Project Update: January 2012

Problem foundation: temperature of the semi-arid rangelands of Mozambique central ecosystem is every day the highest of the country while rainfall is rare and low. This combined with shallow soils limit vegetation growth and results on very high evaporation rates which causes the environment to be particularly challenging. Water deficit frequently results on drought. We argue that drought years are often of famine and new strategies are adapted by villagers and some of them cause habitat loss and decrease of elephant number.

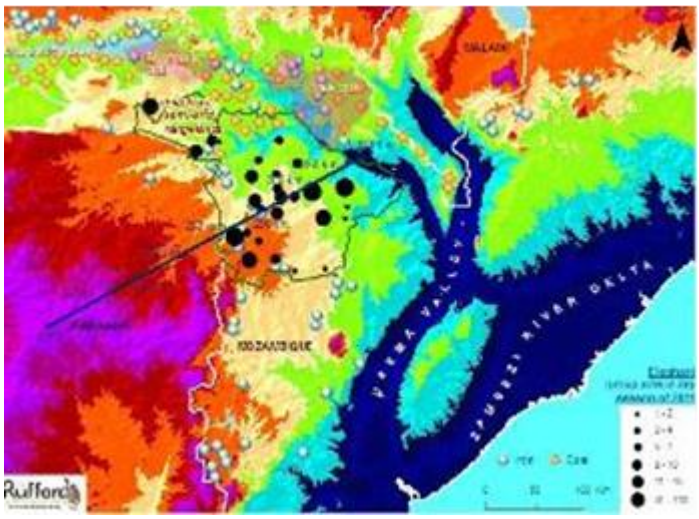


Figure 1: *Elephant group size in dry season of 2011*

Some can document that drought in the semi-arid rangelands is due to its geographic position (south of CIT-center of intertropical convergence). Another argues that it rains but surface characteristics vary and affect water availability distribution. Further comments indicate that water availability is irregular due to surface characteristics variation affected by the presence of valuable minerals such as gold, coal, iron. Given these assumptions we are truly confused on what an eco- development strategy should consider.

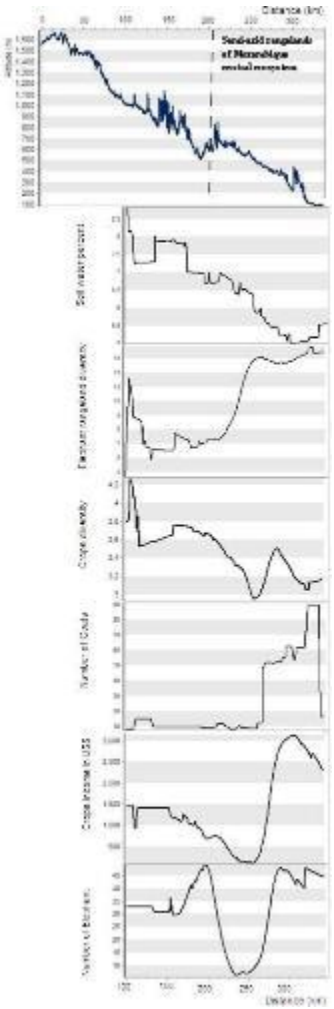


Figure 2: *Spatial correlation of profiles representing main semi-arid rangeland components from highlands of Zimbabwe to lowlands of Zambezi River*

Activities and methods: we did integrated sampling of semi-arid rangelands components. Rainfall impacts on semi-arid rangelands were captured by means of soil water survey. Soil water sampling was based on ziplogs, etiquettes, probe, soil data sheet, digital camera, munsell soil color chart and GPS placed in different elephant rangeland and land based livelihoods along the altitudinal and rainfall gradients. GPS unit helped on acquisition of geographic coordinates and elevation. Soil texture was determined by hand tact; soil color was calculated basing on munsell soil color chart. Soil water was determined as the difference between soil moist weight and soil dry weight (HR %). Laboratory analysis was based on Oven 2000 Series during 24 hours of duration. Mapping of soil water was based on kriging interpolation methods.

Vegetation survey was based on personnel field guide books and checklist provided by villagers. With aid of illustrated elephant rangeland field guide, we short listed the diversity of elephant

rangelands occurring in semi-arid rangelands. Plots of different sizes ensured plants abundance and richness.

Participatory mapping based on geo-referenced scale maps were used to understand villager's natural resources distribution, land allocation for different uses, common concerns and sensitive actions. The position of features on the map was determined by looking at their position relatively to landmarks.

