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Potentials of and Threats to Traditional Institutions for Community Based Biodiversity Management in Dryland Areas of Lower Moshi, Tanzania

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ABSTRACT : Dryland species and ecosystems have developed unique strategies to cope with low and sporadic rainfall. They are highly resilient and recover quickly from prevailing disturbances such as fires, herbivore pressure and drought. Dryland people have engineered pastoral and farming systems, which are adapted to these conditions and have sustained the livelihoods of dryland people for centuries. In this article, we present the status of potentials and threats to dryland biodiversity and explore options for its conservation and sustainable use. Findings of the research can be summarized as follows: (i) The ecosystem goods and services are highly valued by the community but mechanism for wise use of the resources has disappeared, (ii) forests are under the ownership of the government but the local community is the realistic custodian of the forests through village leaderships and environmental committees; (iii) the immediate major threat to dryland biodiversity held in the forests appears to be the degradation of ecosystems and habitats caused by new and powerful forces of environmental degradation such as large scale irrigation of rice farms, poverty-induced overexploitation of natural resources, and disappearance and ignorance of traditional institutions for management of dryland biodiversity. These new forms of disturbances often overpower the legendary resilience of dryland ecosystems and constitute potentially serious threats to dryland biodiversity. Forests, wetlands and oases all of which are micro hot spots of dryland biodiversity, appear to be particularly vulnerable hence the need to set up some rules and regulations for sustainable utilization of these resources.

Keywords : Resilience, Sustainable utilization, Traditional institutions, Wetlands in drylands

INTRODUCTION

Biodiversity resources are indispensable to daily existence by most people living in dryland areas. A frequent use of wild plants and a communication of knowledge from generation to generation give people a profound knowledge of plant resources in the local environment. Practically all local people can give information about a variety of useful species, and many have priorities for natural resource use and management practices. Elderly people can also give information about vegetation changes that have occurred in centuries (Lykke, 2002). Local societies therefore harbor important information on valuable plants and vegetation dynamics that is fundamental for management strategies aimed at sustainable use and conservation of biodiversity.

People living near nature reserves are often allowed to use natural resources from protected areas in a sustainable manner, and it is now widely accepted that local knowledge and priorities should be incorporated into management strategies for nature reserves. Indigenous based management strategies mainly in semi-arid areas, ensure a focus on the species and vegetation types that are most valuable to local societies (Shemdoe *et al*., 2009). Furthermore, an incorporation of local priorities gives management strategies a better

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chance for success, because people are more likely to obey regulations influenced by themselves than those forced on societies from outside.

Dryland ecosystems cover extensive land areas stretching across about 40% of the earth's land surface. Dryland environment have a unique richness of biological resources which are useful to the life of local people and the entire ecosystem structure, function, process and service. Although remnants of healthy dryland biodiversity and indigenous knowledge still exist at various locations, drylands face increasing threats of further degradation. Continued degradation of drylands is a major threat to the ecological functions of drylands and to the species and genes living in these ecosystems and thus to human welfare. Compared to tropical rain forests, the wealth of dryland biodiversity and indigenous bio-knowledge is less well-documented. The lack of biodiversity research in arid and semi-arid environments in the developing countries such as Tanzania has lead to the assumption that drylands are of limited interest to biodiversity.

The aim of the present study was to extract local information of particular importance for understanding status and trends of use of dryland biodiversity and means for improving vegetation management and sustainable use. The focus was on local people's descriptions of frequently used, highly preferred, and severely declining species and vegetation types to highlight the effect of vegetation changes on the lives of local people. Furthermore, the health status of the forests was studied with particular interests in stoking and anthropogenic driven disturbances. We hypothesize that information obtained in this survey can provide a focus for future management strategies that allow a more sustainable use of plant resources and a better conservation of dryland ecosystems in the study area. The study lays a foundation for detailed studies that can come up with in-depth details of measurements and analyses aiming at improved management and use of dryland biodiversity in and outside the study sites.

