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Gums and resins: The potential for supporting sustainable adaptation in Kenya's drylands

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Frequent droughts and conflicts are key challenges faced by nomadic pastoralists in Kenya's drylands. Few options exist for alternative livelihoods. This article investigates the potential of collecting plant gums and resins for livelihood diversification and for contributing to sustainable adaptation to climate change in Kenya's drylands. Observations were made in various studies over a period of two years on dryland vegetation resources, and interviews undertaken with gum collectors. This research found that many households currently collect and sell plant gums and resins as alternative to livestock production. These include gum arabic from *Acacia senegal* and *Acacia seyal*; myrrh from *Commiphora myrrha*; hagar from *Commiphora holtziana*; and frankincense from *Boswellia neglecta*. Collectors include poor people, women and children and some opportunists. Incomes are relatively low, however, and several factors constrain the activity. The case of gums and resins illustrates that key principles of sustainable adaptation are related: supporting local knowledge and adaptation strategies (one key principle of sustainable adaptation) does not contribute to sustainability unless at the same time contextual factors that marginalize livelihoods are addressed (another key principle).

Keywords: adaptation sustainability; drought; drylands; gums and resins; livelihood diversification

1. Introduction

Human survival in the Kenyan drylands is continuously faced with multiple challenges, including frequent droughts and unpredictable cattle rustling and violence. Generally, droughts affect the quality and quantity of water and grazing resources, reduce incomes and aggravate poverty. They may trigger conflicts, cattle raids, loss of life in both humans and livestock and accelerate the rate of land degradation. Conflicts, including banditry and raids, increase pastoralists' vulnerability and hinder human and animal movement (Eriksen and Lind, 2009). Despite these predicaments, drylands are very rich in biodiversity and are important areas for livestock production. The harsh physical environment in the drylands directly support the livelihoods of close to 25% of Kenya's population and slightly more than 70% of the livestock population, whereas 90% of the gazetted national parks and game reserves are located in the drylands (KEFRI, 1992). Although many dryland communities in Kenya continue to rely largely on livestock for their livelihoods, there has been a process of marginalization of pastoralism and a related sedentarization that has increased the vulnerabiliy of these populations (Mkutu, 2007). These processes have come about through a combination of policies and development interventions that have been aimed at settling populations and incorporating them into non-livestock economic activities such as farming or fishing, and livestock losses due to conflict and

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drought (Hogg, 1987; Heald, 1999; Owuor et al., 2011). Insecurity and a lack of veterinary and other livestock support services have meant that it is increasingly difficult to recover and restock after livestock losses, leaving an increasing number of people with small herds or no herds at all (Eriksen and Lind, 2009).

Diversification of livelihoods is frequently cited, both in research and policy, as a main way to cope with and reduce vulnerability to drought (Scoones et al., 1996; Republic of Kenya, 2003). Climate change makes this issue even more pertinent. The local manifestations of climate change are not easily predictable because in East Africa warming is likely to lead to drying in some areas and increased precipitation in others (Boko et al., 2007). However, seasonal shifts in rainfall and higher temperatures associated with climate change mean that growing uncertainty and incidences of prolonged droughts are challenges with which populations may increasingly have to cope (Hulme et al., 2001). The need to alter drought grazing patterns at the same time as insecurity and development policies render many areas inaccessible reinforces the vulnerability of pastoral livelihoods.

The collection of gums and resins illustrates how sustainable adaptation to climate change could potentially be supported – it represents an alternative source of income for poor people during drought and as a non-wood forest resource it is likely to be environmentally sustainable. Strengthening the local adaptation options of pastoral communities requires recognition of the opportunities that the natural resources of dryland ecosystems, provide for diversifying income sources. Plant gums, gum arabic and plant gum resins, myrrh, hagar and frankincense are among these natural resources. One advantage of these resources is their ability to produce in the dry season. Increased exploitation of indigenous gums and resins represents an opportunity to build adaptation on local knowledge, a key principle of sustainable adaptation identified by Eriksen et al. (2011); however, the exploitation of these resources comes with new challenges. This article critically explores whether exploitation of gums and resins can contribute to sustainability in terms of both social equity and environmental integrity. Data on the collection and sale of gums and resins collected between 2006 and 2008 are analysed in order to establish the scale and methods of collection, which groups participate in the collection and the extent to which these resources contribute to incomes. This analysis suggests that harvesting gums and resins could provide a viable option to strengthen livelihoods in a manner that is environmentally sustainable. However, the activity is currently constrained by a range of factors closely associated with the general marginalization of drylands, that is, lack of marketing and infrastructure, poverty, policy neglect, conflict and insecurity. The case of gums and resins illustrates that key principles of sustainable adaptation are related: supporting local knowledge and adaptation strategies (one key principle of sustainable adaptation) does not contribute to sustainability unless at the same time contextual factors that marginalize livelihoods are addressed (another key principle).