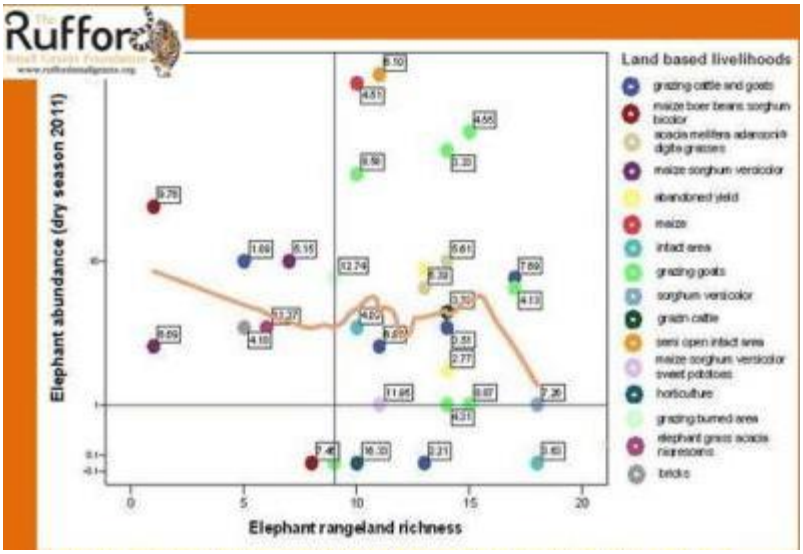


Figure 3: *Ecologically threshold to which land based livelihoods and elephant rangeland loss affect elephant abundance*

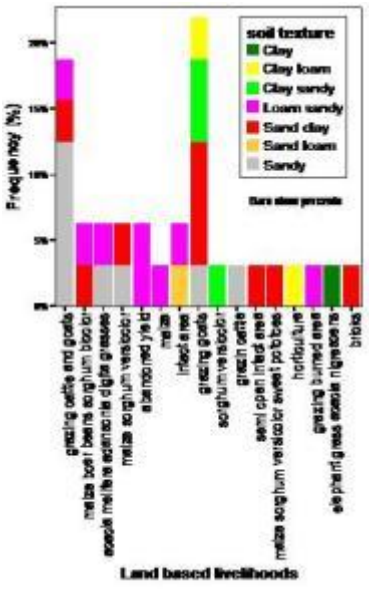


Figure 4: *Frequency of land based livelihhods per soil surface texture*

Questionnaire survey was conducted in each household randomly selected within the Enumeration Area (EA) to measure household income and other socio-demographic indicators and find out villagers' needs and aspirations documented during a participatory approach. Questionnaire survey was also useful on identification and mapping of land based livelihoods and their management in the context of drought and elephant adaptation. Questionnaire results analyses were based on cross tabulation and graphs.

During questionnaire administration, we also weighted the goats in order to find out the ecologically threshold to which rangelands loss affects goats diet. This was also useful on evaluation of the ecologically threshold to which land based livelihoods (grazing goats and crops) affected elephant rangelands richness.

The main results: introduction of goats farming in semi-arid rangelands is a tool for ensuring elephant conservation in the context of drought and ever never seen human demographic numbers every moment worried on satisfying their food security and financial issues. Clearly, farmers owning goats were economically progress-driven (US$1144 -US$4386) better than those only based on crops (US$0-US$149) and tended to invest more in soil-water-elephant conservation (SWEC) practices than others. In addition, the diversity of plants ate by elephant in areas grazed by goats was higher (>32 spp) than those of cropping areas (<8 spp), indicating the scope of areas grazed by goats had more soil water content when compared to cropping areas. Slightly differences were depicted between goats grazing on shallow sandy surfaces which had weighted less (10.425kg at average age of 10 months) compared to these of clay surfaces (11.660 kg at mean age of 6 months), indicating that goats friendship with elephant does not alter soil texture but the rate of accumulation of organic matter

contributing on higher water field capacity, higher vegetation diversity and less exposure of clay surfaces to solar radiation, hence coping with drought impacts. Further, goat's reproduction rate exceeds that observed from both elephant and human and their aggregation strategy, dispersal movement, litter clearance and creation of firebreaks and flexibility on seasonal feeding shifts did not only allow their adaptation to drought, diseases and snakes but also contributed on vegetation regeneration, control of weeds and prevention of forest from uncontrolled fire and consequently increased elephant rangeland diversity.

The way forward: overall results dissemination is based on geo-marketing strategies at five levels and this has been motivating villagers on founding the Semi-Arid Rangelands Forum for Integrated Resources Management (SARFIRM) since they have discovered that drought and elephant are common concern.

