2016

Report ASEC-dryland-Forests

By Aida Cuni Sanchez

CMEC, University of Copenhagen,

Copenhagen, Denmark

aidacuni@hotmail.com

Kenyan phone number: 0739472763

1. Introduction

Tropical montane forests are important ecosystems, because 1) they are rich in animal and plant species found nowhere else in the world, 2) they maintain a special micro-climate with higher rainfall and fog, and therefore water, than lower altitudes or deforested areas, 3) they provide several services (water, firewood, medicine) to surrounding communities, which often depend on them for their livelihoods. In northern Kenya, tropical montane forests are also important habitats for some endangered species, such as the African elephant and the Grevy's zebra (Ngene et al. 2009). Tropical montane forests, especially those found in drylands are known to be particularly sensitive to predicted changes in climate. Population growth and large infrastructure development projects are other challenges for these forests' conservation.

The project named *ASEC-dryland-forests*, focused on Mt Marsabit, Mt Kulal and Mt Nyiro in northern Kenya, aims at providing key scientific information that will help understand how these forests function, how local communities use them and what could be done to ensure their long-term existence. The first report made in August 2015 provided key scientific information on forest use by local communities; observed changes in forest cover and climate; water resources; and discussed the potential future of these forests. This second report provides extra insights gathered during the last year of the project.

2. Impacts of human use of tree species

In the previous report we highlighted how local communities obtained firewood, medicine, fruits and honey, poles, fodder and other things from the forests. Understanding how harvesting affects the plant species being harvested is of great importance for both conservation purposes and for local development planning. Therefore, we assessed the effects of harvesting several important tree species by assessing their density in the forest, regeneration and population structure (see methodology).

Results indicate that harvesting is not necessarily destructive for the tree species being collected. It depends on the characteristics of the species (if a tree can re-sprout), how often it is harvested (every dry season?) and how many uses it has (more uses, more likely to be overharvested). Intensive harvesting of ilkukut in Mt Nyiro (*Xymalos monospora*, used as fodder) does not negatively affect this tree as it is abundant, a few branches are cut and it re-sprouts. However, intensive harvesting of nteroni in Mt Marsabit (*Rinorea convallarioides*, used as fodder) kills many trees as they cannot re-sprout and they dry up. Intensive harvesting of ngeriei/ejerss in Mt Marsabit (*Olea africana*, many uses including firewood) also kills many trees as they dry up. Lack of regeneration was also found to be a problem for some trees such as loleontoi (*Olea capensis*) and malaan (*Prunus africana*). When large trees die (such as ngeriei/ejerss, loleontoi and malaan) their branches cannot longer collect water droplets from the mist and the whole forest dries, with terrible long-term consequences for these forests and the water they provide.

Recommendations: improved harvesting techniques for nteroni (such as cutting branches instead of the main stem) could be a solution. One option could be to fence parts of the forest to prevent cattle and wildlife from damaging e.g. ngeriei/ejerss and loleontoi seedlings. This is a cost-effective method (when elephants are not present). Seedlings could also be transplanted to help natural regeneration. Fodder grass, exotic fodder trees (such as *Sesbania* *sesban, Leucaena leucocephala, Chamacytisus palmensis, Calliandra calothyrsus*) or local species such as ngeriei/ejerss could also be cultivated to help reduce pressure on existing trees.

Fig. 1 Branches of lelei *Pavetta gardeniifolia* used for fodder in Mt Kulal, note how dry is the grassland on top of the mountain during the dry season (left photo); dead nteroni *Rinorea convallarioides* trees used for fodder in Mt Marsabit, note how many dead trees are there (right photo).

3. The importance of fog as source of water

Fog is an important source of water in these forests. We measured rainfall, fog and water dripping from trees in these forests for 15 months, and we collected water samples. Note that this part has not been completed yet as we are waiting for the results of the analysis of the water samples.

Fog contributes to about 1/3 and rainfall to 2/3 of the water entering these forests. For the year 2015, the Lodge received 700mm of rainfall and 350mm of fog. However, fog is very important in the dry months, especially in August (see following graph). Rainfall and fog change with altitude. In general, higher altitudes receive more rainfall and fog, but in Mt Marsabit, the most humid area is around the Lodge.