Materials and methods

Study area

The study was conducted in three forests located in Moshi (rural) district namely Forest I, Forest II and Forest III in Kilimanjaro Region, Tanzania. The forests are located in Kahe and Kisangesangeni wards, some 10 km south of Uchira town along the Moshi-Himo road. During the survey we used GPS to map the location of each forest and some other important features. Due to their large areas and limitation of resources we were not able to map boundaries for forest one and forest two. We managed to measure a complete boundary for forest III, some points along boundaries of forest I and II and the sample areas. The forests and the respective sample plot locations are presented in figures 1 to 3.

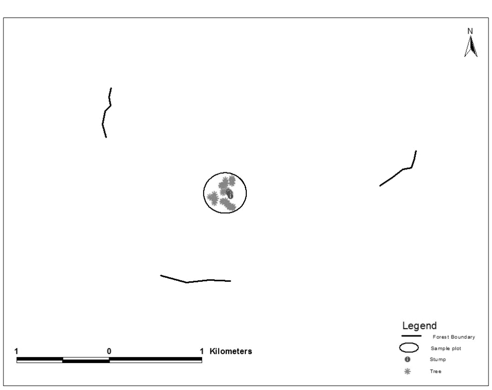

Fig. 1. A map of Forest I located in Kahe ward. The sample area is 15.6 hectares and the unconnected lines represent areas on the borders of the forests. This forest has tree density of 3 stems per hectare and approximately 110 stumps per hectare.

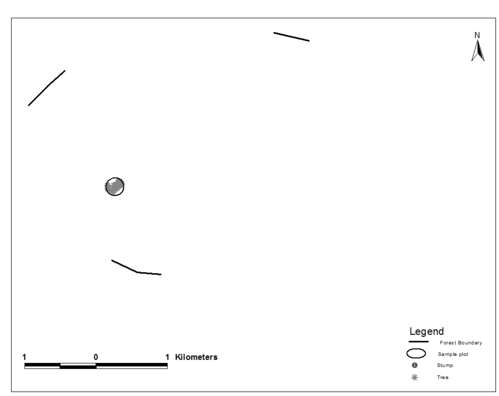

Fig. 2. A map of Forest II, also located in Kahe ward. The sample area is 4.8 hectares and the unconnected lines represent areas on the borders of the forests. This forest has tree density of 10 stems/hectare and approximately 4 stumps/hectare.

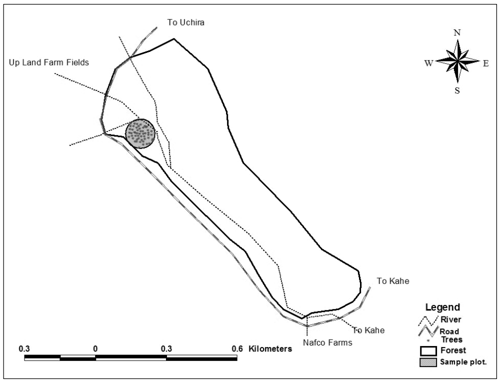

Fig. 3. A map of Forest III (Miwaleni) located in Kisangesangeni ward; the sample area is 1.2 hectares. A complete forest boundary is shown in black line. This forest has stand density of 42 stems/hectare and approximately 2 stumps/hectare.

Study of local knowledge and institutions

Participatory tools were used to collect data on various knowledge and institutions which affects the management of the forests. Rapid Ethnobotanical Appraisal, Pair-wise ranking, matrix, resource mapping and problem ranking tools were used. Participant observation, key informants interviews and focused group discussion were used to collect and concretize data collected using the participatory tools through triangulation. Sampling of villagers who participated in the research was done systematically to include all social groups i.e. gender, age, wealth, etc in the community.