FACT 1: ELEPHANT ABUNDANCE IS FORCED TO DECREASE ABRUPTLY ON AREAS WHERE ELEPHANT RANGELAND RICHNESS IS LESS THAN 8 SPECIES. These areas are predominantly used for maize_boer beans_sorghum bicolor mixed cropping where soil water is 9.76%; grazing for cattle_goats (1.89%); bricks production (4.18%); intact area covered by elephant grass and acacia nigrescens (11.37%) and maize_sorghum versicolor (6.69%). Previous results indicated that elephant rangeland richness will rapidly decrease on mixed cropping of maize_boer beans_sorghum bicolor covering sand clay-3.5% and loam sandy-3.5%; maize_sorghum versicolor_sweet potatoes (sand clay-2.5%); maize_sorghum versiclor (sand clay-3.5% and sandy-3.5%); horticulture (clay loam-3.5%) and grazing for cattle_goats (sandy-12.5%, sand clay-2.5%, loam sandy-2.5%), brick (sand clay-2.5%).

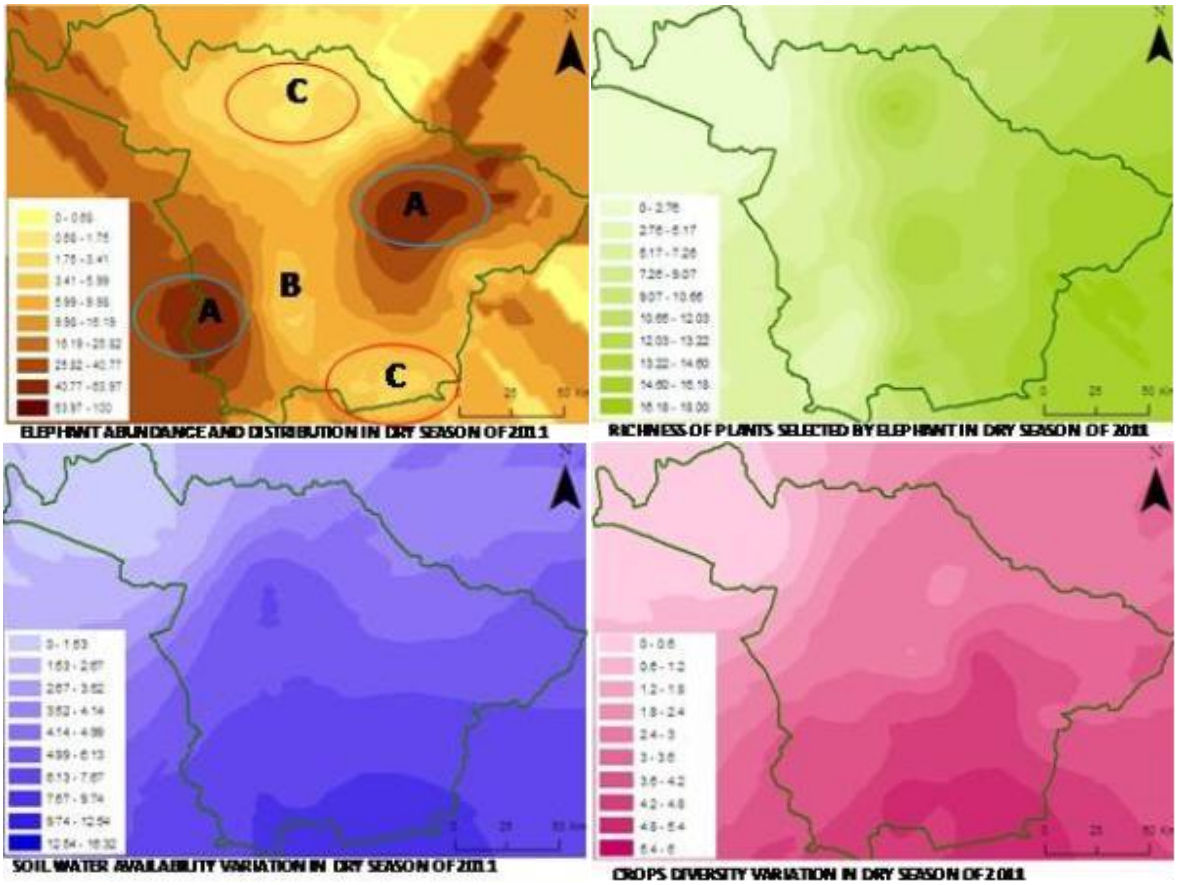


Figure 5: *Crops diversity variation in dry season of 2011*

The documented relationship was also recognized between elephant abundance and elephant rangeland richness and might indicate there is a soil property (e.g. sandy texture) which contributes on water and nutrient loss and consequently less plant species are adapted. In some cases these yields are deserted and in others are used for grazing cattle_goats. This might be the reason cattle_goats grazing wasn't attractive for elephant. Thus, soil texture (sandy) influences elephant rangeland richness and consequently its pattern of use by elephant. Soil texture is innate and of importance is soil aggregation (fine and coarse), which depends on organic matter and biological activity. It means areas of less elephant rangeland richness might be associated with less organic matter that contributes on weak concentration of earthworms which could increase channels and pores of topsoil and in turn overall porosity. Less porosity is observed in sandy shallow surfaces (coarse) and compacted soils (degraded fine structure) of Mandie along Luenha River. On these surfaces the ability of plants to withstand rainless periods is reduced, particularly after tilling since it removes permanent wilting point of water. Primer consequence is the presence of down ravine erosion, increasing sedimentation process of Luenha. This affects fish biota and feeding habits of villagers. When a Woman (Belinha) was interviewed she said: 10 years ago the size of fish was 4 times bigger than this I got and it was not very difficult to capture it. Today I need a canoe to sail deeper river and crocodiles might capture me.