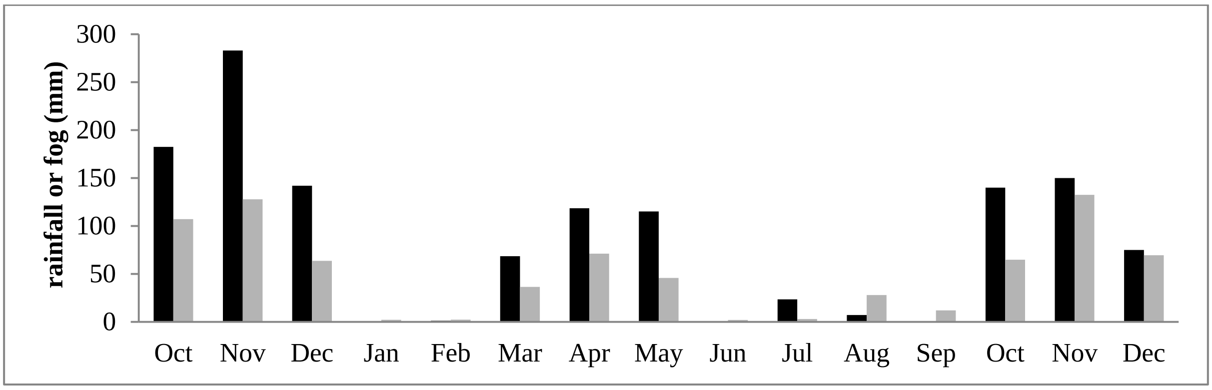


Fig. 2 Rainfall (black) and fog (grey) for the period October 2014 to December 2015 at the Lodge, Mt Marsabit.

If there are fewer trees (due to deforestation), then less fog is captured by the forest and therefore, less water enters the soil, with important consequences for the aquifers in the area. Different aquifers can be found around these mountains, and it seems that most boreholes are exploiting old aquifers not being replenished by current rainfall or fog trapping by trees.

Recommendations: without large trees, no fog is captured. If the forest is reduced in size or it is degraded, there might be some rain but fog will be significantly reduced. It is very important to maintain the size of the forest and particularly the large trees in the forest. See last section.

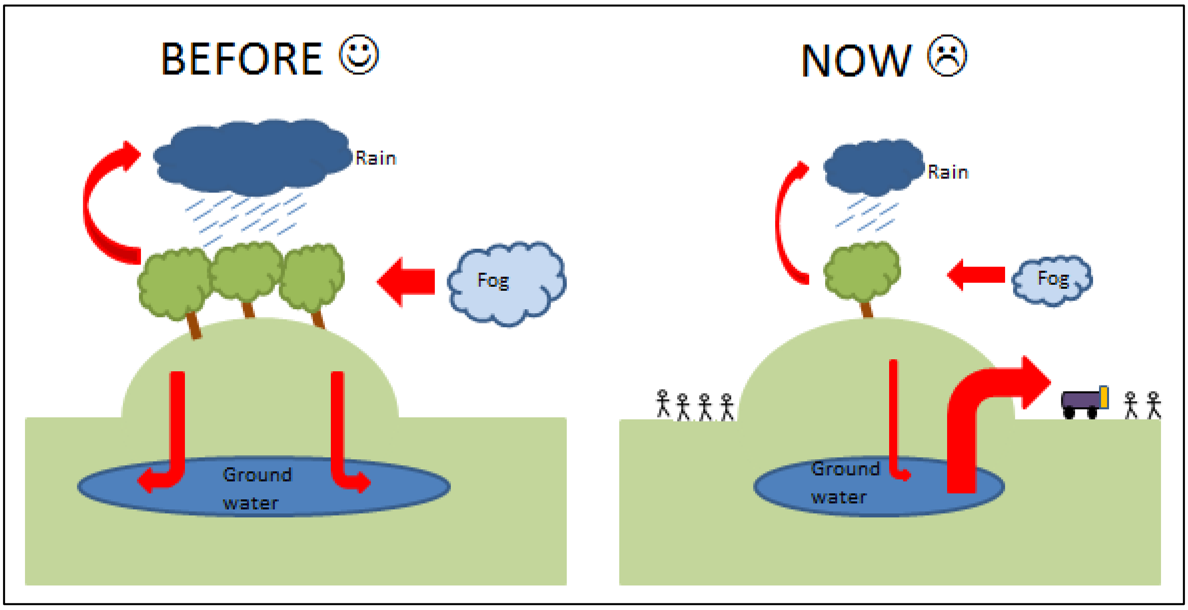


Fig. 3 The interactions between forest and rainfall and fog, and ground water in these mountains, simplistic view.