2. Background: Kenya's drylands

Kenya's drylands, defined as areas receiving annual rainfall below 1,000 mm, are characterized by a hot, dry climate and scant vegetation cover. The rains are not only low but erratic, and typically of short duration but often of high intensity and therefore highly erosive. Recurrent drought and occasional floods are also features of the drylands. The soils are generally poor, with high sand content, poor surface structure due to erosion and often saline with low organic matter. The drylands cover about 80% of total land area (Figure 1). Most of the country's wood-fuel-based energy requirements are met from drylands. Conflict over resources and household food insecurity are common, while the incidence of poverty is the highest in Kenya (Government of Kenya, 2000). The most suitable land use is livestock keeping and wildlife conservation.

Traditionally, nomadic pastoralism is the mainstay of the drylands economy. Vegetation

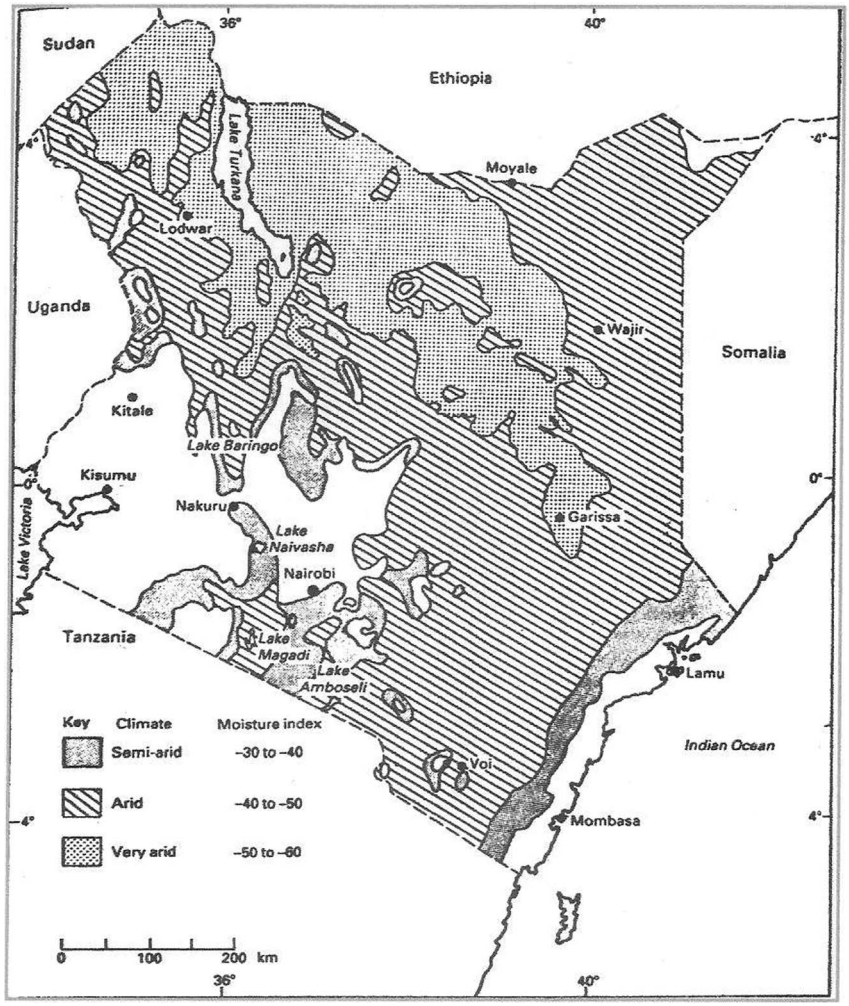

FIGURE 1 A map of Kenya's drylands showing semi-arid, arid and very arid areas and neighbouring countries

is thus vital to the pastoral communities for grazing and browsing. The pastoral production system operates by independent family units exploiting a common resource (e.g. water, grazing land) through privately owned and managed herds. Frequent daily movement of herds between pastures helps prevent overuse of a single area's biomass and helps avoid disease in their livestock. Herd diversification (cattle, camels, sheep, goats and donkeys) ensures that both browsers and grazers are present and that an extended dry spell or a single disease is less likely to wipe out an entire herd. This is a highly flexible system, which has evolved over time as the most efficient means of exploiting transient water and pasture under ecologically marginal conditions, available technologies and the prevailing economy (Chikamai and Odera, 2002).