Bio-resource study

Fifty trees with diameter at breast height more than 10 centimeters were assessed at each forest. Sampling technique adopted a modification of the plotless sampling technique. To begin sampling in each site, one mature tree (≥ 10 cm (dbh) located in the centre of an identified area was used as a starting point. The 49 nearest other mature trees (nearest neighbour) to the starting trees were then included in each forest. This involved moving progressively outward from the starting tree so that the sample is expanded by adding more individuals, but kept compact, until it includes 50 mature individuals. This means that the diameters of the plots vary depending on the tree stocking density. The position

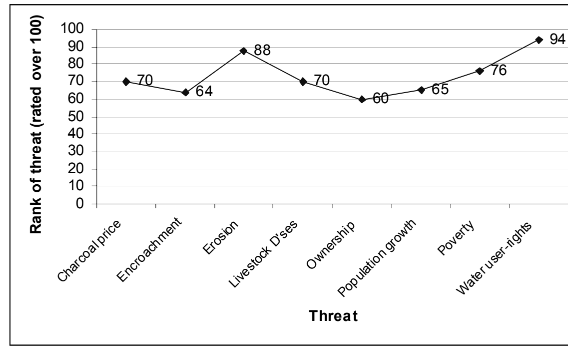

Fig. 4. Prominence of threats to bio-resources based on local people perception and direct observation.

of each tree was mapped using differential GPS and the recorded bearings were used to prepare spatial maps which shows abundance and distribution. Also identification and measurement for dbh, crown diameter and height of the 50 trees was done to enable calculations of volumes, biomass and diversity.

RESULTS

Uses of and Threats to dryland bio-resources

Several threats to biodiversity were identified, summarized and analyzed using problem ranking technique in the field. Figure 4 shows the most prominent threats to dryland biodiversity in the study area as: soil erosion, livestock diseases, escalating charcoal price and demand, improper and discriminative water user-rights, population growth, encroachment, forest ownership linkage to management and use, and poverty related destruction.

Majority of local knowledge on forest management and use is held by minority of elders. Most of the knowledge is directed in preserving biodiversity and sustainable utilization of its resources. Traditionally certain tree species (mainly *Raphia farinifera* (commonly known as Raffia palm or Miwale) and *Ficus thonningiii*) are retained for worshiping and catchment uses while others are retained for traditionally known values of soil protection, rainfall insurance, breeze and shade (*Albizia* and *Acacia* species). Based on local knowledge of the vegetation and forests in general it was revealed that with the exception of the Raffia palm, the other trees are rapidly disappearing. It is strictly forbidden to take a bath or wash inside the catchment and it is believed that if one breaches this traditional rule will vanish in the forest. But this rule has become passive because of weakened traditional institutions and implementation of traditional means of resource management and use. However, little knowledge is held by the normal adults and little to no-knowledge held by the youths. The reason for this is largely lack of documentation, contradiction and changing forest management regimes and urban-rural interchangeable settlements (migrations).

There is a conflict of custodianship and benefit-sharing rights from the forest resources. Water user-rights ranked as the most prominent threat to resource use and sustainability (Figure 4). Forest III is principally an oasis. It supplies domestic water for the immediate community and irrigation water for distant villages and rice projects. The immediate community feels it deserves more that just domestic water and wants an irrigation scheme introduced in their village. The introduction of rice irrigation scheme; some 10km away from the catchment in the 1980s is seen as a major source of conflict on the user rights and benefit sharing to the local communities. Both villagers in Kahe and Miwaleni near these forests are suffering a reduced water supply for irrigation since most of the water was redirected to the rice farms. As a result of this farming has continually lost its popularity as the main economic activity and therefore less paying investment in the area.