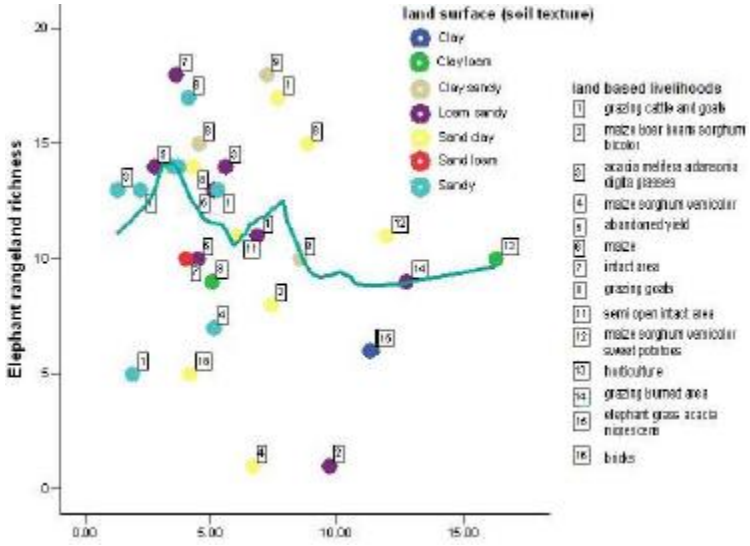


Figure 6: *Soil water-elephant rangeland richness relationship in different land based livelihoods and soil textures*

I remember 1 fish was sufficient to feed my family and weren't necessary to have a large yield.

The longer the rainless, the deeper the soil dries out below the permanent wilting point. When it begins to rain, all the water lost from below the permanent wilting point must be replenished. This is why long rainless periods are so difficult to recover from and it usually takes a prolonged wet period to really remedy a long dry period. Some drying processes of soils may not be reversible since may lose their initial physical properties completely. Reference studies indicate that optimal microbial activity occurs at near "field capacity", which is equivalent to 60% water-filled pore space. In semi-arid rangelands "field capacity" was not more than 20% in fine surfaces. Furthermore, coarse surfaces represented 3.33% of wetness indicating a scope of draining large amount of rainwater due to large pores. As a result low plant richness (> 8 spp.) and low (1-2) diversity of crops were documented.

Income of households on coarse surfaces during the last 4 years varied from US$0-US$149 with US$37.25/year. This was generated mainly from cropping and goat's livestock keeping. Goat's average weight did not exceed 10.425kg at average age

of 10 months and 12 days. This indicates that although drought is in the place goats are adapted to these mountain and dry lands environments.

Thus, sandy surfaces indicate less water (>5%) relatively to sandy clay/clay sandy and loam sandy (up to 12.74%). Although land surfaces differ in terms of water content, their utilization and management are almost closer. This might be due to habits and attitudes of Nyungue, Xtonga and Csicena. Local feeding attitudes strongly affect land use decisions and consequently the soil and water management practices, which affect organic matter that facilitates vegetation roots system development and consequently an increase of elephant rangeland diversity. Surprisingly was the fact that some sites located on sandy clay/clay sandy surfaces had relatively higher elephant rangeland richness than others and elephant was present. This was detrimental to free grazing of goats.

FACT 2: ELEPHANT ABUNDANCE INCREASES ON AREAS OF HIGHER ELEPHANT RANGELAND RICHNESS GRAZED BY GOATS. Elephant by default requires higher quantities of water than goats do. Elephant prefer to browse while goats prefer grasses and shrubs. Goats are tools for clearance of areas of woody species creating in turn firebreaks. Goats grazing in forest increase forest productivity by controlling the thick shrubby understory and thus reducing fire risk. Sometimes goats ate dry mopane litter while elephant browse on fresh mopane leaves. Goats feeding on mopane are antidote to snake's poison that could affect young elephant and also prevent fire risk when cleaning mopane litter. Goats utilise forage resources that cannot be utilised effectively by other Ungulates such as sheep or cattle (thorny plants and species containing high proportions of phenolic compounds). Goat's size and their variable rumen microflora allow them to cope in harsh environments (mountains grazers and dry lands occupants). Thus, ecological niches might explain why households with goats might succeed in times of drought and elephant stress.