Frequent, prolonged and severe droughts are posing great challenges to survival in Kenya's drylands. Dams and wells are drying up and loss of human life and livestock is increasingly frequent. Droughts cause food shortages, affect the quality and quantity of water resources, reduce incomes and aggravate poverty in the region. The vulnerability of pastoral livelihoods is

exacerbated by conflict and insecurity. The causes of conflict are complex, related both to strategies to acquire wealth (cattle), political developments, marginalization, the failure of the state to provide security infrastructure and the loss of – and search for – dry season pastures (Eriksen and Lind, 2009). As pastoralists migrate to areas where they can access pasture and water, bloody confrontations have occurred between various pastoralist communities and among clans of the same community. For instance, on 15 September 2009 *Daily Nation*, a popular national newspaper, reported that 31 people were killed in a cattle rustling battle between community members of the Samburu and Pokot. Conflicts have even crossed country borders creating serious diplomatic feuds between Kenya and its neighbours. On 6 October 2006, *The Standard* newspaper, another popular national daily, reported Kenya police had shot dead 16 Ethiopian cattle rustlers and a Kenyan woman. The northern region of Kenya borders parts of Somalia, Southern Sudan, Southern Ethiopia and Eastern Uganda (Figure 1), where the proliferation of small arms among pastoralists is a major security concern.

In this context of vulnerability and loss of pastoral livelihoods, the harvesting of gums and resins could provide a much needed source of income. At the same time, the same contextual factors with which livestock keeping is faced, including conflict and poor infrastructure, may also constitute challenges for gums and resin harvesting and its ability to support flexible pastoral livelihoods. Investigating the role of gums and resins in current livelihoods is important in order to enhance our understanding of the potential and limits to enhancing social equity and environmental integrity – that is, sustainable adaptation – through livelihood diversification and increased exploitation of indigenous vegetation resources.

3. Methods and study areas

This article presents research carried out between 2006 and 2008 on dryland vegetation resources. The study applied participatory approaches involving a semi-structured questionnaire, and interviews covering a checklist of questions related to various vegetation resources, including gums and resins. This process analysed the socio-economic status and conditions of the rural community through sharing, planning and exchanging of ideas in order to identify problems. The method focused on local communities and local traders in districts in northern Kenya where gums- and resins-producing tree species were abundant and the collection and marketing of gums and resins was well defined. These districts include Isiolo, Garissa, Wajir, Mandera, Moyale, Marsabit and Samburu. Areas with high levels of distribution, collection and marketing of these products (Beentje, 1994; Chikamai and Gachathi, 1994; Gachathi, 1994; Curry, 2000; Chikamai, 2002; Chikamai and Odera, 2002; authors' research) and local communities were given preference.

In the field, a random sampling design was used in the sample plots to determine densities of the resources. The sample plots were in part determined by accessibility, and the approximate location and the total number of the plots were determined by the size of the area of occurrence of the resource; that is, the larger the area covered, the more sample plots. Sample plots of 20 m × 20 m (0.04 ha) were established using a 30 m linear tape. Details of the plots' GPS location were recorded in the field data sheets. Both the botanical and local names of the resources being assessed were recorded. Other details taken in each sample plot were:

- number of mature trees (trees that were producing gums or resins)
- number of juvenile trees or saplings (those that were too young to produce gum)
- soil type (sandy, rocky, loam, black cotton, etc.)
- extent of the resource and names of the collection centres in the area, and
- names of members of the local community interviewed at the site and their contacts.

GIS mapping techniques were applied in generating distribution maps of the resources.

Socio-economic information was collected with the mutual understanding that personal information would be confidential. Personal details included sex, age, marital status and household income. The general objective was to discover the different types of resources traded, the types of collector, the traders and the entire chain through to exporters, to understand the constraints and opportunities in the gums and resins sub-sector. In addition, the socio-economic information was intended to capture the effects of environmental and climate variability and change, including through water shortage, death of animals and increased conflict. Other information included gum collection records, post-collection handling, utilization and marketing. Respondents also provided data on seasonality and distribution of the resources. About 200 members of the local population were interviewed alongside gum collectors, traders and their agents.