Declined returns from agriculture coupled with the rising electricity; demand for charcoal in urban centers continues to increase sharply. Increased demand for charcoal results into increased price for the commodity. The effect of demand and price combined with deteriorating agricultural industry in the study area has forced many households to embark on charcoaling since its returns are lucrative. The rise in prices for charcoal is not only due to rise in electricity tariffs which eventually triggered high demand for charcoal, but is also related to government decisions which was made without careful analysis. When the government announced restriction of charcoaling activities as a measure to combat deforestation; charcoal supplies went down and consequently prices shoot up because there was no another alternative source of energy. Illegal charcoaling intensified to tap the increased net profit and the government lacked the required resources for patrolling the forests. Discussions with villagers in the study area and direct observation in the forests revealed intensive charcoaling activities. Very large and old *Albizia schimperiana* trees were cut for charcoaling especially in the highly destructed Forest One. This is because the commonly used charcoal trees; *Acacia xanthophloea*, are almost locally extinct due to charcoaling and therefore the illegal charcoal makers have no other means but to embark of the few and old remaining hardwood trees. Interview with few charcoal makers revealed that one such large tree produces up to 100 bags of charcoal at a stumpage price of Tshs. 5000 each; and hence one tree is worth around Tshs. 500,000. This is a big impact to arid biodiversity since the regeneration of the species is difficult due to high habitat disturbance through charcoaling and overgrazing. With the problems of shortages of funds for improved management of reserves and complex Community based Forest Management Vs Traditional Management interactions rehabilitation of the forests is far from reality.

Discussions with villagers during PRA revealed that due to increased population pressure in the area, species used for supply of building materials have shrunk and people have embarked on use of miwale as an alternative species. Each of the 300 household in Kisangesangeni has at least one house of which the dominant construction material is Miwale, and this must be supplied from the 44.5 hectare forest with 42 stems per hectare. Miwale is also used to construct fences between shops, schools, mosques, homesteads and local bars in the area.

The scope of this study did not allow to assess volume or branch increment of miwale per year vis a vis annual demand for construction. Due to the importance of miwale as the dominant species at the oasis people are only allowed to collect fallen branches after obtaining a special permit form village authorities. However implementation of this bylaw is difficult due to lack of money to pay forest guards. As a result the guards tend to collaborate with illegal collectors in order to compensate the unpaid salaries.

Villagers are concerned about the degradation of the forests and the surrounding agricultural land. There have been increased washing inside the catchment, increased soil compaction resulted from increased foot trails and illegal cutting of miwale branches.

Deforestation and poor farming practices on the surrounding middle and upper slopes causes intensive floods during rain seasons. The floods cause substantial sedimentation in the catchment and associated Drainage Rivers posing a threat to the catchment resilience.

Coping strategies from villagers perspective

Sustainable management of the forests requires immediate attention. Villagers are willing participate in interventional programs and listed the following as among important intervention measures to reduce destruction on the forest ecosystems

- Improved awareness and knowledge on the management and use of non-wood forest products
- Implementation of sustainable fishing
- Installation of irrigation pumps along the drainage rivers to be used and managed and formal farmer groups
- Improved law enforcement
- Increased support from the district and regional forest administration which is currently passive
- Payment for the ecosystems services through water royalties by Pangani Water Basin Initiative and the irrigation companies. Such money could go in payment for social services and forest security/protection services
- Enrichment planting in degraded forests using indigenous species seedlings

Use of bio-resources

Local communities in the Kahe and Kisangesangeni are very dependent on forest resources. The uses include both ecosystem goods and services (Figure 5). The most important use is ecosystem services (36%). Here ecosystem services include shade; water for irrigation, domestic and livestock use; microclimate improvement; recreation; and potential for generation of hydroelectricity. Apart from ecosystem services, other important use include fuel-wood (firewood and charcoal), herbal medicine, livestock fodder and construction materials (Figure 5). These uses are accrued from 7 most useful tree species and *Raphia farinifera* is the most valuable tree (Table 1). By triangulation technique since *R. farinifera* is the dominant species in the oasis then this finding is congruent with the data in figure 5 which indicates that ecosystem services are the most important uses of dryland biodiversity in the area.

