

Water Tower Ecosystems Services and Diversification of Livelihood Activities to Neighbouring Communities; A Case Study of Chyulu Hills Water Tower in Kenya

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Authors' contributions

This work was carried out in collaboration between all authors. Authors TIK and JKK designed the study, collected data, performed the statistical analysis and wrote the protocol. Author MRM managed the literature searches, final analysis and manuscript preparation. All authors read and approved the final manuscript.

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ABSTRACT

The study was commissioned by the Kenya Water Towers Agency (KWTA) to provide information that would guide the agency in achieving one of its key strategic objectives of providing community livelihood support for sustainable management of water towers. The focus of the study was to provide information on how the neighbouring community benefits from Chyulu hills water tower and also provide suggestions of the community on livelihood activities that can be undertaken to ease pressure on the hills. The study was done at Chyulu hills water tower and the neighbouring community.

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Questionnaires, key informant interviews, field observations, photography and Focus Group Discussions (FGD) data collection methods were used to collect data. Focused group discussions with representatives of 10 key stakeholders involved in Chyulu hills conservation and interviews through structured questionnaires to 12 randomly selected community members residing within 10 Km from the boundary of the water tower were undertaken. Resident's mainly apportioned their land for crop; livestock farming or both but had no land ownership documents. The main three livelihood options were livestock keeping, crop farming and poultry rearing while main crop preferences were green grams, maize and cowpeas farming. Main benefits from the forest were medicinal herbs, rain, grazing and recreation facilities. The main development options were provision of water, bee keeping, goat farming, poultry rearing, capacity building, dairy & fish farming and tree farming in the order which they are listed. A development action plan was recommended to ease pressure and prevent destruction of the water tower. Those who benefit from the water tower could contribute towards the community development actions. The information gathered gives insights into ways of protecting water towers in Kenya and elsewhere in the world.

Keywords: Chyulu hills; water tower; action plan; livestock; crop; poultry.

1. INTRODUCTION

Regionally, forests have immense value, and are essential for economic development, biodiversity conservation and equitable growth in the region [1]. The forest cover of 6.99% of the land area of Kenya is still below the Kenyan constitutional requirement of 10% [2]. Forests play critical ecological, social, cultural, and economic functions. They contribute directly and indirectly to the national and local economies through revenue generation and wealth creation, and it is estimated that forestry contributes to 3.6% of Kenya's GDP, excluding charcoal and direct subsistence uses. Forests also support most productive and service sectors in Kenya, particularly agriculture, fisheries, livestock, energy, wildlife, water, tourism, trade and industry that contributes 33% to 39% of the country's GDP. They also contribute about 80% of all energy used in the country [2].

Forests comprise the country's water towers and catchments, where over 75% of the country's renewable surface water originate, and therefore serve critical water regulation roles which are important for human livelihoods, irrigated agriculture, and production of hydro electric power. The forestry services provided by the water towers include local climate regulation, water regulation, water purification and waste treatment. Other services provided include erosion control, natural hazard and disease regulation. Forest adjacent communities benefit directly through subsistence utilization of the forests [2].

Locally, those people living around the edges of the forests (e.g. Chyulu hills), use the forests as

source of firewood, other wood products, medicinal purposes, honey, for hunting, and for livestock grazing. Some of these uses are destructive while others are not [3].

Chyulu hills have been in the limelight due to invasion of the area by squatters because of the resources found in the forest. This is in spite of its importance as a watershed area for many communities in the South Eastern region of Kenya. The hills act as a water tower and play a great role in the provision of water to livestock, wildlife as well as Kenyans in places as far as the Kenyan coast [4,5,6].

Kenya's vision 2030 targets to increase forest cover to 10% by 2030 [7]. One of the projects initiated to achieve this goal is the rehabilitation and protection of indigenous forests in five main water towers namely; Aberdares ranges, Chelangany hills, Mau escarpment, Mt. Elgon, Mt. Kenya and other small significant water towers and catchment areas [8]. Rehabilitation of Kenya's water towers by the Kenya government is further evidenced by resettlement of squatters away from water towers like the Mau and Chyulu hills [9].

GOK (2013) national climate change action plan recommends that rehabilitation of water towers be accomplished through joint management in collaboration with communities living near the forests and other stakeholders. The GOK has also established the Kenya Water Towers Agency [10] that commissioned this study to provide information that would guide the agency in achieving one of its key strategic objectives of

providing community livelihood support for sustainable management of water towers.