4. Findings

4.1. The use of gums and resins resources

Kenya has significant resources of gum arabic and gum resins, with commercial production confined to the north of the country (Figure 2). Trees and shrubs that dominate the drylands and form an important component of the vegetation are often referred to as *Acacia-Commiphora* woodland (Beentje, 1994). Traded gum arabic is from *Acacia senegal* (L.) Willd. var. *kerensis* or *Acacia seyal* Del. var. *seyal*. Gum resins are myrrh from *Commiphora myrrha* (Nees) Engl., oppoponax or hagar from *Commiphora holtziana* Engl. and frankincense from *Boswellia neglecta* S. Moore.

The study revealed that the production of gums and resins is relatively widespread. A total of 198 temporary sample plots were marked in all areas where the resource occurred, which were used to assess densities and distribution. *A. senegal* was distributed throughout the seven districts, with densities ranging from 975 to 1,008 trees/ha. *A. seyal* was found in Moyale, Wajir and Mandera where densities of 278 and 277 trees/ha were recorded. *C. myrrha* was confined to Wajir and Mandera and had densities ranging between 100 and 83 trees/ha. *C. holtziana* occurred in all districts with densities ranging between 221 and 154 trees/ha. *B. neglecta* was found in all the districts with densities ranging between 600 and 95 trees/ha. Annual production estimates were: 2,000 tonnes for gum arabic; 2,500 tonnes for hagar; 900 tonnes for myrrh; and 100 tonnes for frankincense.

Interview data suggest that the collection of gums and resins is an activity largely carried out by pastoralist peasants who can be classified as follows:

- Poorest of the poor in the community. These are people who either have no livestock or have very few animals left. Mostly they or their parents have lost livestock due to raids through banditry, rustling, drought or disease or when a father dies and the children are left as orphans or without proper care.
- Women and female children as they fetch water, firewood or tend livestock.
- Emerging gums and gum resin opportunists, that is, those cashing in on emerging opportunities in the sub-sector in addition to their normal livelihoods activities.

Gum and resin harvesting appears to represent a source of income for many of the poorest and vulnerable groups (in addition to emerging opportunists) and may therefore contribute to alleviating poverty. The extent to which this activity is able to counteract social inequity (and support sustainable adaptation) depends on the levels of income, in particular the potential to provide an income high enough to meaningfully compensate or substitute that of livestock herding, or to assist people back into higher-income livelihoods, for example, through enabling restocking. The levels of collection,