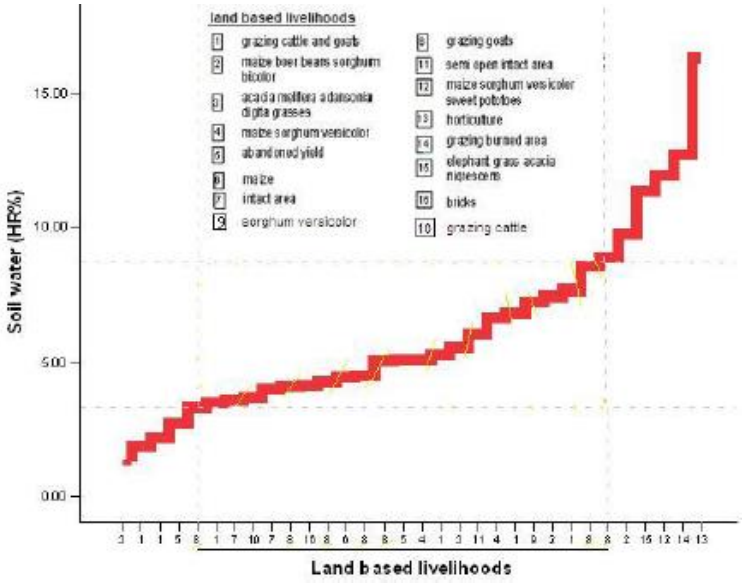


Figure 7: *A model to estimate wise water and elephant friendly land based livelihoods in semi-arid ranglands*

On surfaces grazed by goats elephant abundance was completely higher (>50) but may disappear due to contiguous maize yields. On these areas soil water varied from 3.33% to 8.68% indicating the scope of: as soil water increases elephant rangeland richness is forced to decrease due to increasing diversity of crops. Grazing for goats is frequently on sandy clay (15.0%), clay sandy (5.0%), sandy (2.5%) and clay loam (2.5%).

This might indicate that: (1) goats tolerate to a range of soil textures due to their flexible feeding habits expressing rapid seasonal shifts; (2) the same soil texture (e.g. sandy clay) might attract or not elephant depending on underlying land based livelihood (e.g. goats and cropping); (3) crops located on

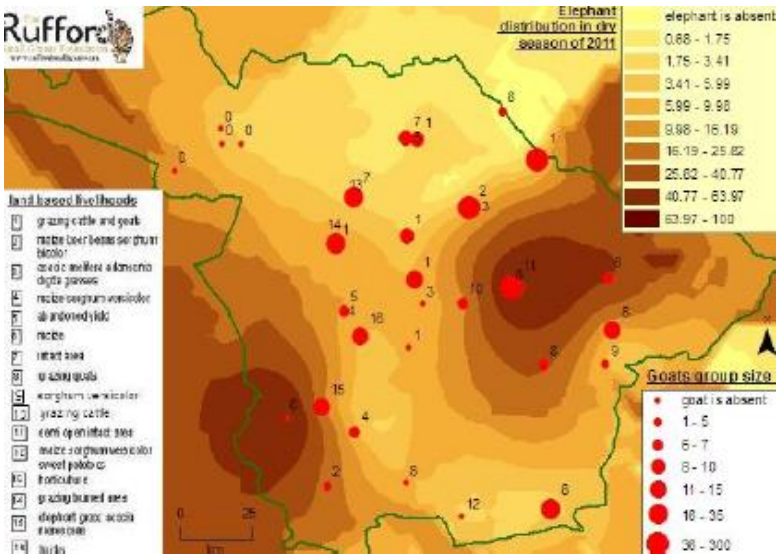


Figure 8: *Spatial correlation between goats and elephant group sizes*

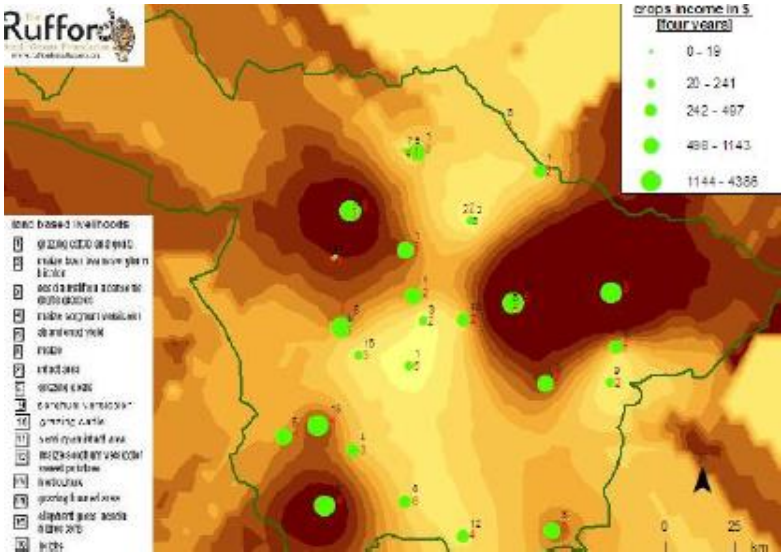


Figure 9: *Income spatial variation by land-based livelihoods*

sandy soils are subject of failure due to water deficit during growing period; (4) some grazing areas for goats might document higher elephant rangeland richness but controversy negatively related to elephant abundance maybe due human attitudes; (5) clear segmentation pattern is observed on the relationship between crops diversity and soil water with regard to higher diversity of crops on areas of higher soil water, decreasing the chance of crops diversity on areas of less soil water.