Table 2 shows that F3 (Miwaleni forest) have the largest volume than the other forests. However much of this volume is influenced by remnants of branch continuation along the main stem of Raffia palms, structures known as ligule in plant morphology. When Miwale branches/leaves

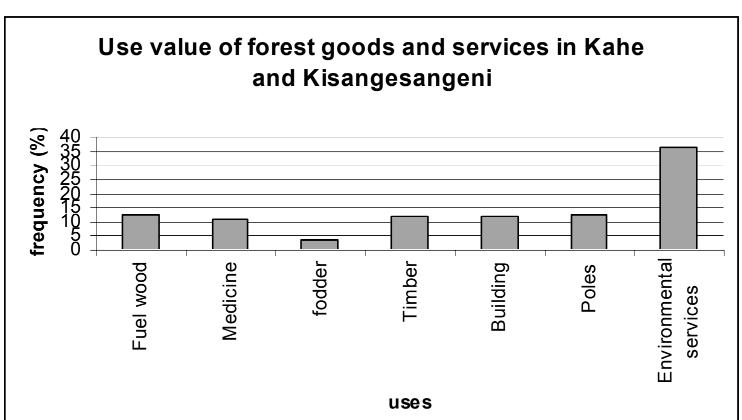

Fig. 5. Use of dryland biodiversity by immediate communities.

Table 1. Matrix scores for seven most useful species in the study area.

Species \ Uses	Fuel wood	Medicine	Shade	Fodder	Timber	Building	Climate	Poles	Ornamental	Hydropower	Total
Salvadora persica	5	6	5	0	10	0	2	7	0	0	35
Sterculia africana	8	5	8	0	10	8	3	8	0	0	49
Raphia farinifera	7	5	10	0	0	10	10	8	6	10	66
Acacia xanthophloea	10	6	8	5	0	5	8	9	5	0	56
Albizia schimperiana	10	4	8	0	10	3	2	2	0	0	39
Milicia excelsa	1	5	8	0	10	10	2	4	0	0	40
Ficus thonningii	1	5	8	7	0	4	9	4	0	8	46
Total	42	36	55	12	40	40	36	42	11	18	

Table 2. Volume, basal area and diversity of trees.

	Average DBH class (cm)	G (m2)/ha	Volume (m3)/ha	Average Cr-height	Average Cr-Diameter	Cr Volume (m3)/ha	Stems/ha
FI	4	0.92	8.75	8.98	22.63	2532.88	3
FII	3	2.05	23.00	14.60	7.03	11409.99	10
FIII*	5	11.52	122.96	16.39	7.47	38731.09	42

FI- Forest one; FII – Forest two; FIII – Forest three (Miwaleni); DBH of 4 – average DBH is 30-40 cm; DBH class 4 – Average DBH is 40-50 cm; DBH class 5 – Average DBH is 50-60 cm; G – basal area; Cr – Crown; F3* - diameter influenced by ligule.

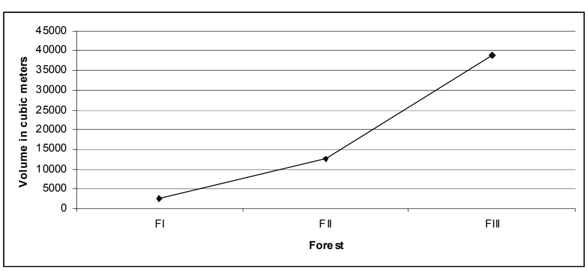

Fig. 6. Crown volume for forest one, two and three in the study area.

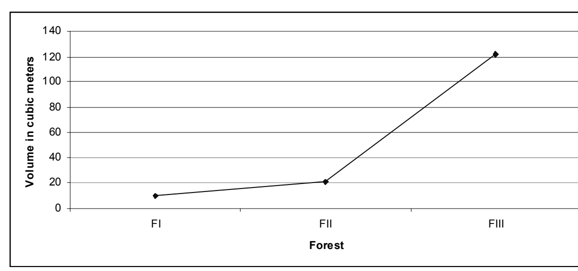

Fig. 7. Standing tree volume for forest one, two and three in the study area.

die off or are pruned a continuation of the leaf which attaches to the main stem remains for almost the entire life of the tree. So when taking measurements for DBH the remains adds a considerable difference to the actual diameter for the inner wood biomass. It will be very useful to develop a formula for volume estimation with a factor that will take care of the ligule remains in species with such morphological features. So in reality forest two is the one with the largest standing wood volume. The formula used is

*tree diameter2*tree height*0.4/4.*

The results have been converted to per hectare basis; the 0.4 is a form factor which has been developed to take care of the change of diameter of a tree from the butt to the tree top. As depicted in table 2, and figure 6 & 7, the Miwaleni forest has the largest crown volume. This is because Raffia palms crown height is substantially large; it can go up to 19 metres and therefore displaying a thick vertical intersection of forest cover.