4. Adaptation to climatic changes

In the previous report we highlighted how important changes in climate were observed in these forests in the past three decades, mainly decreased rainfall and fog and increased temperatures. We discussed with local communities (focus-groups) how they had adapted to these changes in climate and what else could be done to help them in the future.

Two adaptive strategies were mentioned in most villages: shift to farming and camel herding. Diversifying livelihoods (casual labour or small business), migrating longer distances with herds, turning to the forest for fodder and growing fodder grass were mentioned in Mt Nyiro and Mt Marsabit, while reducing the number of herds and starting khat cultivation were mentioned in Mt Kulal and Mt Marsabit. In Mt Marsabit growing drought resistant crop varieties and using wild tubers as fodder were also mentioned.

The main challenges identified were lack of water for everyone to farm, especially in the lowlands where it needs to be piped from the mountain, and the high cost of acquiring a camel. Interestingly, villages in the lowlands highlighted their interest in farming, provided the government or NGOs could help them get piped water, '*we have already cleared and fenced land for it*' (participant comment in Sesiai, Mt Nyiro) and villages on top of Mt Kulal highlighted the need for NGOs to also help them acquire camels, '*we can keep them in the lowlands with our family members there, we are also very keen to exchange some cows for camels'* (participant comment in Lamugul, Mt Kulal). Apart from the abovementioned strategies, fodder trees could be sustainably harvested or cultivated, and fog could be trapped with the trees or with nets for irrigation (pers. Obs. in Hurri Hills 2015).

Recommendations: local communities have used a range of strategies to adapt to climatic changes, but external help is required e.g. to pipe water from highlands to increase irrigation in lowlands, or to acquire camels. More should be done towards a greater 'bottom-up approach' to adaptation, involving local communities from the very beginning of the process.

5. The potential of a Carbon Project

Large companies in rich countries can pay to conserve forests in the tropics so that they look good (even if they keep polluting the atmosphere, as the large trees they protect clean the atmosphere). This is what is called a Carbon Project. In order to determine if a Carbon Project could be established, we estimated the carbon that is kept in the trees of these forests by measuring the number of trees in a hectare; their diameter, height etc. (see methodology).

Forests at lower altitudes and those in windy areas (with short trees) had less carbon than more humid forests with very tall trees at mid altitudes. *Podocarpus* dominated forest (biribiriti and jilima forest) in Mt Nyiro had lots of carbon (> 300 Mg /ha). Overall, results indicate that the forests studied are good candidates for Carbon Projects (Table 1). Note that a Carbon Project can only sell the carbon of the part of the forest that would have been deforested without the project, so it is important to consider deforestation rates (one cannot sell all the carbon in the whole forest). We also determined that current use of trees (for fodder and firewood) does not affect the carbon stocks of the forests, so even if a Carbon Project is implemented, as long as only small trees are harvested, these activities could be continued.

Table 1. Information on forest surface, deforestation rates and carbon credits. Note that values are approximate and more work is needed.

		Values
Mt Marsabit	Total Forest Surface	12150 - 13356 ha
	Total Forest Carbon stocks	913680 - 938959 Mg C
	Note: deforestation rate period 1986-2014	32 ha / year
	Mean carbon stocks hectare	80 Mg C / ha
	Avoided deforestation in 30 years approx.	76800 Mg C
Mt Kulal	Total Forest Surface	2772-3470 ha
	Total Forest Carbon stocks	293158 - 340858 Mg C
	Note: deforestation rate period 1986-2014	28 ha / year
	Mean carbon stocks hectare	100 Mg C
	Avoided deforestation in 30 years approx.	84000 Mg C
Mt Nyiro	Total Forest Surface	6743 - 9225 ha
	Total Forest Carbon stocks	1507992- 1825351 Mg C
	Note: deforestation rate period 1986-2014	139 ha / year
	Mean carbon stocks hectare	220 Mg C
	Avoided deforestation in 30 years approx.	91400 Mg C

Recommendations: in order to establish a Carbon Project, professional assistance is needed as lots of paperwork is required and it takes time and money to organise it. Some NGOs help communities do that, e.g. The Northern Rangelands Trust. We think that this is an interesting option to help preserve these forests.