Several other partners like the African Wildlife Foundation, David Sheldrick Trust, Wildlife Works and Chyulu hills Conservation Trust are also working towards conservation of Chyulu hills ecosystem; Chyulu hills Conservation Trust has been implementing “The Chyulu hills REDD+ (Reducing Emissions from Deforestation and Degradation) Project” that aims to prevent the emission of 28,122,572 t CO₂e over the project’s 30 year crediting period by stopping deforestation, forest degradation and grassland conversion. This will be achieved largely by enhancing and strengthening landscape protection, improving livestock management practices, employing forest rangers, bolstering employee motivation, creating alternative income, jobs and employment opportunities and supporting stricter environmental law enforcement. Furthermore, it aspires to restore degraded forest and grassland areas, which will increase the quantity of sequestered carbon from woody biomass and soil. The establishment of tree nurseries, reforestation programs and other afforestation / reforestation efforts are examples of some initiatives that will be undertaken [11]. David Sheldrick Trust rescues injured wildlife [12,13] while Wildlife Works pioneers in the use of REDD+ carbon credits (VERs) to finance large scale tropical forest conservation [14].

The unplanned human settlement in Chyulu hills continues to exert pressure on the ecosystem; examples include rising cases of human wildlife conflict, damage to crops, destruction of property, poisoning and spearing of wildlife [5]. In her research papers, [15] has discussed the importance of capacity building and provision of alternative livelihoods and targeted efforts for conservation in Chyulu hills. To date other than the Chyulu hills Redd+ Carbon Project and Mbirikani Carbon Credit project no targeted conservation efforts have been mounted [16,17].

The study objective was to provide information on the Chyulu hills water tower ecosystems services and diversification of livelihood activities to Chyulu hills community to ease pressure on the ecosystem and thereby protect the water tower. Specific objectives included sizes of land owned and their utilization, community livelihood support activities, community crop preferences, types of community benefits from Chyulu hills and community suggested action problems and solutions.

2. METHODOLOGY

2.1 Study Area Map

The Chyulu Hills located at 37° 52.62' East 2° 39.24' South, is a vast montane forest – savanna grassland ecosystem found in South eastern Kenya (Fig. 1).

The Chyulu Hills Water Tower area is situated on the semi-arid and arid zones. The prevailing climatic condition in the eastern part of Chyulu Hills is of the savanna type with two dry seasons. The western side of the Chyulu Hills is made up of semi-arid and the arid zones. The hills have no rivers but rainfall on the hills feeds rivers Tsavo, Galana and Mzima springs [18]. During this investigation the vegetation was noted to be dramatically regenerating. Chyulu hills are home to many mammals, birds and plant species [19,20,21]. The population on the Eastern side is mainly Kamba tribe while on the Western side are the Maasai tribe (Maasai Group Ranches) [22]. There were a total of 71 households just outside (5 Km) the water tower with a total of 87 persons consisting of 76 males and 11 females. The hills cover an estimated area of 775.8 Sq. Km with a population density is 0.11 per sq Km. The hills are covered by montane forest and are surrounded by grassland with thickets (Fig. 2) [23]. Rainfall occurs in bimodal pattern annually.

The soils of the Chyulu hills are of volcanic origin’ during this study, methodologies similar to those used on Arabuko sokoke were used [24,25]. Chyulu hills are a protected area and no crop farming goes on within the area as it is illegal.

2.2 Data Collection and Analysis

The sampling population was 87 persons from 71 households. Sample size was 12 households which were randomly selected mainly from the eastern side comprising the Kamba community. No sampling was done on the western side comprising the Maasai community due to their migratory tendencies in search of pasture and logistical challenges.

Sources of data during this study were from primary data obtained through interviews, photographs and focussed group discussions including two categories of key stakeholders. Secondary data was obtained through literature search. Key stakeholders include all individuals

or organisations that play a greater role in conservation of Chyulu hills.

