



THE ROLE OF *BOSWELLIA* AND *COMMIPHORA* SPECIES IN RURAL LIVELIHOOD SECURITY AND CLIMATE CHANGE ADAPTATION IN THE HORN OF AFRICA: CASE STUDY OF NORTH- EASTERN KENYA

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Abstract

*This paper focuses on local people's knowledge and attitudes towards vulnerability to climate change and impacts – including adaptation measures – on their lives. It also examines the important role of the aromatic resin producing species of *Boswellia* and *Commiphora* species in alleviating poverty, providing a large variety of products for household consumption, direct sale, and generally protecting the environment. A survey was conducted in the Wajir district of north-eastern Kenya among four community livelihood categories, through questionnaire based interviews. Results from descriptive statistics suggest that management of *Boswellia* and *Commiphora* species for goods and services has a definite added economic advantage, both at community and national levels, and lends incentive in combating land degradation based on the principle of multiple uses. This study demonstrates that Kenya adopts an integrated approach addressing the environmental and socio-economic aspects of the impacts of climate change and integrates strategies for poverty eradication into efforts to adapt to climate change. The study emphasises the potential for using these species, as a component of a silvo-pastoral system, for not only fulfilling subsistence requirement, but also for increasing land productivity, improving the economic condition of farmers and helping to achieve policy impact at the government level, the private sector and civil society on this subject of climatic change and adaptation.*

Keywords: *adaptation, resins, boswellia, climate change, commiphora, livelihood, north-eastern Kenya.*

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Introduction

Climate change, interacting with human drivers such as deforestation and forest fires, is a threat to Africa's forest ecosystems (Boko et al. 2007). According to available records, about 80% of the landmass in Kenya is dryland wherein agriculture is exposed to the vicissitudes of an irregular rainfall pattern. These areas support about 30% of the human population and slightly more than 70% of the livestock population.

Boswellia and *Commiphora* species, which belong to the family Burseraceae, are useful multipurpose trees growing naturally in the dry areas of the Horn of Africa (consisting of Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan and Uganda) and southern Arabia. However, proper development of the *Boswellia* species and frankincense sub-sector is constrained by lack of reliable information and data on which to make informed decisions and formulation of appropriate policies to support the industry. No significant effort has been made to fill the knowledge gaps on how to improve yield, quality of the product and marketing. Furthermore, the contribution of the olibanum trade in improving the livelihoods of the communities remains unknown (Luvanda et al. 2007). Besides, these species are under threat of being cleared for farming purposes in the drylands of Kenya. This paper discusses the effect of *Boswellia* and *Commiphora* resources on livelihood improvement and poverty alleviation in Wajir in north-eastern Kenya. The study also describes the livelihood groups (pastoralists, agro-pastoralists, villagers and internally displaced persons (IDPs) in the light of climate change adaptation and mitigation. Livelihood as used in this paper refers to "the capabilities, assets (including both material and social) and activities required for a means of living. The following paragraphs provide a summarized overview of the livelihood groups.

In this study, nomadic pastoralists are considered as those who get more than 50 % of their livelihood from livestock and livestock related products (cf. Encyclopaedia Britannica 1973-10974). Pastoralism has long been an integral part of dryland inhabitants' history, land use and economy. According to Chikamai and Odera (2002), among pastoralist groups, seasonal transhumance and regular daily movement of herds between pastures help avert overuse of a single area's biomass and help avoid disease in their livestock.

Agro-pastoralists are farmers who practice mixed farming of livestock and rainfed agriculture. They are also considered in this study as those who earn more than 50 % of their livelihood from crop production and the rest from livestock production. They represent the second most important category and encompass both the original inhabitants and immigrants from high potential areas.

Apart from pastoralism and agro-pastoralism, most of the urban dwellers, in either bigger towns like Wajir or other divisions, earn their livelihood from other sources, other than livestock or crop production. They are either formal employees earning salaries or informal employees, such as shop owners, firewood collectors, resin collectors. On the basis of the foregoing, villagers are classified as those who derive more than 50 % of their daily livelihood from either formal or informal employment, other than livestock rearing or crop production.

In this paper, IDPs refer to persons or groups of people who have been forced or obliged to flee or to leave their homes or places of habitual residence in particular, as result of or in order to avoid the effects of armed conflicts, situation of generalised violence, violation of human rights, or natural or human made disasters, and who have not crossed an internationally recognised state border (Clover 2002).

The contention of this paper is that improved commercial extraction of NTFPs is an important economic incentive to manage the woodlands sustainably, and integrated *Boswellia* and *Commiphora* species as components of silvo-pastoral systems could significantly contribute to reduction of rural poverty and enhance adaptability to climate change in Kenya.