Notable was the experience of: when soil water availability increases, the diversity of crops (independently of fine or coarse surfaces) also linearly increases and consequently the diversity of elephant rangeland is forced to decrease and elephant will be absent. Thus, a sequence model was created to highlight wise water and elephant friendly land based livelihoods in semi-arid rangelands.

Some of adaptation strategies included goats free grazing on sandy salt soils and dry mopane leaves as it's illustrated on figures above. Crops income and livestock keeping were particularly for nourishing an average household member's size of 40.2; indicating the scope of poor villagers tend have large average family size relatively to a national rural mean of 6 members per household documented by the National Bureau of Statistics (2007). These poor villagers tend to occupy sandy coarse surfaces and drought prone mountains.

Contrary, soil water holding capacity increased on sandy clay surfaces from 3.33% to 11.95%, expressing a large heterogeneity of elephant range richness on areas of cropping, grazing cattle_goats while loam sandy surfaces water varied from 3.63% to 12.74% and majority represented a negative relationship with elephant range richness on areas of maize boer beans sorghum bicolor, acacia melifera adansonia digitata grasses, maize, grazing for goats.

Within the optimal range of soil water for elephant conservation, the most frequent activity is 8 followed by 1. If households persist on cropping as a mean of expressing their cultural heritages option 9 with good management might lead to success. The model also states that if drought persist it's better to select options 10, 16, 11, 5 and 7. Thus, the more the left and frequent is the land based livelihood within the optimal range, the more is the fitted to drought and elephant. The optimum is where the curves start levelling down out with small standard error (lower variance) and ends were the curve again rises out with larger variation, indicating the scope of water stress (first rise is severe drought and last rise is severe flood).

However, to which extent elephant conservation combined with goats and complemented with ordered conservation agriculture of sorghum can optimize soil water and contribute to success of rural development?

The reason behind land based livelihoods amend is to become smallholder farmers resilient to drought and elephant stressors and create an ecological and socioeconomic sustainability towards biodiversity conservation.

With aid of illustrated elephant rangeland field guide, we short listed the diversity of elephant rangelands occurring in semi-arid rangelands.

We conducted questionnaire survey in each household randomly selected within the Enumeration Area (EA) to measure household income and other socio-demographic indicators and find out villagers' needs and aspirations.

We weighted goats in order to find out how they respond to differentiation on rangeland loss. This indicator is also used to estimate the quality of elephant rangeland, since goats demonstrated to be elephant friendly land based livelihoods. Results indicate that:

Sandy clay/clay sandy soils when wisely managed are potential resource for poverty alleviation and biodiversity conservation

Large group size (36-300) of goats were found in sandy clay surfaces where elephant varies from 64-100 individuals and mainly use the depressions of Mupa, Donga, Nhapade, Nhamapasse, Fideza, Muira, Pompue and Luenha rivers as a dry season adaptation corridors. Rivers' order defines its stage of use. E.g. in the middle of wet season elephant concentrates on seasonal pans along Nhapade and Nhamapasse rivers. As the drought continues they will gradually shift to Mupa and Donga rivers and if it persist elephant will concentrate along Fideza, Luenha, Pompue and Muira rivers tributaries of Great Zambezi, indicating the scope of: planning for elephant conservation should include both communal and regional scales affected by land uses and rainfall, respectively. Sandy clay goat mean weight was 11.660 kg at mean age of 6 months comparatively to 10.425kg at average age of 10 months in sandy soils. Mainly the clay goats feed in elephant dry rangeland composed by Adansonia digitata mixed with Colosphospermum mopane, Strychnos spinosa, Acacia nigrescens, Acacia xanthophloea, Sclerocary birrea, Ziziphus mauritania, Berchemia discolor, Sorghum versicolor and Sporobolus africanus, which covers the black-brown colored soils of clay to loam sandy texture, having a water content that varies from 4.02% to 11.37%. On these black-brown soils the destruction of dry elephant rangeland

gives place to Sorghum versicolor, Diospyros mespillifromis, Phaselus vulgaris, Arachis hypogaea, Cocunis sativus, Citrullus lanatus, Ipomoe batatas and Zea mays. A quantification of the last 4 years income revealed figures ranging from US$1144 - US$4386 (US$555/year compared to US$37.25/year in sandy soils), indicating the scope of high productivity of clay soils not only in terms of many plants capable to establish deep root systems and contributing in higher diversity of rangelands (10-32 spp.) and consequent higher number of foraging fauna (>50 elephants) but also in terms of diversity of crops. Clay surfaces also offer opportunity for bricks production mixing nitrogen and wise water plants in their yields, selling livestock in order to avoid overgrazing, decrease males and maintain females since one male can mates more than 5 females.

