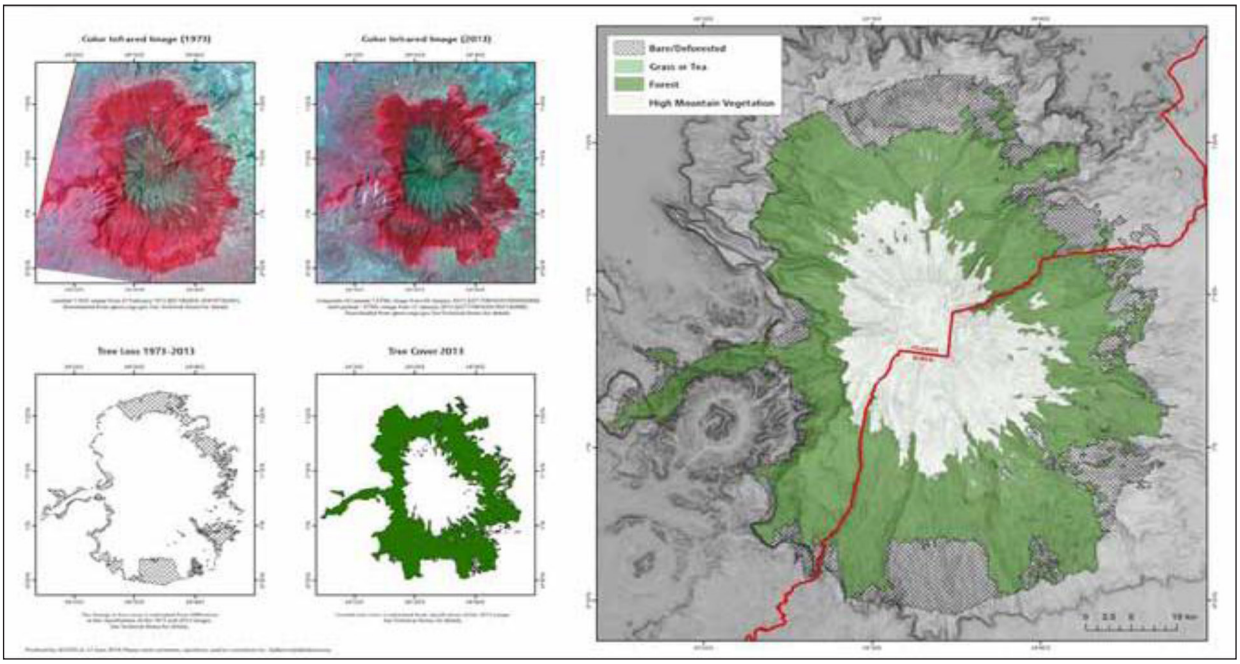


Figure 4. Land use and land cover changes in Mt. Elgon ecosystem (1973–2013)
Source: ACCCESS/IUCN, 2014

Over-abstraction of the ecosystem goods in the Mt. Elgon has been linked to people viewing the resources as free goods that are open to exploitation by all. IPCC (op cit) observes that, because many of the ecosystem goods and services have always been freely available, with no markets and no prices, their true long-term value is not included in society's economic estimates. It calls for "hercynian" decision to value these goods and services in monetary terms. Further, promoting better governance, and strengthening the rules that help to protect this ecosystem is encouraged in order to enhance the ecosystem health, which culminates in enhanced EbA services.

3.2. Uncoordinated management of the ecosystem

Cumulatively, 77% of household are of the opinion that there is uncoordinated approach towards managing the ecosystem resources. This has led to the degradation of the individual natural resources and consequently affecting their livelihood sources **(table 6)**.

Table 6. Respondent views on coordination the management of ecosystem resources.

There is poor coordination in the management of natural resources		Frequency	Percent	Valid Percent	Cumulative Percent
	Strongly Agree	160	39.5	39.5	39.5
	Agree	152	37.5	37.5	77.0
	Don't know	35	8.6	8.6	85.7
	Disagree	46	11.4	11.4	97.0
	Strongly disagree	12	3.0	3.0	100.0
	Total	405	100.0	100.0	

Source: (*Author, 2018*)

Responses indicate that 32% of households have not witnessed nor do they have knowledge these collaborative meetings while 26.7% have seen these meetings being held yearly (**table 7).**

Table 7. Household view on inter-sectoral ecosystem management meetings.