Materials and Methods

Study Area

The study was carried out in Wajir District of north-eastern Kenya, 492 km north-east of Nairobi. The District lies between latitude 01° 45' 0'' N and longitude 40° 03' 40'' E. Wajir District is the largest district in North-Eastern Province and the second largest in the Republic of Kenya after Turkana. The total human population of Wajir district was 400,000 persons (1999 census), with a population growth rate of 3.7 %. More than 50 % of the population is younger than 26 years old and the average family size is six members (PricewaterhouseCoopers 2005).

Climatically, Wajir lies in the arid and very-arid zones prone to drought. The rainfall is scarce and erratic in the region, with two rainy seasons: the spring rains, locally known as *gu* is from March to May; and the autumn rains, locally known as *dayr* lasts from October to December. With an annual average rainfall between 250 mm to 300 mm, Wajir is classified as Arid Land, prone to droughts. The area has a mean annual temperature of 28°C. The hottest months are January to March, during these months temperatures exceed 30°C. June to September is the coolest time of the year. Though these months are dry, the cool weather and low evaporation rate favour continuous growth of vegetation (PricewaterhouseCoopers 2005). Generally, the vegetation of the zone is bushland and shrubland. To some extent in Wajir

District, *Acacia-Commiphora* woodland can be found. The three most common genera are *Acacia*, *Boswellia* and *Commiphora*.

Data Collection and Analysis

Data were collected based on questionnaire as well as group discussions to gather information from the households and from village leaders, special groups and key informants. A survey of 45 households was carried out in Wajir District in July 2007. A representative sample of 31% nomadic pastoralists, 33% Villagers, 20% IDPs and 16% agro-pastoralist, were randomly selected for the study. Respondents were selected by a simple random sampling procedure, which was representative of the farming system categories in Wajir District.

A reconnaissance market survey was carried out to investigate to what extent *Boswellia* and *Commiphora* available in the study area had any commercial potential. During this survey, a number of parameters had been taken into account (Table 1).

Table 1. Parameters and Type of Information Gathered for the Market Survey

Parameter	Information gathered
Marketing channels	- Location of assembly (retailers/wholesaler)
Efficiency	- Factors influencing location of assembly
	- Number of enterprises
	- Characteristics of enterprises (owners, size, diversity and quantities of products etc)
	- Adaptation of new practices
Products	- Consumers
	- Quality and stocking of frankincense and myrrh
	- Possible substitutes
	- Conservation
Yield	- Quantity bought and sold
Prices	- Buying and selling prices
	- Seasonality of availability and price fluctuations
	- Organisation of transport
	- Constraints of transport

Sources of secondary data used included previous inventories, project documents, articles, published reports, books and statistics, which provided baseline information for study. Data collected were coded, computerised and analysed using Statistical Package for Social Sciences (SPSS) for Windows.