- 12 respondents randomly selected from Chyulu hills water towers and at a radius of at most 6 Km from the boundary of the hills. The above group of stakeholders were interviewed through structured questionnaires to provide data and suggestions on: Community based income generating activities, community and Chyulu hills interactions, livestock production systems, preferred livestock and suggestions for community development action plan, problems facing livestock production and possible interventions, crops and crop preferences, problems facing crop production including markets, community development action priorities and enterprises, capacity building and land resources owned.
- Another group of stakeholders provided information through a focused group discussion on: Insights/challenges the Chyulu hills Tower Ecosystem faces due to pressure by the human population, suggestions about possible interventions to safeguard Chyulu hills water towers'

ecosystem. Agricultural and Veterinary offices provided information on agricultural and livestock related activities taking place in the area. They also suggested community development actions that could be started/ strengthened. Their representation is shown in Table 1.

Table 1. Key stakeholders who participated in the focused group discussion

S/No	Stakeholder name	Number of participants
1	Kenya water towers agency	4
2	Kenya forest service	3
3	Kenya wildlife service	1
4	Water resources management authority	4
5	Chiefs	2
6	Sub county commissioner	1
7	Government agricultural officers	2
8	Government veterinary officer	1
9	Forest guards	2
10	Community based organisations	2

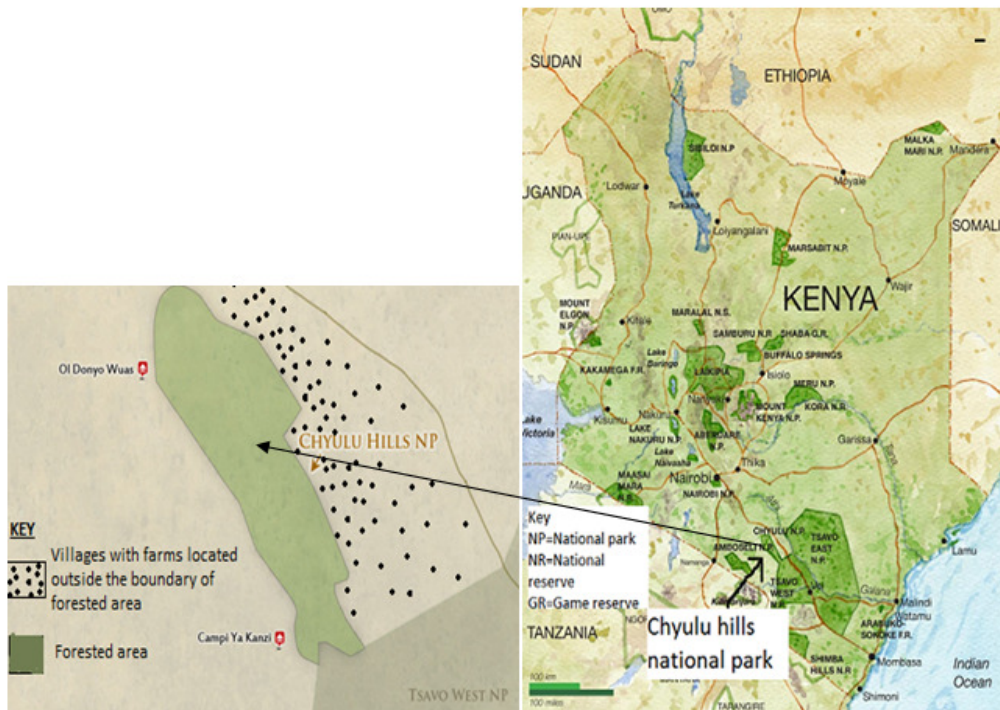


Fig. 1. Map of Kenya showing Chyulu Hills National Park



Fig. 2. Part of the Chyulu hills Water Tower. Forested area can be seen at the top of the hills

The data collected was cleaned and analyzed using simple descriptive statistics. The data is presented in form of bar graphs and tables.

3. RESULTS AND DISCUSSION

3.1 Land Sizes Owned and Their Utilisation

12 key respondents interviewed resided within 0 – 3 Km from the boundary of the Chyulu hills water tower. The land holding for each resident was apportioned for livestock keeping and crop production (Fig. 3).

6 respondents (50%) apportioned all the land for crop farming though they had livestock; 3 respondents (25%) apportioned the land equally for both livestock keeping and crop production. 1 respondent (8.33%) apportioned more land for

crops while 2 (16.7%) apportioned more land for livestock farming. All respondents had no land ownership documents for their parcels of land. According to Luca Alinovi et al. [26] classification, the study area falls under small holder farmer's categories who are also the majority farmers in Kenya. Muui et al. [27] Indicates that over 50% of farmers in eastern Kenya own less than 2 hectares of land. AGRA [28] also points out that most of agriculture in sub-Saharan Africa comprises of crops and livestock farming.