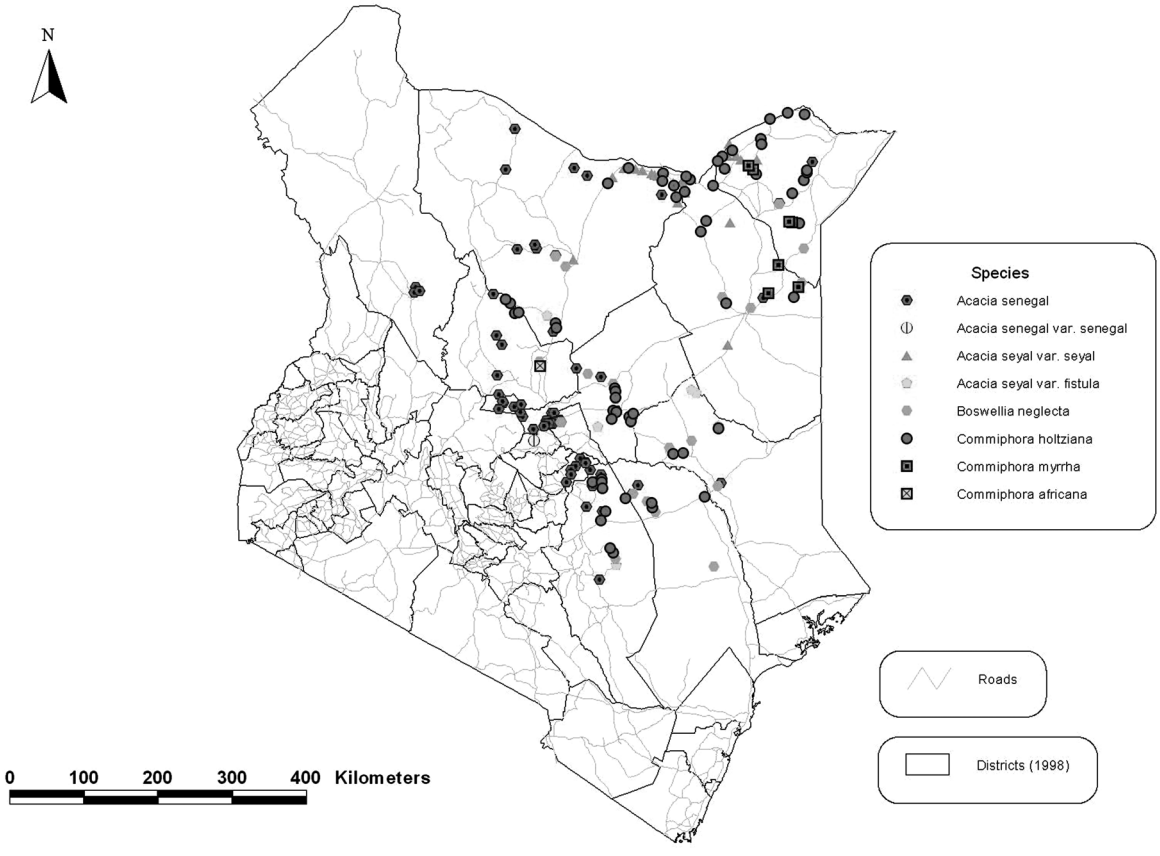

FIGURE 2 Distribution of gum arabic and gum resin resources

trade and incomes from this activity are investigated below.

4.2. Gum arabic: description, collection and trade

In its natural state gum arabic comes in a variety of shapes, colours and sizes. The colour of the gum may vary from colourless through different shades of yellow, amber, orange, red and dark brown. The best grades from *A. senegal* are in the form of whole, round 'tears', orange-brown in colour and with a matt surface texture. Gum from *A. seyal* is more friable than that produced by *A. senegal* and is rarely found as whole lumps. Use of gum arabic falls into three main sectors: the food industry, the pharmaceutical industry and industries such as printing, ceramics and textiles (Chikamai and Odera, 2002). Locally, it is eaten as food and has some medicinal uses.

The local population exploits the resource for both subsistence and commercial purposes. Subsistence exploitation, which involved collection of gum arabic for use as food, is common in times of food scarcity and when herding livestock. Commercial exploitation involved collection of gum arabic for sale in cash or in exchange for commodities including foodstuffs.

Gum arabic is not tapped but usually collected from natural exudation or other forms of injury. The gum is removed by hand, or if hard, knocked off by a machete or stick, occasionally dropping on the ground and getting contaminated with soil. No special container is used although most collectors use plastic or gunny bags (burlap sacks). The amount collected varies depending on the collector and the season.

During a good gum season a collector can collect an average of 5 kg in a day. Allowing for other family activities, a collector may work an average of four days a week and the total volume collected in a month be as high as 100 kg. The gum is brought home and kept in similar but bigger containers while awaiting sale. The gum is sold either to local agents in remote areas in the bush or traders in local trading centres. Two modes of sale are commonly used: barter, which involves exchange of gums for foodstuffs (e.g. sugar, maize flour, rice, beans, tea leaves, salt) or other goods (beads, tobacco, human or livestock medicines) and cash. Prices vary greatly, from a peak of KES120 per kg in 1994 to an average of KES35 per kg in 2010. This translates to KES 4,000 per collector per month. Costs incurred by a collector are mostly in kind. Table 1 presents a summary of the activities in production and income.

4.3. Myrrh: description, collection and trade

Myrrh is the gum–resin exudate from the stems of *C. myrrha*. It oozes and hardens to form lumps of varying shapes and sizes of variable colour from red, brown to dark brown. Locally, it is used to make ink used in Quranic schools, for burning to repel snakes and offensive insects and in medicine to treat various ailments. Its commercial uses are mainly essential oils, cosmetics, flavourings, antiseptics and other medicines.