6. Local perceptions on forest change and future management

The findings from the first report were shared with local communities (focus-groups with village elders) and we discussed the potential future of these forests considering different management interventions.

Local inhabitants identified different reasons for the current situation on the conservation of these forests. In Mt Kulal and Mt Nyiro, local communities highlighted the lack of alternatives: fodder during drought events, water in the lowlands, etc. They identified several interventions which could help reduce pressure on the forests. For example, '*water could be piped from the mountain to the lowlands and we could grow crops and fodder grass for the dry season'*, '*we could plant some seedlings in the forest (enrichment planting)'* and '*we could establish a more restricted forest use regulation, but alternatives for forest users are first needed*' (participant comments in Mt Kulal and Mt Nyiro). In these two more isolated mountains, lack of incentives to protect the forest or the need of more forest guards was not mentioned in the discussions with village elders. Local communities highlighted that they are the ones protecting their forests through their customary laws. They emphasised the limited government presence in the area and the role NGO play in development projects ('*they act faster'*, participant comment).

The situation in Mt Marsabit was different. Lack of incentives to protect the forest ('*if you do not cut this tree someone else might do so*', participant comment) and the need for more forest guards and/or forest fencing were mentioned in most discussions with village elders. '*The problem is that there are too many people, too many cows and not enough water and fodder for everyone'*, participant comment. The conflict between ethnic groups was also mentioned e.g. '*they* [other ethnic group] *are the ones cutting the trees in the forest*', participant comment. Around Mt Marsabit local inhabitants mentioned the need of greater involvement of the communities [and the different ethnic groups] if the forest had to be preserved. Interestingly, in this mountain a rather fatalistic view was common among communities, with statements such as '*the forest will soon disappear*', '*our children will have to find another place to live*' and '*I wonder if it is too late to do something*' mentioned often.

7. General recommendations

The montane forests of northern Kenya provide vital water supply in the region. They also provide many services to surrounding communities which completely depend on them for their livelihoods, and there are home to several endemic and threatened species. Their uniqueness and relevance for both humans and biodiversity is outstanding and **their conservation should be a regional priority.** Particularly worrying is the possibility of reaching a point of no return, which would condemn these forests to their disappearance because of the existing feedbacks between forest, fog and local climate.

Conservation of these forests should focus on (i) promoting alternatives for surrounding communities, particularly fodder and firewood; and (ii) forest restoration. The option of a Carbon Project, which could help finance conservation, is also very interesting.

For more details on our ideas for a brighter future, see ANNEX 2 in our previous report, which discuss tree planting, alternative livelihoods, agroforestry, eco-tourism and improved management.

8. The importance of educating the next generation

Children are the citizens of tomorrow. It is very important to teach them from a young age about the importance of preserving their environment, and in particular, these forests. That is why we were involved in preparing teaching material and trying it in several schools in Mt Marsabit, in collaboration with NEMA. The materials are attached at the back of this report. We also prepared a short film to let the world now about these beautiful forests and their welcoming people. This short film can be found at https://vimeo.com/150996468. We are also preparing a longer one.

9. Methodology

Methods section 2: Permanent plots 100 x 20m were set up in different parts of these forests and all trees >10 cm diameter at breast height (dbh, 1.3 m) within these plots were measured. Diameter, tree height, tree species and signs of harvesting were recorded. Population structure was studied using size-class distributions (SCDs). Tree density, percentage of trees harvested per size class and percentage of harvesting at tree level were also calculated. For more information see Cuni-Sanchez et al. (submitted).

Methods section 3: Measurements reported here were made for 15 months at the Lodge site (1500m), in Mt Marsabit. We recorded rainfall (automatic rain gauge), fog occurrence (wire harp connected to a tipping bucket mechanism), throughfall (using 30 1l. plastic containers located under the trees manually sampled once per day) and incoming solar radiation and temperature, wind speed and direction (using a an automated Weatherhawk 232 Signature Series weather station installed at c. 2m at the same location, provided by WRMA). Rainfall and fog data was corrected for wind speed and direction. Measurements were also made at 4 more locations at Mt Marsabit and 4 locations in Mt Kulal using a similar approach. The analysis of the data gathered on this section has not been completed yet.