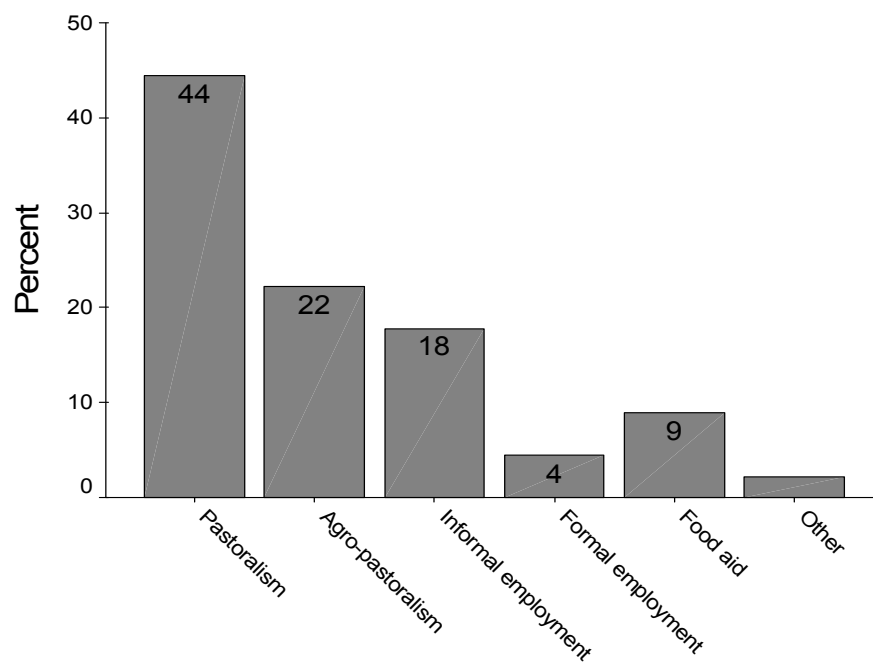
Results

Livelihood Assets

a. Main Source of Household Income

From the economic related information of the respondents, there were various categories of alternative income sources. The results show that 44% of the respondents get their livelihood support from pastoralism, 22% from agro-pastoralism and 18% from informal employment. Results also indicate that 9% depended on food aid. Four percent of respondents received income through formal employment while 2% from other sources (Fig. 1). When the level of education with means of household income was examined, about 60% of the respondents who engaged in pastoralism, agro-pastoralism and informal employment were illiterate. The result also shows that about 11 % of the illiterate respondents depended on food aid.

Fig.1. The Sources of Subsistence of the Respondents in the Study Area



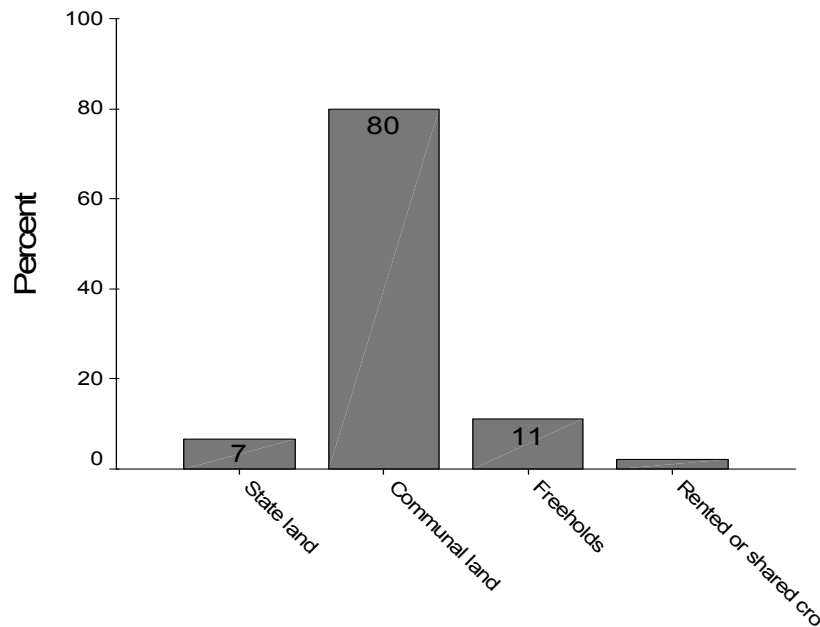
b. Land Tenure

The study result shows that, four major land tenure arrangements exist in the study area, namely, communal land⁵ (80 %), freehold⁶ (11 %), state land (7 %) and rented land (2 %) (Fig.2).

⁵ Communal land: land collectively owned by particular tribes or clans.

⁶ Freehold: Land held freely. Simply, it represents absolute ownership of the land.

Fig. 2. Land Tenureship in the Study Area



c. Socio-Economic Role and Uses of *Boswellia* and *Commiphora* Tree Products

- *Specific Uses of Boswellia Neglecta in the Study Area*

During the survey, the key informants were asked to list the specific uses of different parts of *Boswellia* and *Commiphora* tree species. The questions included parts of tree normally used and for what purpose i.e. for home consumption, for livestock feeding or for cash (see Tables 2 and 3).

Table 2. The Specific Uses of Different Parts of *Boswellia Neglecta* as Indicated by Respondents in the Study Area

Parts of Tree	Local Uses/Home Consumption	Commercial Uses
Leaves	Fodder for browsing animals	-
Flowers	Bee forage (honey production)	-
Bark	Dyes/tanning used for skin and hides processing,carves colouring, and also feed for goats and antelopes	-
Branches	Tool handles and the dry branches used for fuelwood.	-
Resin/frankincense	Incense/fumigation, chewing gum	Cash

- *Specific Uses of Commiphora species in the Study Area*

Photographs (Fig. 3) show that the stem and trunk of the *Commiphora* tree are used for making wooden utensils such as: “Heero” used for eating, “Dhiil” used for milking cows, camel, goats and sheep, “Haan” used for storing or carrying milk to market, and “Haruub” used as a lid for Haan and also for drinking milk. The branches are also used for tool handles, e.g. knife handle, axe handle.

Fig. 3. Household Dishes Made from *C. Molmol*



From left to right: Heero; Dhiil; Haan; Haruub (Photo: Badal A. Hassan).