Myrrh is collected after the trees are tapped. This is done by organized groups of men called malmaley (malmal collectors). They live in camps each covering about 4 km^2 where each person is allocated an area with about 200–300 trees and can tap up to 100 trees per day. A specially designed axe is used for tapping and collecting myrrh. A single malmaley can collect up to 5 kg per day during the pick season. As they are in the camp throughout the tapping season, collection is a continuous process and a person can collect up to 150 kg in a month. Myrrh is collected in a tin or plastic container and stored at a collection centre in gunny bags with a polythene lining to prevent loss of volatile components. Myrrh is sold to wholesalers who also own general shops. Prices of myrrh ranged between KES80 and KES120 per kg. Taking an average of KES100 per kilo, a malmaley earns up to KES15,000 per month. Costs incurred are either in kind or foodstuffs, medicines, tapping and storage equipment, which account for up to 3,500 per malmaley per month. A malmaley therefore has a net income of about KES11,500 per month. Table 1 presents a summary of the activities in production and income.

TABLE 1 A summary of activities and income at collection stage (100 KSh is approximately 0.75 GBP)

Activity	Gum	Myrrh	Hagar	Frankincense
Average amount collected per day/person (kg)	5	5	8	4
Average monthly collection (kg)	100	150	160	80
Operational costs (labour, transport, etc.)	Kind	3,500	Kind	Kind
Average sale price (KES/kg)	35	100	45	35
Gross income per month per person (KES)	3,500	11,500	7,200	2,800

4.4. Hagar (opoponax): description, collection and trade

Hagar is oily resin exudate from the stems of *Commiphora holtziana*. It oozes out and hardens to form lumps of various sizes and shapes with variable colour from yellow to dark brown or black. Locally, hagar is used as acaricide against ticks, snakebites, scorpions, foot rot, mange and other livestock ailments. Commercially, it is a well-established herbal medicine, and used in essential oils and cosmetics.

Hagar is tapped in the same way as myrrh. But unlike myrrh, which is restricted to Wajir and Mandera districts, hagar has a very wide distribution and has the highest volume of commercial gum resins traded in northern Kenya. In addition, women are also involved in collection of hagar. Experienced tappers would collect up to 8 kg per day in the pick season and the total volume collected in a month could go up to 160 kg. Prices of hagar ranged from KES30 to KES60. At an average of KES45 per kg, a collector earns KES7,200 per month. Table 1 presents a summary of the activities in production and income.

4.5 Frankincense: description, collection and trade

Frankincense is the exudate from the stems of *B. neglecta*. It oozes out in small droplets that harden to form nodules or large lumps. It is of two types, black and white. Locally, it is used as chewing gum, burnt as incense, as perfume and as medicine for a wide range of ailments. Commercially, it is used for essential oil in the perfumery, cosmetics and the flavouring industry.

Collection of frankincense is done by women and children. Frankincense is largely marketed locally. Collection is tedious as much of it is gathered from the ground. During the study period, an average collector would collect about 4 kg per day or 80 kg in a month. Prices of frankincense ranged from KES20 to KES50 per kg, which translates to KES2,800 per month. Table 1 presents a summary of the activities in production and income.

The investigation reveals that the income from gum and resin collection can be substantial, but is probably fairly low for many. Incomes are highly gendered since the highest income activity, myrrh collection, is carried out mainly by men. The results indicate that at present, gum and resin collection cannot substitute livestock herding as a viable and profitable livelihood option. Nevertheless, the collection only takes place during the dry season and drought hence providing an important additional income and may in principle alleviate the need to sell off livestock. Clearly, many of the collectors were poor, but the data cannot easily reveal whether gum and resin collection is an indication of a failed pastoralist and lack of decent income options or an option to rebuild livelihoods. Only some of the members of the first category of collectors (poor people in the community) could potentially directly use the proceeds to restock since the other categories, including women and children and emerging opportunists were not livestock owners. Since a head of cattle costs several thousand Kenyan shillings (the exact price depends on the state of the animal and the season), a collector would have to be at the higher end of the income range and save most of a month's earnings to be able to buy a head of cattle (although small stock such as goats and sheep are cheaper and hence more easily acquired). The extent to which restocking actually took place in practice, directly or indirectly through the incomes of men and women collectors, could be a topic for future research. The next section explores some of the constraints and opportunities for making the activity an economically and environmentally viable activity, contributing to social equity and sustainable adaptation.