		Land ownership status			
		Permanently titled	Ancestral inheritance	Temporarily leased	Total
Sex of the household head	Male % of Total	46.9%	34.4%	3.1%	84.4%
	Female % of Total	3.1%	3.1%	9.4%	15.6%
Total	% of Total	50.0%	37.5%	6.3%	100.0%

Some improvements on their rangeland management practices might include training traditional leaders on land use planning since they ensure land law regulation at the level where elephant range exist. They participate in conflict resolution, and implementation of titling processes and definition of the limits of land they occupy. Also before the state grants the land to investors; they consult traditional leaders on whether the land is occupied. However, local authorities use customary laws and practices that discriminate women.

Although woman needs to feed large number of household members (9-40.2), customary land ownership laws do not recognize women in land inheritance so many of them lease the land for current issues. This is mostly critical since woman manage clay surface water selecting wise water crops. Woman is the vector on enforcing feeding habits change. In addition, she is responsible on harvesting natural resources present on their rangelands. Furthermore, she is responsible on decision making on where to locate her yield in order to maximize productivity. Thus, she directly affects the future of elephant of semi-arid rangelands.

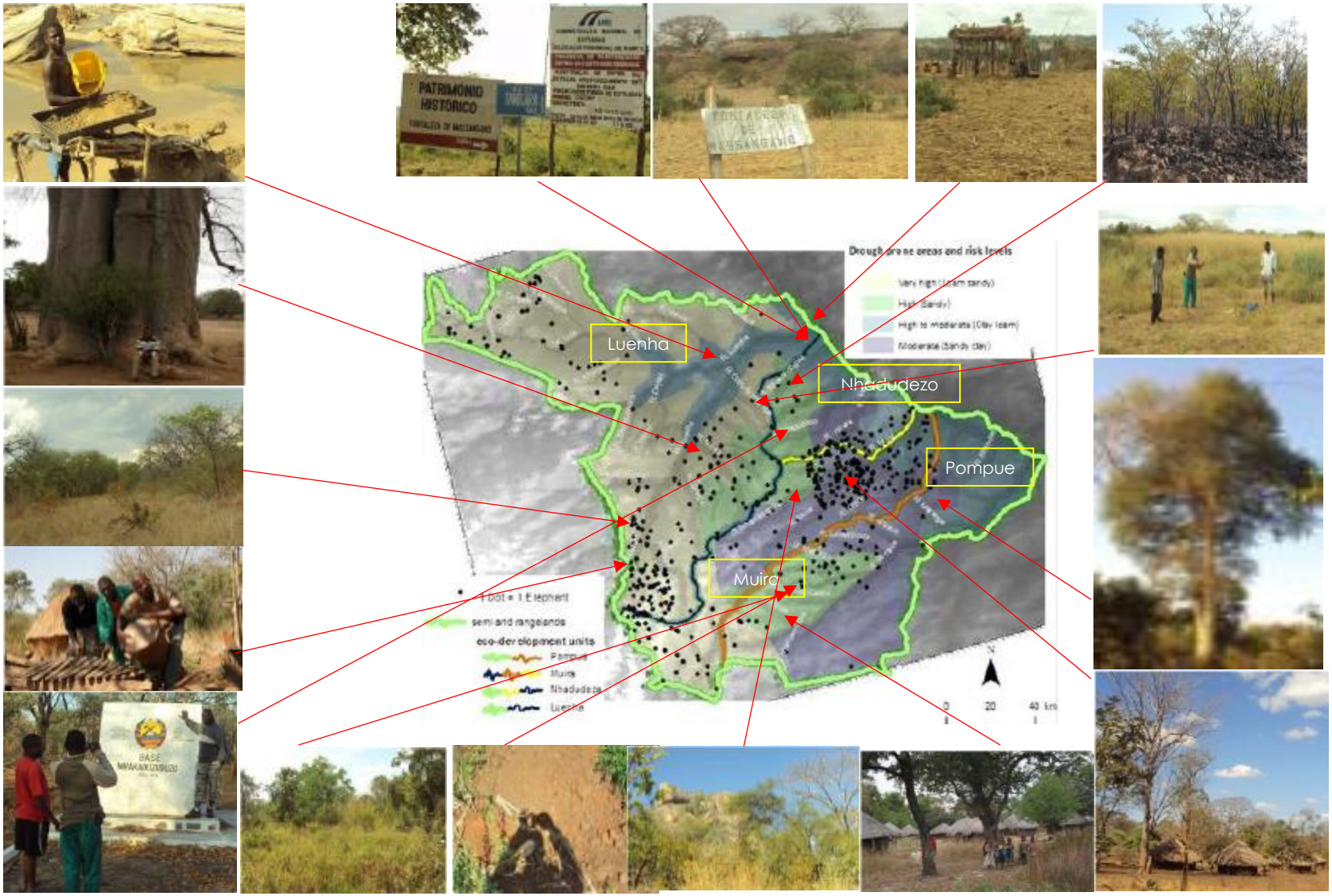
Supplementary, along Zambezi River some yields are fenced against hippos crop raiding. Fencing critical water sources or rangelands during wet season and open them in dry periods it seems to enforce positive outcomes for rangeland management.