Methods section 4: Focus-group discussions were organised in twelve permanent villages located around each mountain studied. Each focus-group involved 5-10 male elders including the village chief, as it is a custom in the area. Focus-group discussions were organised in same villages one year ago. Informal discussions centred on how they had adapted to the observed changes in climate and what else could be done to help them in the future. For more information see Cuni-Sanchez et al. (submitted).

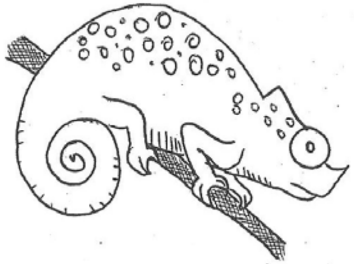
Methods section 5: Permanent plots 100 x 20m were set up in different parts of these forests and all trees >10 cm diameter at breast height (dbh, 1.3 m) within these plots were measured. In each mountain, plots were established within three distinct forest types (dry, mixed species and elfin). Diameter, tree height, tree species and signs of harvesting were recorded. All plant species mentioned were collected for identification and verification of their local name at the Herbarium of University of Nairobi and using Beentje (1994). We calculated above ground biomass (AGB) using Chave et al. (2014) allometric equation and a carbon fraction of 0.47. Soil carbon stocks were not included in this study. We applied a relatively simplistic but effective approach to upscale plot level carbon estimates to the landscape level using freely-available Landsat 8 images of February 2014 classified using geo-referenced field observations of forest types. Plot-level carbon estimates of these different forest types were multiplied for each forest type surface. Deforestation rates were calculated by comparing Landsat 1984 and 2014. For more information see Cuni-Sanchez et al. (submitted).

Methods section 6: same as section 4.

ANNEX 1

Leaflets used in primary schools to promote the conservation of these forests, see that the main species change for Mt Marsbait, Mt Kulal and Mt Nyiro (3 leaflets).

Cloud forests in the desert



Cloud forests are forests on top of mountains that have lots of fog. They are important because they have animals and plants found nowhere else in the world, such as the Mt Marsabit chameleon called *Trioceros marsabitensis* and the tree Nteroni (*Rinorea convallarioides*).

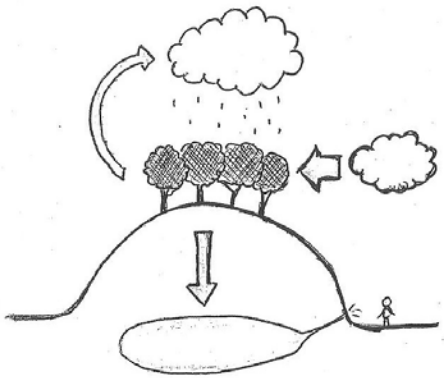
They also have endangered animals such as: E_ _ _ _ _ _ _, GREVY'S Z_ _ _ _ and ____________.

They provide lots of things to the people leaving near the forests such as: F_ _ _ _ _ _ _, M_ _ _ _ _ _ _, H_ _ _ _ and __________________.

They also provide lots of W_ _ _ _, because the trees attack rains and also the branches of the trees collect drops from the fog, making the area cold and humid.

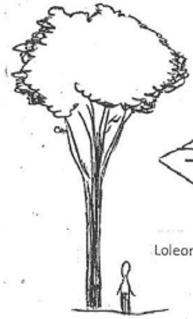
However, when many trees are cut, the area becomes drier and tree seeds can no longer germinate and grow and the forest can disappear!

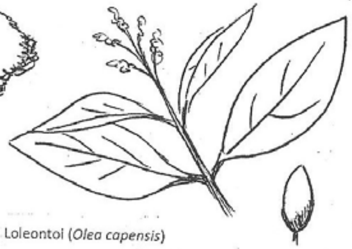
Look at how it works (you can colour it):



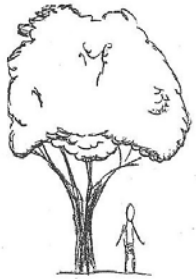
Important fodder trees

People cut trees for firewood and poles to make houses. But they also cut trees to feed their goats and cows during the dry season. The best trees for fodder in Marsabit are:





Loleontol (*Olea capensis*)

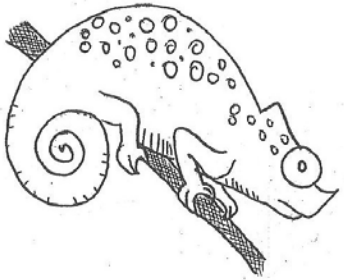


Lelei or Muhudima (*Drypetes gerrardii*)

Nteroni (*Rinorea convallarioides*)

Note that Nteroni is only found in Mt Marsabit! To protect the forest, it is better to cut some branches of the trees to feed the animals and not fall the whole tree! Otherwise the forest can disappear, and with it the rains and fog, and the water!