3.2 Livelihood Support Characteristics

All the 12 respondents (100%) were engaging in livestock keeping, crop and poultry farming. Out of the 6 respondents (50%) who were employed, 2 were permanent while the other 4 were casuals. Only 1 farmer (8.33%) practiced; bee keeping, dairy farming, fruit farming, or horticulture (Fig. 4). All livestock and poultry kept were of indigenous type. They were kept under free range production system because it was cheap and depended on family labour. Farming was for subsistence and where possible some cash income.

The Kenya land alliance [2], Indicates that farmer's view land as a property to be owned and a source of livelihood. Land uses include crop and livestock farming as found in the study area. Other uses of land could include conservation of indigenous forests, wildlife sanctuaries, water catchments, marine life, monuments, cultural sites, urbanization and mining.

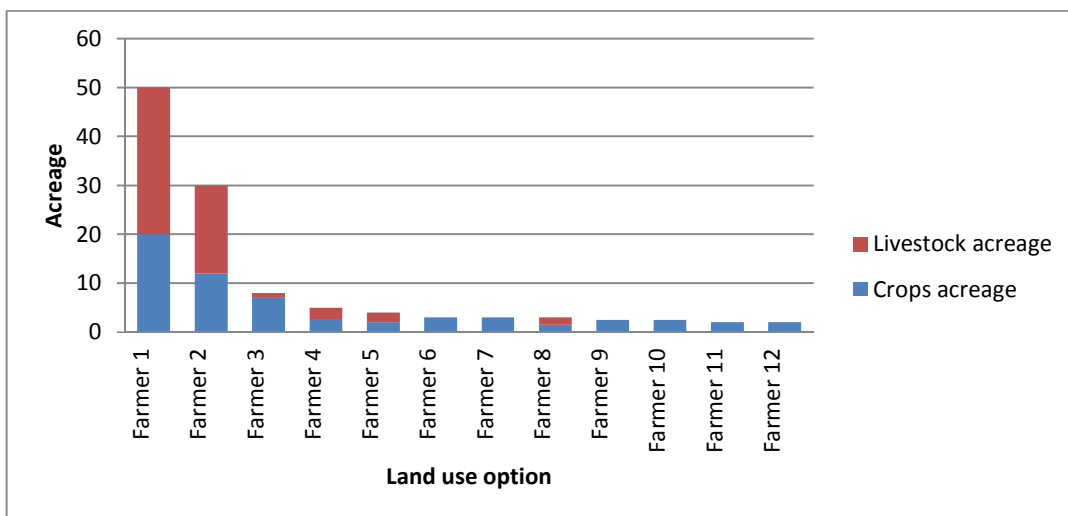


Fig. 3. Land size and utilization by community members in Chyulu Hills area

3.3 Crop Production Preferences

Out of the 12 respondents; 10 respondents each (83.3%) engaged in green grams, maize and cowpeas farming, 6 respondents each (50%) engaged in pigeon pea and dolichos beans production, 5 respondents (41.7%) engaged in beans farming, 4 respondents (33.3%) engaged in sorghum/millet production while 2 respondents each (16.7%), engaged in fruit, horticulture, and cassava production (Fig. 5). These crops were planted outside the boundaries of the forest and hence could not interfere with its conservation, however conservation efforts could be affected if human encroachment occurs.

The crops listed were grown because climatic conditions were favourable. Green grams were most preferred as a source of cash income, the rest were grown for subsistence purposes. Cash income from the crops was negligible except from green grams. Introduction of horticultural crops, cassava, sorghum and millet farming was suggested. Muui et al. [27] indicates that in eastern Kenya where the study area is found, farmers practice mixed farming system by intercropping sorghum, cowpeas, maize, green grams, pigeon peas, finger and pearl millet, beans, and dolichos. The author also indicates that most of these crops are for subsistence purposes.