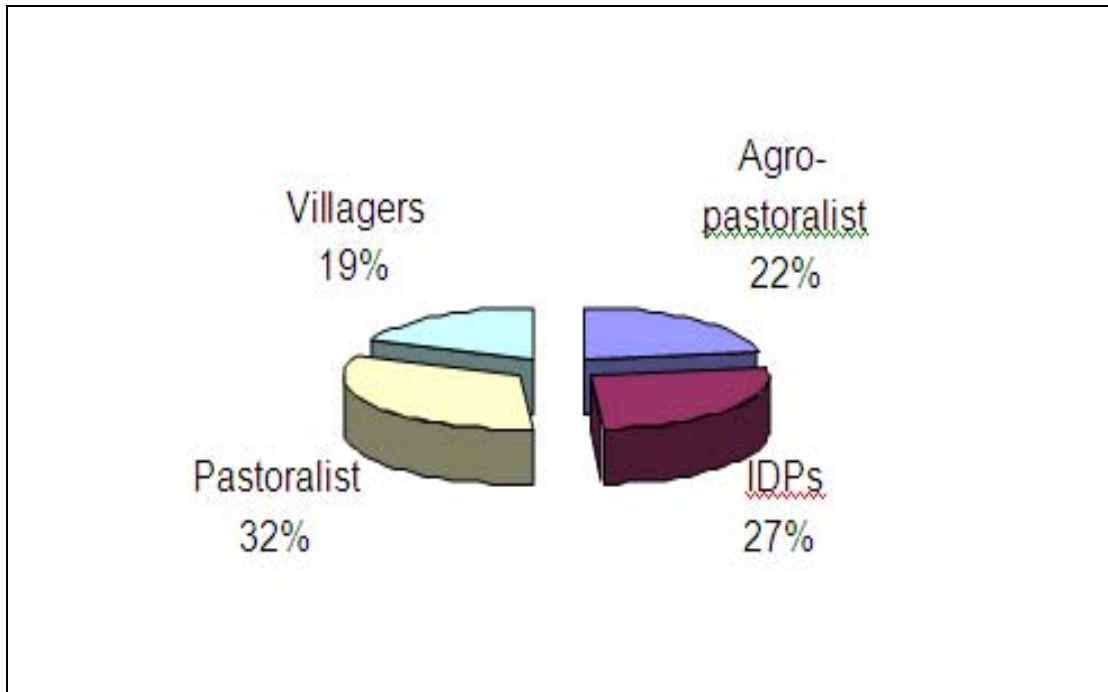
Table 3. The Specific Uses of Different Parts of *Commiphora* Trees as Indicated by Respondents in the Study Area

Parts of tree	Local uses/home consumption	Commercial uses
Leaves	Fodder for browsing animals	-
Flower	For bee forage	-
Stem	Wood carving, bee nesting	Yes
Branches	Tool handles and fuelwood	-
Bark	Dyes/tanning used for skin and hides processing, carves colouring,	-
Myrrh	Medicine, ink, fumigation, insecticide	Yes

- *Collection/Harvesting of Frankincense and Myrrh*

The study shows that, nomadic pastoralists (32%), IDPs (27%), agro-pastoralists (22%) and villagers (19 %) are the main collectors of frankincense and myrrh in the study area (Fig.4).

Fig. 4. Collection of Frankincense and Myrrh among Different Categories of Respondents



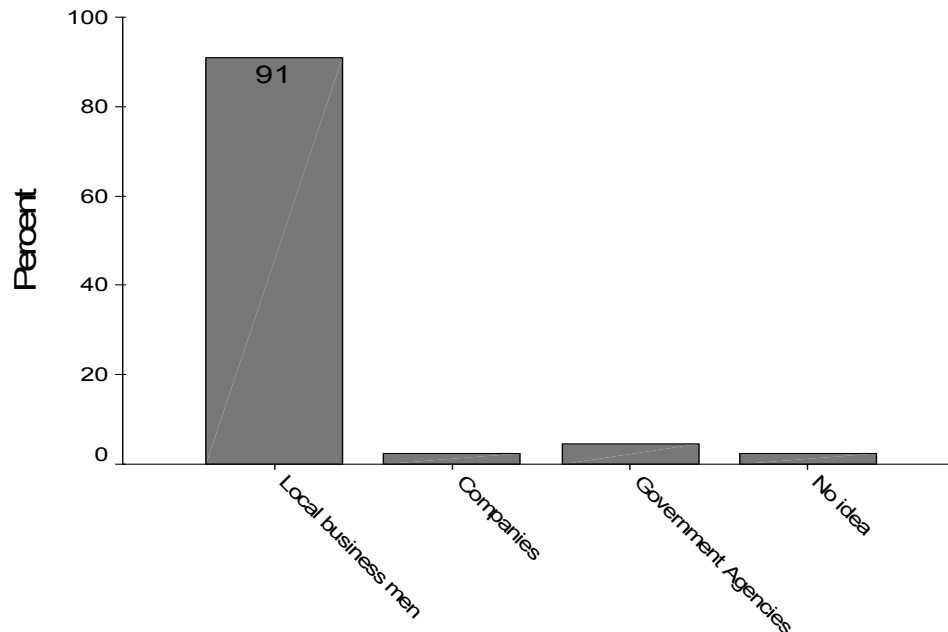
- Local Market Prices and Financial Returns from Selling Frankincense and Myrrh