Also it's crucial passing messages such as ADAPTATION TIME HAS ARRIVED. Adaptation must begin on our feeding habits. Instead of maize it's better to shift to sorghum and at the end pearl millet. HEC is a fact however; more sign posts are needed with a message of: Be Carefull Elephant. Accordingly to villagers this means do not do your yield on elephant corridors, do not across elephant corridors above 4:00 pm. These messages reveal urgent calls to modify farmer's attitudes and develop strategies for soil and water conservation (SWC) by means of conservation agriculture extension service of semi-arid rangeland. Two factors might undermine this progress: the diversity of farmers within each village (Nyungue, Xtonga and Csicena), and farmers who are progress-driven and economically better (US$1144 -US$4386). From the experience of sandy and clay surface farmers it's clear that clay farmers are better economically than those on sandy soils and tend to invest more in SWC practices than others. Similar

societies are found in Peru (Latin America) and similar management of natural resources is tackled by promoting new technological practices. An important characteristic of these projects is the transfer of decision-making and responsibility for planning and financial resources to the villages. Each participating village receives financial support to hire direct technical assistance. These external service providers can be farmers with much experience ''the best farmers'' (US$1144 -US$4386). When a contest is organized, the villagers themselves select and contract these privatized services to provide training to a number of selected farmers. By means of farmer-to-farmer training, the trained farmers in turn teach the other villagers the new techniques they have learned. Contests are held both at village level, with farmers competing against each other, and on district level between villages. Moreover, the contests encourage farmers to experiment and to decide which practices best fit their specific conditions. However, strict rules at village level that are respected by all villagers need to be enforced for strategies maintenance. Hence, only when such regulations are collectively agreed upon will vegetative and for that success traditional leaders are the key.

Communicating with traditional leaders and government managers to share research outcomes for sustainable natural resources management

Geo-marketing strategy has been adapted to inform key stakeholders on matters related to drought and elephant habitat loss. We did not only disseminate data but also we learnt from them. Accordingly to Mandie Leader when temperature increased to unsustainable levels two consequences affected crops such as soil water scarcity and explosion of insects that killed remain' crops. In Nhamassonge the Administrative Post Chief said that higher temperature resulted on large number of snakes that killed 6 villagers in 2010 and more than 645 livestock. From his view drought coping does not only include SWC practices but also measures that minimize local drought outcomes such as increasing the number of rats, cats and pigs. Rats will be eaten by snakes and cats. Cats competing with snakes will fight and probably cats can eliminate snakes. Pigs when beaten by snakes reduce the poison. The same for goats feeding on mopane leaves. Further the Administrative Post Chief was worried on how to find a market that could buy a quota for hunting the diversity of snakes in Nhamassonge. This needs a specific FORUM. The Semi-Arid Rangelands Forum for Integrated Resources Management (SARFIRM) recognizes that out of agriculture alternative opportunities that tackle wildlife management can help on farmer's development and amend aridity indices. SARFIRM will assist the community in identifying its own developmental objectives and a programme of action, and then to coordinate the activities of service providers through collaborative action in support of the community vision and action plan. A more integrated approach to rural development is documented from this research, including the management and development of water infrastructure, rangeland, livestock, wildlife, wildlife-human interactions and tourism. SARFIRM action plan is based on four eco-development units: 1: Luenha unit; 2: Nhadudezo unit; 3: Muira unit and 4: Pompue unit as it's shown on plates below.


PATRIMÓNIO HISTÓRICO
Drought prone areas and risk levels
Very high (Loam sandy)
High (Sandy)
High to moderate (Clay loam)
Moderate (Sandy clay)
Luenha
Nhadudezo
Pompue
Muiro
1 Dot = 1 E lephant
semi arid rangelands
eco-development units
Pompue
Muiro
Nhadudezo
Luenha
0
20
40 km