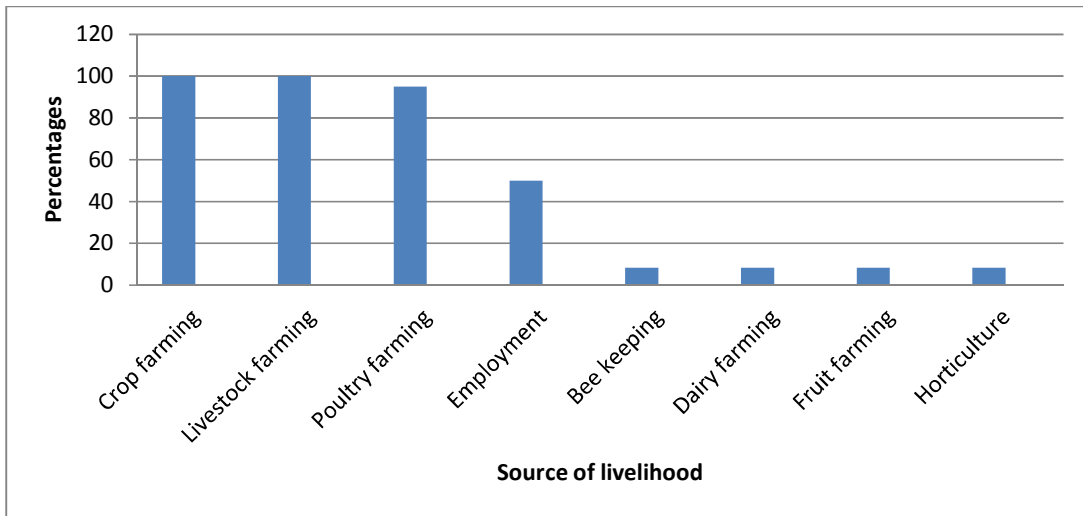


Fig. 4. Existing Chyulu hills Community Livelihood support enterprises

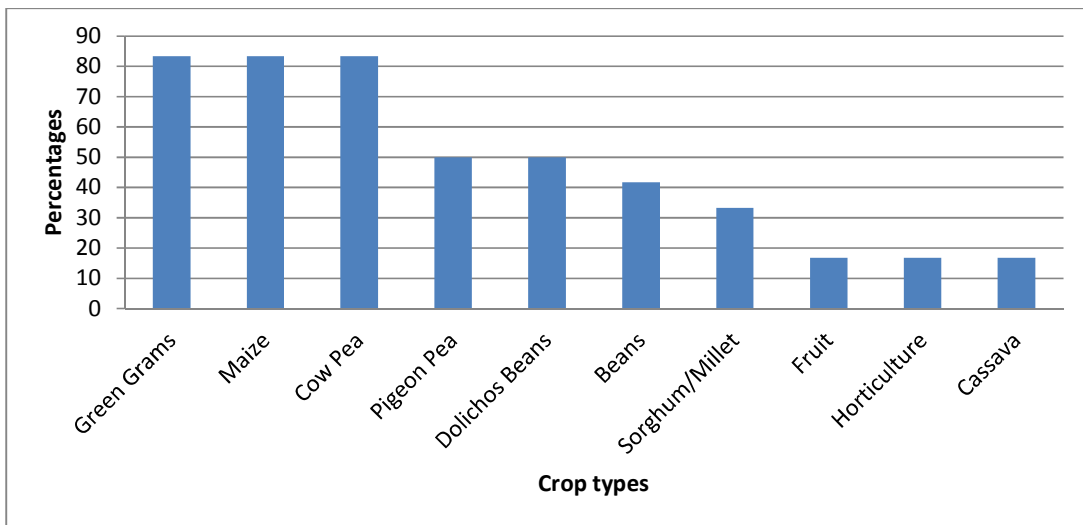


Fig. 5. Crops Planted by Chyulu Hills Community Members

3.4 Community and Chyulu Hills Interactions

Of interest was to learn how the Chyulu hills water tower interacted with the community particularly those who were within 10 Km from the boundary of the water tower (Fig. 6). All the respondents (12) interviewed had benefited from the water tower through collection of medicinal herbs and rainfall. 8 respondents (67%) benefited by grazing their animals. 3 (25%) benefitted through collection of firewood. 2 respondents (16.7%) used the hills for recreation purposes while 1 respondent (8.3%) benefitted through collection of construction stones and soil respectively.

About 64% grazed livestock and used the water tower for recreation, while 22% collected firewood. Apart from the benefits of rainfall and recreation, all other benefits like collection of medicinal herbs, construction stones, firewood, soil and grazing negatively affect conservation efforts as they aid in biodiversity destruction. Grazing and firewood collection negatively affects rainfall amounts and availability of medicinal herbs from Chyulu hills.