4.6. Constraints and opportunities

A number of constraints were identified in the gums and resins sub-sector. Generally, there was a lack of sound market information to guide opportunities, trends, prices and general quality requirements and there were no reliable buyers and/or local markets. This was more serious particularly when a buyer was 'on and off', usually with different prices for the same commodity. The price of gums and resins was also highly variable. Interviews with gum merchants revealed that trade in gum arabic in particular greatly depended on world demand and supply. There were low volumes of production in the major producing countries of Sudan and Nigeria in 1992/93

and the resulting shortage led to an increase in prices and a search for potential production areas in other countries. Consequently, the prices soared in 1994/95 stimulating high production among Kenyan producers, which in turn led to plummeting prices the following year.

There was lack of operational capital to both collectors and traders. The collectors required cash to meet their basic needs and to be able to fully engage in collection. Equally, traders required enough available capital to buy all gums and resins from collectors. Often they lacked such capital, and it was observed that most traders used some form of barter trade using groceries in exchange for gums and resins. The issue of poor-quality gum and gum resins was also significant. Reduced quality resulted from harvesting, cleaning and handling practices; adulteration by either accidental or deliberate mixing of various gums or resins by the collectors or traders; and collection of immature products. This contributed to the fall in prices after the 1994 peak. Collectors lacked experience on tapping and handling of gums. There was a lot of damage to some of the resources, especially *C. myrrha*, through poor and excessive tapping.

These products were collected in the wild and on communally owned land. There was no clear government policy in support of production and marketing of gums and resins in the country or on access and use of dryland resources. Insecurity caused by bandits and cattle rustlers was a major concern and limited the extent to which gums and resins could be fully exploited. Dangerous wild animals also posed problems, including snakes. Lack of access roads and infrastructure/facilities and inadequacy of transport to potential production areas made mobilization of collectors, collection and transportation of harvested gums and resins very difficult. These resources are found in hot and dry areas. Drinking water requirement for the collectors was very high, but drinking water is very scarce in these areas, contributing to inefficiency of the collectors. The activity is affected by threats to the trees from which gums and resins are harvested. Recurrent droughts as experienced in 1998, 2000, 2004 and 2008 greatly affected gum production and many trees died. Tree damage through clearing and de-branching by local people for fencing *bomas* (homesteads) resulted in decreased production. Natural regeneration was often affected largely by livestock, especially goats through grazing and trampling and humans through burning. Gum and resin collection is hence limited as a livelihood option by a combination of market factors, poverty, conflict, policy neglect and environmental factors. The same development shortcomings that contribute to the marginalization of dryland populations in general also constrain the potential of gum and resin collection to form part of sustainable adaptation.

Despite these limitations, the previous section showed that gums and resins provide a valuable source of income for many poor households and casual labourers as well as businessmen in Kenya's drylands, while creating jobs for the end-user industries, as thousands of people make use of these natural products in their everyday life. Drylands are characterized by high poverty levels and food insecurity. Livelihood options are limited and the majority of the population are classified as poor. Gum and resin collection offers potential to diversify the local communities' income base and hence improve their livelihoods. There are some efforts to exploit this potential. The Gum Arabic and Resin Association (GARA) was formed to coordinate and spur the development of the industry in the country. GARA is a useful body for advising the government on formulating enabling policies; producers on sound production and quality control practices; and traders on good business practice for the benefit of the domestic and export markets. There are also training programmes for collectors run by the Kenya Forestry Research Institute (KEFRI) aimed at promoting activities for the development of gums and resins in drylands. However, these efforts cannot fully compensate for the lack of policy and infrastructural support in the drylands to date.

There is great potential in the cultural and social knowledge inherent in gum and resin collection, both in terms of social and environmental sustainability. The majority of the northern Kenya dryland inhabitants are (Kenyan) Somalis and the Oromo group, the majority being Muslims. These groups have a strong attachment to gums and resins, which are used for subsistence as well as commerce. They value these resources and have conserved them over long periods. The Somali community in particular traded these products through the former Somalia Republic. With the collapse of the Somalia Republic in the 1990s, most dealers relocated to Nairobi, helping to widen the trade of gums and resins in the country. All these players had a rich history in and knowledge of gums and resins, presenting opportunities for increased collection and local demand for the products. Efforts to strengthen local knowledge and indigenous plant-based activities could be linked to international programmes. International conventions on environment, especially the Convention on Biological Diversity and Convention on Combating Desertification, indirectly support development activities in the gums and resins sub-sector. Programmes developed in the light of these conventions stand a better chance of accessing funds from various international donors.