Interview results for the price estimates of frankincense show an average of 16 Ksh/kg (\$0.2) of first grade frankincense and 9 Ksh/kg (\$0.1) of second grade frankincense. Results also indicate that the price of myrrh in the local market was 150 Ksh/kg (\$1.9) for grade one and 100 Ksh/kg (\$1.3) for grade two

Major Buyers of Frankincense and Myrrh in Wajir District and Employment Opportunity

Figure 5 indicates that 91 % of the buyers of frankincense and myrrh in the study area were local businessmen while 9 % belonged to government agencies, companies or others. Three big gum and resin stores in Wajir town employ local people.

Fig. 5. The Main Buyers of Frankincense and Myrrh in Wajir District as Indicated by Respondents



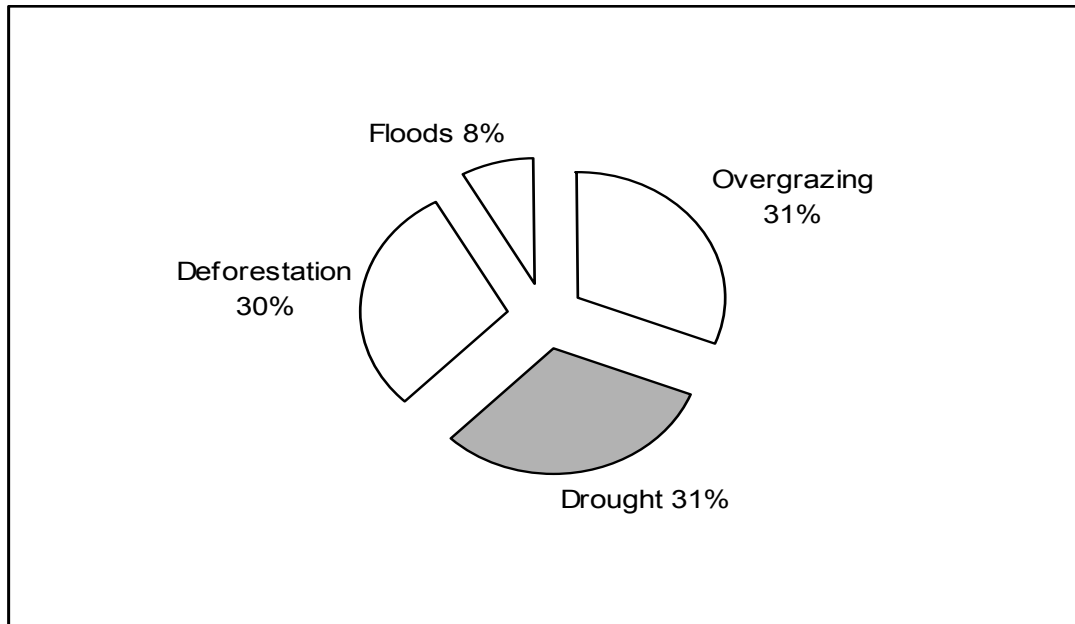
*Willingness to Plant *Boswellia* and *Commiphora* Trees for Agroforestry Purpose*

As part of focus group discussions, the interviewees were asked about their willingness to plant *Boswellia* and *Commiphora* species for agroforestry purposes. Eighty percent of male respondents and 90% of female respondents answered in affirmative that they were willing to plant. When asked where they would like to plant, however, they gave different views. For example, during the oral discussions, most of the women participants, preferred to plant *Boswellia* and *Commiphora* on the communal land, while men preferred to plant on the farm.

Climate Vulnerability

In terms of vulnerability and seasonality, factors undermining livelihoods were linked to reduction in resources as perceived by local people in study area. The number of people who referred to certain cause was interpreted as indicating the strength of that particular factor. Results (Fig.6) indicate that respondents ranked the causes of resource degradation in the following order: Overgrazing (31%), Drought (31%), deforestation (30%) and floods (8%).