Similar findings were reported by David Sheldrick Wildlife Trust [29]. The respondents were aware that the water tower is a restricted area. The East African Wildlife Society [30] Indicates that local people can derive many benefits from such

forested areas including water, firewood and traditional medicine. UNEP [31] adds that water towers in Kenya provide economic resilience to local communities. Fuelwood and charcoal represent an important energy source for the population. These water towers also create both formal and informal job opportunities, especially in rural areas in addition to providing goods for consumption by households. Other benefits from water towers include storing rainwater, regulating river flows and preventing runoff (KEFRI) [32]. These landscapes also recharge ground-water aquifers, improve soil fertility, and reduce soil erosion and sediment loads in river water. They further regulate local climatic conditions for commercial agriculture, energy generation and act as carbon reservoirs and sinks (KEFRI) [32].

3.5 Diversification of Livelihood Activities as an Intervention to Protecting Water Towers

Information was obtained on community development action preferences as stated by stakeholders living within 3 Km of the Chyulu hills water tower (Fig. 7). Of the crops grown, only green gram were singled out for Community Development action. The community was of the view that Green gram farming is a viable option that could be further developed via provision of quality seeds, fertilizers, value addition and capacity building.

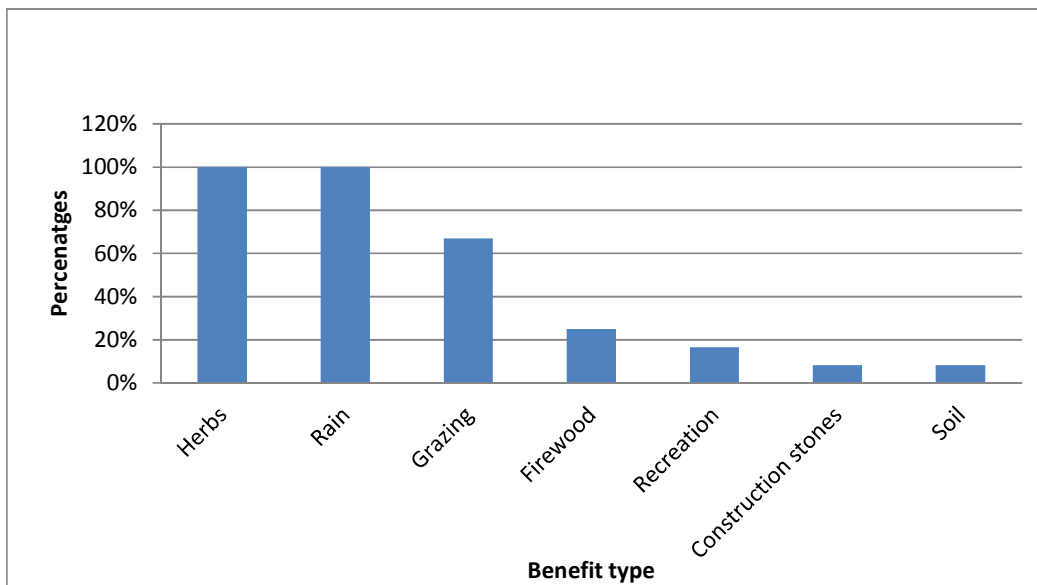


Fig. 6. Community benefits from Chyulu hills ecosystem

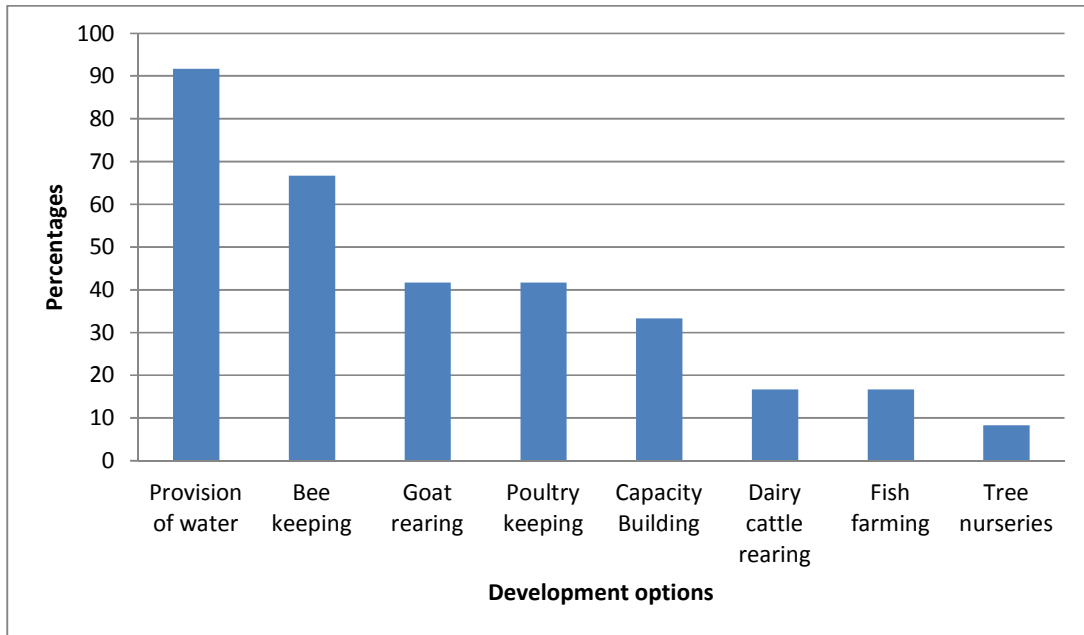


Fig. 7. Suggested livelihood activities by Chyulu Hills Community Members

About 11 respondents (92%) living within 3 Km of the Chyulu hills water tower indicated that provision of water was their number one priority. In order of preference, other community development options recommended were; bee keeping (66.7%), goat rearing (41.7%), poultry keeping (41.7%), dairy cattle rearing (16.7%), fish farming (16.7%) and establishment of tree nurseries (8.3%). Development of market linkage for each of the community development options was also emphasized. Keeping of improved goats, cattle and poultry was recommended. For the community development options to succeed 33.3% of the respondents requested for capacity building.

During the focused group discussions, other important issues raised were occurrences of forest fires, logging (wood carving), charcoal burning, poaching and human wildlife conflict. There was agreement that ongoing electric fencing of the water tower should continue. Also, an alternative source of wood for carving and medicinal plants be sought and residents should be compensated when their property/crops are damaged by wildlife. [29] notes the importance of scientific data in management of Kenyan water towers. [2] also notes that communities around Chyulu hills need capacity building on implementing home grown projects that are compatible with wildlife conservation, some of these projects include establishing of tree