5. Discussion and conclusions

There is potential for gum and resin collection to contribute to social equity and environmental integrity and hence support sustainable adaptation. This potential is largely underused, however. Plant gums and resins fall into the category of non-wood forest products. They are renewable resources that could be sustainably exploited for household income and still conserve biological diversity and ecosystem functions while increasing the overall productivity of the land. This requires addressing the market, poverty, insecurity and policy factors currently constraining incomes as well as improving some of the tapping practices currently leading to damage to trees. Sustainable forest use would guarantee that goods and services could continue to be provided from the forest ecosystem under environmental, social and economic parameters. They could serve as raw materials for enterprises based on them, thus generating employment and raising the socio-economic status of poor populations (FAO, 1995). Forest investments based on non-wood products could even be more efficient and resilient, particularly if certification is included. This is especially important to Kenya's drylands since there exist few alternatives for supporting livelihood because of the difficult environmental conditions. The conditions have been worsened by increased recurrent drought and occasional flooding that has killed many livestock; the main economic, cultural and social support for the local population. One advantage of gum and resin resources is their ability to produce marketable products in the dry season when forage is scarce. The potential prospects for these resources would be even greater if they were to be properly developed (NAS, 1979; Stiles, 1988).

Gum and resin collection as a livelihood option is consistent with many policy goals. However, policy implementation has failed to support the activity in practice. Woodlands producing gums and resins have the potential to address climate change through carbon sequestration, or fixing of carbon. Among the many local environmental services they provide are soil conservation (i.e. protection against erosion and maintenance of fertility), shelter against wind and shade. Vision 2030 is a policy document that aims to launch Kenya's economic recovery strategy to bring the country up to a middle-income status with an average annual growth rate of 10%. The strategy recognizes the potential of the drylands to supply marketable commodities on a sustainable basis, among them, gums and resins. The Poverty Reduction Strategy Paper (PRSP) covering the period 2001–2004 puts a lot of emphasis on embracing environmentally sustainable development. It highlights the causal links between poverty and

environment, health, government policies and institutional failures. However, the government has so far failed to implement the PRSP as per the action plan (SIDA, 2003). Environmental benefits of forest in the drylands have long been underemphasized or ignored by planners and decision-makers because they are very hard to value, and many lie far outside formal markets and pricing mechanisms (Republic of Kenya, 2003).

Successful development calls for recognizing the potential of dryland ecosystems and key commercial natural resources, supporting institutional structures and opportunities for diversifying income sources, a transition to a cash economy, creation of employment and sustainable management of the resource base. The role of gums and resins is one component of a number of non-wood forest products, which if integrated and balanced with other opportunities for dryland management, can contribute to the economic well-being and long-term viability dryland areas. There is, however, a need to understand local knowledge, land-use systems and social structures in order to be able to assist in adapting and strengthening them. As all gum and resin collection is from communally owned land, land tenure change, for example, has crucial impacts on land use and conflicts.

This study illustrates that local knowledge-based activities do not automatically lead to viable incomes and sustainable management of the resource base. However, if some of the constraints identified above can be addressed, plant gums and gum resins remain a potentially important option for livelihood diversification in Kenya's drylands, which could complement livestock production and alleviate vulnerability associated with conflict, livestock loss, drought and marginalization of pastoralism. The sub-sector has a positive impact on the economy at individual, household, community and even at national level. However, strengthening the development of this sub-sector requires a wide range of measures. Areas to emphasize include: human resource development, community participation, marketing of resources, infrastructure development, promotion of micro-enterprises and research.

Many of the constraints to gum collection identified in this study are related to poverty and a lack of infrastructure. This observation suggests that some of the contextual factors leading to the marginalization of livestock keeping are also limiting gum and resin harvesting as a livelihood option. Clearly, contextual factors creating social vulnerability among dryland populations need to be addressed if gum and resin collection is to successfully contribute to sustainable adaptation. This has important implications for how we understand the principles of sustainable adaptation identified by Eriksen et al. (2011); that is, adhering to one of the four principles alone is unlikely to successfully lead to socially equitable and environmentally sound forms of adaptation. Instead, the principles are closely related and interdependent and need to be addressed together. In the case of gum and resin collection the third principle – building adaptation on local knowledge – will not contribute to sustainable adaptation unless the first principle – contextual factors and multiple stressors – is also addressed.

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