Fig. 6. Major Causes of Resource Decline as Indicated by the Respondents



Discussion

Livelihood Assets

a. Main Source of Household Income

Occupations and associated total annual household income level of respondents varied greatly between different categories in Wajir District. Results indicate that pastoralism was the main source of household income in the district as majority of the district population is nomadic. In spite of fragile ecosystems of Wajir District, results revealed that the area was rich in biodiversity. Results revealed that woody plants (e.g. *Boswellia* and *Commiphora* spp.) and woodlands constituted the major sources of essential goods and services, income, employment and capital. Although the communities continued to rely on livestock production, it was realized that communities lacked diversity in utilization patterns, and technologies for promoting multi-production systems.

Informal employment (e.g. petty trading) was also noted as a major means of household income. A possible explanation is that Wajir is close to the borders of Somalia and Ethiopia, therefore the district has potential market and people are trading along the borders. Against this backdrop, for successful development in the district, it is important to bear in mind the potential of Wajir area's ecosystems, the key resources, institutional structures and opportunities for supporting the drive toward diversifying income resources, the transition into the cash economy, creation of employment and sustainable management of resource bases.

b. Land Tenure

In the study area, four different types of land tenure, were noted, namely, communal land, freehold, state land and rented land. The result shows that, majority of the land was communally owned by pastoral community in the study area. A general characteristic of communal land system as practiced in the area showed that local authorities such as chiefs or village elders assigned certain land right to each member or household of the community. Communal land ownership and freehold land right were the two most common land tenure characteristics in the district. Some earlier studies confirm that customary systems are the de facto systems of land tenure in operation in many dryland zones, rather than statutory laws. In Africa, for example, most people hold their land under indigenous customary systems irrespective of formal legal position (UNDP 2003). Gausset et al. (2003) also suggest that, chiefs are in charge of distributing the land.

Information obtained from respondents, key informants and during group discussions revealed that, it was quite easy to own land in Wajir District under freehold: by clearing a piece of land or fencing, gives an individual the right to own that land under freehold. Similar study carried by Muok and Cheboiwo (2000), found that majority of the household sampled in Kitui District (Eastern province of Kenya) hold land under freehold.

However, key informants in the study area confessed that the land tenure systems were sometimes often complicated and necessitated mutual understanding and relationship between crop farmers and pastoralists in the study area, and between neighbouring pastoral communities. The mutual relationship was seen in cases of un-expected events e.g. drought affecting a community, the affected community can migrate to neighbouring community to graze their animals and vice versa in time of need.

According to Chikamai and Odera (2002), many communities in dryland areas still observe customary communal tenure systems, while the country recognizes private and state property- ownership regimes. This has tended to introduce an intolerable state of uncertainty of tenure for participants of communal property regimes.

Climate Vulnerability

a. Major Causes of Resource Degradation

In terms of vulnerability and risk factors undermining livelihoods, the study revealed that the natural resource base in north-eastern Kenya continues to be seriously threatened, disappearing or degrading at alarming rate due to over-grazing, long spells of drought and deforestation. Facts distilled from the analysis undertaken at the household level revealed the following.

b. Overgrazing

Possible explanations of overgrazing are that in Wajir District, both livestock from the farmers and from the pastoralists make excessive use of the limited fodder resources in the communal silvopastoral areas freely available for everyone. Livestock and other wildlife are mostly browsers and damage the barks of woody perennials e.g. *Boswellia* and *Commiphora* trees leading to outbreak especially on *Malma*. Land tenure arrangements were a disincentive to conservation; thus fencing off some areas was not acceptable at the individual level.

Results from group discussions and key informants revealed that pastoralism in Wajir was rapidly worsening at an alarming rate due to persistent droughts and overgrazing which continued to adversely affect the quality of the pastures in the area. They added that the situation was also made worse by influx of livestock from neighbouring districts as well as from the adjoining countries of Ethiopia and Somalia. This influx continued to exert increased pressure on an already fragile eco-system. Key informants in the area gave an estimate of the population of pastoral communities within Wajir District living below the poverty line as high as over 70%. A possible explanation for this finding is that the district is affected by unsuccessful natural resource development policies, which have led to inappropriate exploitation of the vast resource base.

In the study area, as in other parts of semi-arid Africa, the utilization of external inputs (e.g. chemical fertilizers) was not profitable under the circumstances, and land productivity depended largely on the natural resources.

The problem of resource degradation has received particular attention since the 1970's, when throughout the semi-arid zones in sub-Saharan Africa drought periods caused massive starvation of animals and food shortage among human populations. Katie (1993) in a study conducted in Baringo reported that drought can claim up to 80% of the stock and many years of recovery can force the pastoralists to settle.