Cloud forests in the desert



Cloud forests are forests on top of mountains that have lots of fog. They are important because they have animals and plants found nowhere else in the world, such as the Mt Kulal chameleon called *Trioceros narraioca*.

They also have endangered animals such as:

E_______, GREVY'S Z____ and ____________.

They provide lots of things to the people leaving near the forests such as: F_______, M_______, H____ and __________________.

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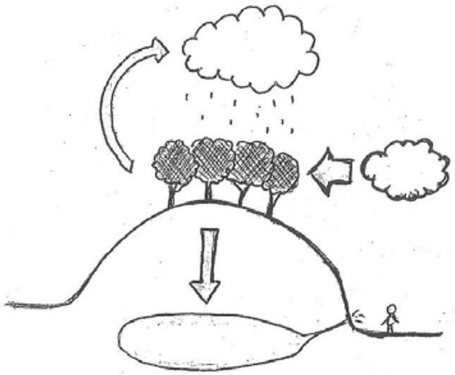
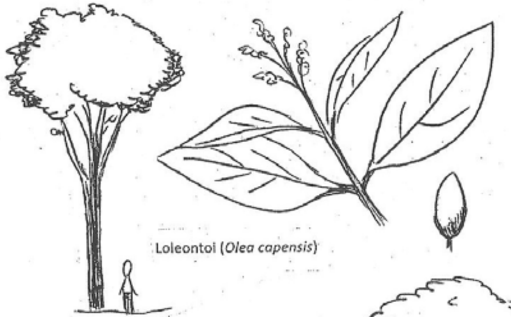
Look at how it works (you can colour it):



Important fodder trees

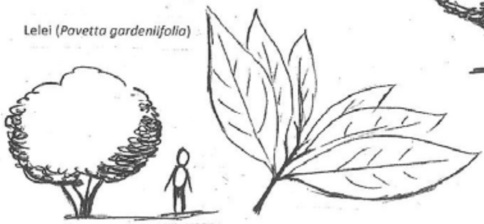
People cut trees for firewood and poles to make houses. But they also cut trees to feed their goats and cows during the dry season. The best trees for fodder in Kulal are:



Loleontol (*Olea capensis*)

Sagumai (*Maytenus heterophylla*)

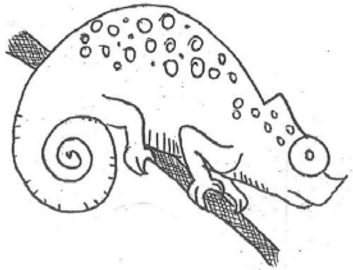
Lelei (*Pavetta gardeniifolia*)



To protect the forest, it is better to cut some branches of the trees to feed the animals and not fall the whole tree! Otherwise the forest can disappear, and with it the rains and fog, and the water!

Cloud forests in the desert

Cloud forests are forests on top of mountains that have lots of fog. They are important because they have animals and plants found nowhere else in the world, such as the Mt Mount-Nyiro Bearded Chameleon called *Kinyongia asheorum*.



They also have endangered animals such as:

E_ _ _ _ _ _ _, GREVY'S Z_ _ _ _ and ____________.

They provide lots of things to the people leaving near the forests such as: F_ _ _ _ _ _ _, M_ _ _ _ _ _ _, H_ _ _ _ and ___________________.

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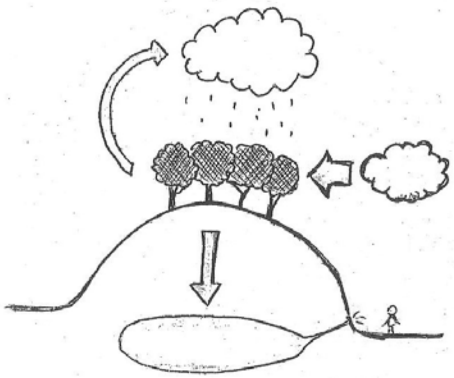
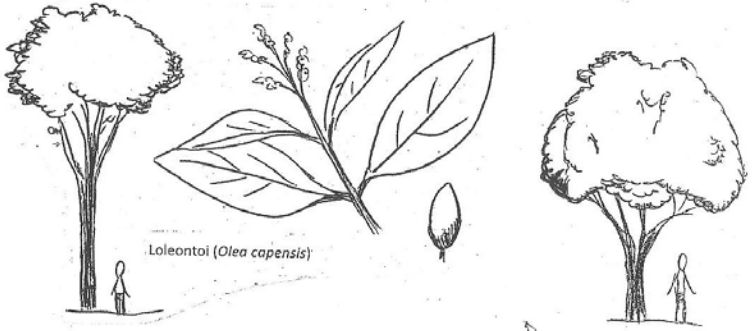