nurseries and tree planting to reduce deforestation of Chyulu hills, ecotourism, poultry rearing, bee keeping and wood carving using fast growing wood species as opposed to hard wood.

The implication of these study findings is to improve conservation of Chyulu hills ecosystem. Also, there will be reduced community members benefits from the ecosystem. However, this will be compensated by gains realized after implementation of alternative livelihood options in the action plan.

3.6 Action Plans

Problems, weaknesses, opportunities and possible interventions that will facilitate in protection of the Chyulu hills ecosystem are summarized in Tables 2 and 3. These action plans were expected to bring more satisfactory results in Chyulu hills conservation because there is community ownership/ consultation.

3.6.1 Agriculture (crop farming and intergrated water resources management)

Due to low incomes from agricultural activities there were high poverty levels and the community was forced to raid Chyulu hills forest in search of supplementary livelihood support like charcoal burning. Table 2 summarizes the problems and weaknesses in the crop production

Table 2. Weaknesses in Agriculture (water harvesting and crop farming), opportunities and solutions)

Problem/weakness	Opportunity/Solutions
Lack of water	Development of water sources e.g. roof/rock/run-off harvesting, construction of earth water pans, earth dams and boreholes, capacity building in integrated water resources management
Lack of small scale gardens	Development of irrigation systems for small home gardens/vegetable gardens; sack gardens, small drip irrigation systems and/or green houses.
Unsuitable land use systems	Terracing for water harvesting, use of manure, compost preparation and application, conservation agricultural practices- zero tillage, farm agro-forestry practices,
Low quality and expensive seed varieties	Train residents to develop/select home grown seeds and plant at appropriate times, subsidize quality certified seeds, encourage residents to plant drought tolerant crops like sorghum, millet and cassava cow peas, pigeon peas, dolichos beans and green grams. Support seed agribusiness.
Unavailability of fertilizer	Train residents on the use of manure, preparation of compost manure, adopt farm agro-forestry.
Expensive fertilizers	Avail subsidized fertilizers
Pest management	Search for natural methods of pesticide control and affordable pesticides. Train residents on the safe and correct use of pesticides, and post harvest technology
Lack of organized markets	Identify and link farmers to markets, facilitate access to market information, value addition, train on business skills
Lack of farm agro-forestry, deforestation	Train residents on development and care of tree nurseries and trees. Thinning of trees for firewood instead of cutting. Planting of fodder trees, Development of medicinal herb/tree home gardens