A study by Lemenih et al. (2007) in north-western Ethiopia, confirms that woodlands in general and *Boswellia* forest in particular are declining from time to time, and deforestation and other human induced problems are the main causes of deforestation (tragedy of the commons), as they lack a responsible body for their management and conservation. The results of over-exploitation are well known: reduction of the vegetation cover and soil depletion by over-cropping and over-grazing lead to erosion, water runoff, loss of topsoil with its accompanying soil nutrients) and reduction of biodiversity (local disappearance of most palatable grasses, fodder trees and most wildlife). As land degradation proceeds, the productivity of the ecosystem decreases, leading to a reduction of crop and pasture yields

(Kessler 1993). This concurs with the observation in the field that many of the respondents in the area were destitute; as they faced shortage of fodder for livestock, lacked fuelwood and had limited incomes. The result of the present study is consistent with earlier findings of FAO (1993), which emphasized that overgrazing is widespread, thereby constraining the sustainable development of drylands, requiring inputs to improve animal husbandry and the integration of grazing control with water development. The same observations were made by Minae (1988) and O’Niell (1996) in a study conducted on the slopes of Mt. Kenya, in Embu District of the Eastern Province of Kenya. In their research, they found declining soil fertility, soil erosion, shortage of fodder for livestock, shortage of fuelwood and other wood products for households and farms, and limited income. This also in line with the findings of Akhtar-Schuster (2004), who stated that, the intensity and expansion of land degradation in arid, semi-arid and dry sub-humid regions affects the stability of rural households.

According to Kessler (1993), one of the main causes of degradation in sub-Saharan Africa was considered the energy crisis, leading to excessive woodcutting. Reforestation was therefore considered an important remedy. Early attempts of reforestation were mainly large-scale and centralized. Major disadvantages appeared to be the high costs and the low rate of participation from the rural communities. It should be mentioned that energy crisis has been rather overemphasized as a causal factor for land degradation. Clearing of land for agriculture is by far the most important factor contributing to reduction of the woody vegetation layer (Kessler 1993; Glover 2005; Luukkanen et al. 2006).

Mounting pressure on our natural resources due to rise in overgrazing, drought and deforestation has resulted in large-scale degradation of our environment and ecosystem, calling for immediate attention for seeking newer approaches in farming system to meet the basic needs of local people. Adoption of agroforestry on a wide range of land in Wajir District and incorporation of multipurpose trees in the existing farming/cropping system seems an apt option to achieve the objectives. Moreover, crop productivity is enhanced under tree canopy due to improved soil fertility (Young 1989) and ameliorative influence of shade in a hot dry environment by reducing understorey temperature and mitigating evapotranspiration (Bunderson et al. 1990). Experience has also shown that the benefit of deep-rooted vegetation for maintaining ecosystem functioning is a major attraction for using agroforestry for sustainable land and water management in areas where high energy input large scale agriculture is impractical (Ong et al. 2002 citing Kidd and Pimentel 1992). Uncertainty in production due to fluctuations in total rainfall and changes in its distribution, as well as decrease in relative

productivity in rainfed lands affect the livelihoods of many poor and marginalised farmers.

c. Deforestation

Exploitation of the vegetation in the silvopastoral areas also included cutting of woody plants, both illegally by people from urban areas and “legally” by villagers in search of extra incomes, together with exploitation of *Boswellia* and *Commiphora* trees as a wood reserve in times of scarcity. As a result, the natural resources of the silvopastoral areas were also increasingly overexploited. A possible explanation of the increasing pressure of livestock on silvopastoral areas may be the disappearance of the palatable, preferred species (both woody plants and herbs) and an increase in unpalatable, less preferred species. Moreover, herders were opening up woodland for agricultural development resulting in vegetation destruction. Such a development can be considered as a reduction of the carrying capacity of the rangelands. It was obvious that the resource degradation had adversely affected the livelihood of the people of Wajir, as the trend was mainly one of increasing exploitation of the natural resources, leading to over-exploitation in large areas from a lack of alternatives for a growing population.

d. Seasonality: Drought

By their very nature, agriculture in the drylands is exposed to the vicissitudes of an irregular rainfall pattern or frequent drought. Uncertainty in production due to fluctuations in total rainfall and changes in its distribution, decrease in relative productivity in rainfed lands along with other reasons affect the livelihoods of many poor and marginalised farmers. The geographic location and high sensitivity to climatic variability make north-eastern Kenya vulnerable. Large swathes of this area already experience more frequent and severe droughts and shrinking agricultural production. Information obtained from key informants, respondents and during group discussions revealed that droughts endangered and exacerbated poverty in Wajir District, where an average household was said to lose 40% of its cattle and 20% of its sheep and goats with each drought. Results also linked effects of drought with food deficiencies, food quality, high rate of land degradation, loss of human life and livestock, and drastic reduction of water resources particularly of pastoral communities.