Species distribution and diversity

Measurement was done on 150 trees in three forests. Seventeen different species were identified with varying diversity, richness and evenness in each forest. Simpson and Shannon indices show that forest II is more diverse (index 0.764 and 1.665 respectively) (Table 3). This implies that forest II has many species and therefore biodiversity in terms of different types of species is high compared to the other two species. Forest III is more even (evenness = 0.387) meaning that it is less diverse in terms of species composition (Table 3).

Discussions

Local knowledge on the institutions guiding use and management of a forest resource in the study areas is almost extinct as results have shown that it is held by the elder minority in the society. This situation is a threat to sustainability of management and utilization of the forests. The forests are owned by the state but in reality the managers and users of the forests are the surrounding local communities and therefore traditional knowledge is key to the health and continuity of the availability of goods and services from the forests. Despite the fact that knowledge is held by minorities in the society, immediate measures to document and analyse it are required. This knowledge should thereafter be integrated in the management of the forests which is under the mandate of the Ministry of Natural Resources. There are emerging concerns that Community Based Forest Management (CBFM) is much of paperwork but in real practice it has been difficult to implement (FBD, 2006). This may be due to 'copy and paste' of interventions without prior and careful integration with local realities which are locality-specific. CBFM as it is on paper is a good approach, and in deed it has proved successful in Asia where it originates as well as in some other areas like in Duru Hai Temba in Manyara. However local institutional settings which are a major player in CBFM vary from place to place; they can even vary from one village to the next (Dino, 2006). These local settings (mainly local knowledge and other institutions) therefore need to be carefully synthesized and defined when CBFM is introduced in various forests. The lack of such an approach might be the key factor behind the mismanagement of the forests in the study area. The authorities would tell that the forest is managed jointly by the villagers while the villagers would claim that their roles, responsibilities and rights over the forests are not clear (Dino, 2006 *pers comm.*). This will remain a real obstacle even if the two sides (central and local government) had discussed their particular and respective mandate; in most cases such interventions are explained to few villagers in reasonably short periods of time and at the same time it is expected that they will understand and put them into practice.

Forest one is highly damaged due to charcoaling and animal grazing. Volume and crown diameter for forest one is small compared to the other forests as shown in the results section. With the intensity of charcoaling and move into open access resource tenure it can be predicted that forest degradation is a problem in the area and it will affect annual tree volume increment, forest cover and tree species diversity. Some trees whose regeneration is slow may be pushed to risks of local extinction.

As mentioned earlier the forests are state owned but with the state effectively unable to manage the forests, resource-use tend to acquire the characteristics of an open access system (Barton and Thompson, 2000). It is not surprising therefore that forest one have been the scene of some of the greatest environmental degradation in the area with 110 stumps/ha. The open access condition is one where resources are the property of no-one and are available

Table 3. Species richness, distribution and diversity for the three study forests.

	Forest I	Forest II	Forest III
No. of trees/sample	50	50	50
Richness	9	9	5
Evenness	0.491	0.587	0.387
Simpson Index	0.670	0.764	0.292
Shannon Index	1.487	1.665	0.661

to everyone. It is therefore not strictly a property rights regime at all, nor is it a management regime since people use, opportunistically, the resources, but do not manage them. Under these circumstances every community member has various interests on the resources and the intensity and means of acquiring resources differs (Barton and Thompson, 2000; William *et al*., 2003). We cannot glibly assume that everyone, everywhere, has the same reasons for an interest in the environment (Tom *et al*., 2009). People seek to manage the environment for two reasons: first, because the management of natural resources improves the conditions of their livelihood. Second, because environmental degradation is perceived to be threatening, either to life-sustaining processes (e.g. through pollution or soil erosion) or to peoples' aesthetic values. People seek to manage the environment when the benefits of management are perceived to exceed its costs (Torsten and Anthony, 2005; Tom *et al*., 2009). This is clearly seen in forest I while in Forest II and III some form of medium level encroachment indicate they may follow the same trend in the coming years.