Table 3. Weaknesses in livestock farming, opportunities and solutions

Problem/weakness	Opportunity/solution
Bee keeping not taken up	Environmental conditions are suitable for native bee keeping. An excellent opportunity for income generation. Provide initial bee hives and capacity build community.
Lack of improved goat rearing	Improve goats to produce more milk and more meat. Provide Gala and Dairy goat bucks. Capacity build community about health care and husbandry of improved goats
Lack of sheep rearing	Sheep has the potential to contribute to house hold incomes and nutrition security but are not kept in Chyulu hills. Introduce Dairy sheep rearing, change traditional believes about sheep through community engagement. Capacity building community on animal health and husbandry.
Dairy cattle rearing rare	Improve indigenous cows to produce more milk. Assist community with subsidized Artificial Insemination services. Train farmers on the care of Dairy Animals: their health and husbandry. Establish a system of animal health care. Capacity building the community.
Poultry farming poorly developed	Assist in the improvement of indigenous chicken kept by provision of high grade indigenous cocks. Assist in the introduction of intensive rearing of indigenous and exotic chicken. Training/capacity building in poultry feeding and health will be important.
Fish farming not developed	Assuming development of water sources is done fish farming could be introduced where farmers are interested. Assistance will be required in the establishment of fish ponds. Training in fish farming, fish health and feeding will be needed. Community engagement will be necessary to break barriers in the eating of fish.
Lack of markets/poor marketing	The livestock markets available are far away from Chyulu hills and not easily accessible. Access to market information is not available. The farmers depend on middlemen who offer very low prices for the livestock. Livestock markets that are easily accessible need to be developed. A slaughter house for meat for sale out of the county needs to be developed.

sector and opportunities identified during the Participatory Rural Appraisals. Also summarized are solutions proposed during the PRAs.

Farmers through guidance by trainer should be given hands on training of various aspects of on-

farm activities as detailed in Table 2. Demonstrations should be held in nearby agriculture station or a selected farm belonging to one of the farmers. Agricultural officers deployed by the Government in the area are useful in information dissemination.

3.6.2 Livestock production systems

Free range livestock keeping (cattle and goats) is an important livelihood support activity in Chyulu hills. It was found that some livestock farmers did not allocate any of their land for livestock pasture. These farmers depended on the Chyulu hills water tower for pasture. Table 3 summarizes the problems/weaknesses; opportunities and solutions that came out during the PRAs. The proposed development actions will go a long way in enabling the community to be self sustaining without destroying the Chyulu hills ecosystem.

Also, capacity building the community on feed conservation and preparation of affordable animal feeds was indicated, this should take place in the local veterinary/livestock offices and/or farm and in farms of selected farmers. Physical activities suggested were preparation of bee hives, application of dewormers, spraying for tick control, feed formulation, feed conservation techniques and animal housing. The proposed trainings and physical activities should be organized to take place in between the rainy seasons when farm activities are less. In spite of farmers requesting for introduction of exotic chicken, dairy goats, sheep and cattle this could eventually lead to loss of indigenous genetic resources like the loss of disease resistance capabilities present in indigenous chicken.

4. CONCLUSIONS AND RECOMMENDATIONS

Main livelihood sources were livestock, crop and poultry farming. The main crops grown were green grams, maize and cow peas. Main community benefits from Chyulu hills were medicinal herbs, rainfall, grazing and recreation facilities while main community development options were provision of water, bee keeping, poultry and goat rearing.

It was recommended that green grams should be promoted as a cash crop. Also, capacity building and demonstrations to farmers on various aspects of conservation agriculture, water resource management, agro forestry, animal health, proper feeding, value addition and access to markets. Demonstrations on various feed conservation and animal husbandry techniques were recommended. Other suggestions were development of dairy goat, cattle and indigenous chicken sectors for increased yield in addition to introduction of fish, sheep and bee farming in the area.

The information gathered gives insights into ways of protecting water towers in Kenya and elsewhere in the world. Ways should be sought of bringing on board all those who benefit from the water towers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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