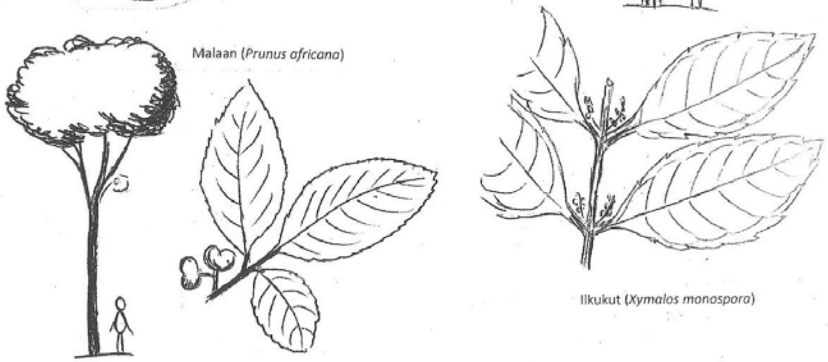
Important fodder trees

People cut trees for firewood and poles to make houses. But they also cut trees to feed their goats and cows during the dry season. The best trees for fodder in Nyiro are:



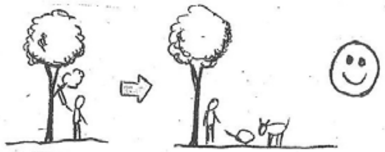
Loleontoi (*Olea capensis*)

Malaan (*Prunus africana*)



Ilkukut (*Xymalos monospora*)

To protect the forest, it is better to cut some branches of the trees to feed the animals and not fall the whole tree! Otherwise the forest can disappear, and with it the rains and fog, and the water!



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Ngene SM, *et al.*, 2009. The ranging patterns of elephants in Marsabit protected area, Kenya: the use of satellite-linked GPS collars. Afr. J. Ecol., 48, 386–400.

Previous report:

Cuni-Sanchez, A., 2015. ASEC-dryland-Forests, 1-year report. CMEC, University of Copenhagen, Copenhagen, Denmark. Available at: https://www.york.ac.uk/media/environment/documents

Publications from this project:

-Cuni-Sanchez A., Pfeifer M., Marchant R., Burgess N.D. (2016) Ethnic and locational differences in ecosystem service values: insights from the communities in forest islands in the desert. Ecosystem services 19: 42-50.

-Cuni-Sanchez A., Omeny P., Pfeifer M., Olaka L., Mamo B.M., Marchant R., Burgess N.D. (in review) Climate change in montane forests in the desert: local perceptions, meteorological evidence and societal adaptation. Climatic Change

-Cuni-Sanchez A., Pfeifer M., Marchant R., Calders K., Sørensen C.L., Pompeu P.V., Lewis S., , Burgess N.D. (in review) New insights on relationships between tropical dry montane forest biomass, structure, and diversity: from the plot to the landscape. Forest Ecology and Management

-Cuni-Sanchez A., Pfeifer M., Marchant R., Burgess N.D. (in review) Harvesting indigenous fodder trees and implications for conservation in three montane forests of East Africa. Biological conservation

-Delbanco A.S., Burgess N.D., Cuni-Sanchez A. (in review) Medicinal plant trade in northern Kenya and its implications for conservation. Economic Botany

-Cuni-Sanchez A., Marchant R., Pfeifer M., Olaka L., Calders K., Burgess N.D. (in preparation) The importance of fog for forest islands in the desert.

-Cuni-Sanchez A., Pfeifer M., Olaka L., Marchant R., Sørensen C.L., Burgess N.D. (in preparation) The irreplaceable forest islands in the desert: a review.

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Knowledge is power…
Make good use of it.