Apart from charcoaling, dairying is a second alternative economic activity in the study area. Although the dairying is through pastoralism, if carefully implemented it can yield a much more sustainable income compared to charcoaling which involves deforestation of trees which takes time to recover. Degradation of land and water resources particularly in the semi arid areas can lead to adverse economic and ecological consequences in rural arid societies, where survival, sustenance and growth are intimately linked to the health and productivity of the surrounding natural resources (Hodgson, 2000). In such mixed farming systems, typical of the study area, milk production is a gainful secondary occupation and can generate surplus but only when a significant part of material inputs come from commons and agriculture residues. It is known from various studies that nearly 40 % of the total fodder and forage intake of milk animals come from the common lands, which are usually degraded forest lands, grazing lands and wastelands near villages (Shemdoe and Mwanyoka 2006). However groundwater depletion has already raised serious questions about the viability and growth of agriculture and dairying; which is reflected by water user right conflict between different villages in the study area. Lack of fodder and water tend to influence both the quantity and quality of milk production of small farm households. This situation is a challenge and call for improved management of farmlands and the degraded common lands so as to increase the quality and quantity of fodder production. Conservation of water sources, specifically the forest III needs immediate improvement to avoid further destruction. Such measures are expected to rehabilitate the vegetation consequently sustaining its water retention and release capacity. Distant and other commercial water users depending on the water source need to pay part of their net profits as royalties. Such income will be used to motivate the immediate community to support and intensify conservation measures.

Conclusion

The Kahe and Kisangesangeni dryland ecosystems contain a variety of animal and plant species that have developed special strategies to cope with the low and sporadic rainfall, and extreme variability in temperatures that prevail in these ecosystems. Such adaptive traits have local importance, especially in the context of stabilizing the resilience of the environment to be able to support mankind. Pastoralists and farmers in the area have developed efficient pastoral and mixed cropping systems adapted to the difficult conditions of drylands. These systems have sustained the livelihoods of generations of people. Furthermore, these dryland pastoralists and farmers have successfully created and maintained high levels of agrobiodiversity of crops and livestock breeds. Yet, awareness about the great value of these drylands remains frustratingly low. Compared to other areas, for example, the wealth of this dryland biodiversity and indigenous knowledge is less well documented, and has received much less support and advocacy in conservation media. Although remnants of healthy dryland biodiversity and indigenous knowledge still exist in the study area, the drylands face increasing threats of further degradation. Thus, continued degradation of drylands is a major threat to the ecological functions of drylands and to the species and genes living in these ecosystems and thus to human welfare. Updating and improvement of ownership and management regimes of the forests need urgent attention. Efforts in the past to address the forest degradation through CBFM approaches have achieved much less than expected. Thus improved and/or new paradigms are needed to go sustainable manage and use the resources. From the findings reported in this article we recommend:

Documentation, analysis and preservation of local knowledge and other rules and regulations (institutions) for management of biodiversity. Such information has to be used in formulating or reviewing sustainable intervention for improved management and utilization of the biodiversity at present and in future.

Improving biomass production both from commons and improve productivity of the farming system and increase availability of fodder and non-timber forest produce from forests and private lands

Improve water availability through conservation of water sources, to meet the needs of agriculture and pastoralism

Bringing all forms of commons under active village governance by strengthening village-based people's institutions and provide legal rights on the usufructs from forests to the user community by creating forest-based people's institutions under Joint Forest Management.

Assessing people's livelihood requirements, improving the livelihood and reducing the risks to livelihoods of the community during periods of drought.

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