Frequency of inter-sectoral meetings	Frequency	Percent	Valid Percent	Cumulative Percent
Weekly	6	1.5	1.5	1.5
Monthly	43	10.6	10.6	12.1
Bi-monthly	11	2.7	2.7	14.8
Quarterly	107	26.4	26.4	41.2
Yearly	108	26.7	26.7	67.9
Never	130	32.1	32.1	100.0
Total	405	100.0	100.0	

Source: (*Author, 2015*)

A major pre-requisite for effective utilization of ecosystem-based adaptation to climate change is the presence of inter-agency collaborative management of the natural environment. Mt. Elgon ecosystem is not a homogenous landscape. It is made up of at least four discrete eco-climatic zones that support different plant and animal communities [11]. The situation calls for a management arrangement that reflect the ecological diversity and inter-connectedness of ecosystem processes. Contrary to this expectation, ecosystem restoration activities geared towards addressing ecosystem restoration, resource management and conservation in the Mt. Elgon ecosystem often take a sectoral approach. This is often associated with to an old age common practice in government in which departments are used to working sectorally while enjoying the benefits of selective mandate. In this kind of setup, the departments lobby and direct much effort to oppose any move towards holism and collaborative management. Under this arrangement, ecosystem restoration activities and natural resource management are often characterized by sector fragmentation with a number of government departments managing specific resources which focuses on specific uses.

There are consequences of fragmentation that may affect the ecosystem health of Mt. Elgon and by extension EbA. Mhlanga et al [12] observes that sectoral fragmentation of conservation efforts in a homogenous ecosystem can lead to some negative outcomes such as; lack of continuity caused by almost constant programmatic and structural change, loss of public confidence in both the processes of governance and government; and the rapid shift of natural resource management policies to community-based programs without adequate funding and other support. Mt. Elgon ecosystem risks the same consequences should this challenge of sectoral fragmentation fail to be addressed.

3.3. Duplication of conservation efforts

Fragmented management of strategic activities by different actors in one ecosystem is contributing significantly to ecosystem degradation. This poses a threat of interfering with institutional frameworks. There are possibilities of weak enforcement of polices and legislation at all levels of governance, right from the ecosystem to the national level. Morrison et al [13] notes that governments regularly restructure departments in the natural resource management and environmental arena, sometimes for the purpose of improved policy integration, but most frequently to meet ministerial and bureaucratic aspirations. He further observes that fragmentation of policies and their implementation seriously diminishes the overall effectiveness of natural resource management programs.

A major recommendation given in his study is the adoption of an integrated ecosystem management system which requires active but sustained involvement of all resource users and stakeholders on how the available financial and human resources are allocated and utilized. Conflicts mitigation is crucial too in order to encourage long-term supply of ecosystem goods and services for improved livelihoods.

Diversity of statutory instruments in the Mt. Elgon can make the management of an ecosystem's resources very effective if properly coordinated. Such coordination can create synergies between and among various government departments which is necessary for sustainable production and utilization of ecosystem goods and services hence cushioning against the effects of climate change.

3.4. Natural resource governance challenges

Findings show that 73.2% of government and civil society respondents report that there exist inter-sectoral policy inconsistencies

(**table 8)** and incoherencies as regards the management of Mt. Elgon ecosystem natural resources whereas a paltry 26.8% have not noticed any policy inconsistencies.

Table 8. Presence of inter-agency policy inconsistencies.

Presence of inter-sectoral conflicts	Frequency	Percent	Valid Percent	Cumulative Percent
Yes	30	73.2	73.2	73.2
No	11	26.8	26.8	100.0
Total	41	100.0	100.0	

Mt. Elgon Ecosystem offers a range of benefits and opportunities for local and national economic development, improved livelihoods and provision of environmental goods and services. This call for a good environmental policy that ensure that there is harmonized and integrated approach towards the management of natural resources to ensure that there is sustainable provision of goods and services to beneficiaries. In this manner there will be reduced vulnerability to effects of climate change by ecosystem goods and service dependent communities. Management of renewable natural resources in Mt. Elgon as separate entities becomes difficult because of the complexity of their interlinked social and ecological components.

The observed policy inconsistencies in managing natural resources found in the same ecosystem is a major factor that could determine the health of this ecosystem and its sustainable supply of livelihood goods and services. A good ecosystem plan and management policy should aim at maintaining an ecosystem in a healthy, productive and resilient condition so that it can meet human needs into the future [14]. The plan should embrace an all-inclusive approach to management that considers the entire ecosystem, including the various stakeholders.

Co-management, where management responsibility is shared between government and resource-users, may improve the suitability and perceived legitimacy of management rules when there is policy coherence. However, despite the potential for such arrangements to improve the resilience of natural resource systems, how co-management works in the face of the glaring policy inconsistencies remains poorly understood [14].

4. Conclusion and Recommendations

Conclusion

The study area is characterized by a specialty economy dominated by maize farming. The fact that it is basically supported by rain-fed agriculture, this specialty agricultural practice exposes the community to climate change impacts. Since the prevailing climate still favors agriculture, residents should be encouraged to adopt mixed farming which caters for both crop and livestock farming. This, coupled with complete value chains, will lead to diversified income sources.

For effective utilization of EbA, the decentralized governance system must make deliberate effort to enhance the ecosystem health of Mt Elgon through sustainable management, conservation and restoration of natural and agro-ecosystems, taking into account anticipated climate change impact trends to reduce the vulnerability and improve the resilience of ecosystems and people to climate change impacts.

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