One-third of the people in Africa live in drought-prone areas and are vulnerable to the impacts of droughts (World Water Forum, 2000). During the mid-1980s the economic losses from droughts totalled several hundred million U.S. dollars (Tarhule and Lamb, 2003). Droughts have affected mainly the Sahel, the Horn of Africa and southern Africa, particularly since the end of

the 1960s (see Richard et al., 2001; L'Hôte et al., 2002; Brooks, 2004; Christensen et al., 2007; Trenberth et al., 2007).

Adaptation to Climate Change

a. Increased Agro-Silvo-Pastoral System and Farm Diversification

North-eastern Kenyan farmers have developed several adaptation options to cope with current climate variability (Boko et al. 2007). For millennia, the pastoral communities living on the margins of society in the Horn of Africa have derived sustenance from forests mainly through harvesting and use of the Non-Timber Forest Products (NTFPs). The management and development of NTFPs are therefore viewed as one of the major participatory survival options for pastoral communities in the changing scenario of forest management in third world countries like Eritrea, Ethiopia, Kenya, Somalia and the Sudan. With regard to adaptation to the scarcity of forest products, respondents revealed that resident households reacted in two major ways as described in a comprehensive article entitled "Coping with deforestation: An analysis of local level responses" by Ghimire (1994): "*self-squeeze*" and "*self-reliance*". In *self-squeeze*, the farmer households developed various internal methods that allowed them to adapt to the growing shortage of forest products. Some rural households and communities diversify their livelihood sources due to climate change. For instance, some people seek off-farm wage employment during climatic hazards. Migration in search of non-farm employment and resettlement are other important measures adopted by communities and during the time of climate change. Another coping strategy usually adopted by livestock-owning households in response to climate change or in the dry seasons is to migrate with their livestock to open access dry season grazing sites (Agrawal 1999) and water points where forage is available. One of the principal *self-reliance* mechanisms involved the planting of trees, even though most households recognized that these trees occupy land that could be put to an alternative use and that annual crop yields may be reduced through the effect of tree shade (Ghimire 1994). Farmers in unproductive land have also begun planting trees for fodder and fuelwood.

Generally, a considerable number of local people already had considerable amount of experiences and benefits acquired from *Boswellia* and *Commiphora* tree species, and expressed their willingness to adopt an agro-silvo-pastoral system. The most important motive for adopting the system was the multipurpose benefits the local people could obtain from crop, tree, and livestock combinations. The most important result found on this study was the willingness among the majority of local people, especially women, to participate in tree planting. The emphasis was stronger among women as compared to men. Clearly, a majority of women wanted to have more trees

for income generation and satisfaction of their basic needs from the sale of products.

A majority of men also found tree planting acceptable, although some had different perceptions about its practicality and how it could be managed. Few held the opinion that giving up prime land for tree planting was not their desire, as they perceived that trees would regenerate naturally and did not see any evidence of planting. Likewise, responses received from a cross-section of respondents showed that the most important restraints were livestock grazing and unclear ownership although commercialization of the resource could lead to clear ownership of the land.

Results also indicate that men who showed interest in planting trees found integration of trees with their own farmlands acceptable. A similar study carried by Chikamai and Kagombe (2002) found that the Somali community respects ownership within the homestead and in these areas improvement of the resource has been done. A recent study in Gedaref area of eastern Sudan by Glover (2005) showed that land tenure and land security are crucial issues for the success of any tree planting project. He added that farmers who engaged in private tree planting were those who owned or had secure rights to the land they cultivated. However, contrary to his findings, results of the current study shows that land availability was not the limiting factor, because most of the land area of the district was communal, thus allowing every member of the community to plant trees like *Boswellia* and *Commiphora*. Also, in a study by Chikamai and Kagombe (2002), it was shown that the species have the potential for plantation establishment wherever the land is available.

With regard to community-level responses to overcome the problems associated with deforestation and forest degradation, it was observed that communities tried to strengthen their traditional resource management practices through collective actions. In this, several households came together to express their grievances or advance their specific interests. The prime aim of this was to increase productivity of available natural resources as well as to adopt wise resource-use practices.

Wiersum (1996) points out that the development significance of indigenous forest management is twofold: they are expressions of the livelihood strategies of rural households as well as expressions of indigenous knowledge of and experience in managing forest resources. He added that indigenous forest management practices are the expression of the multiple ways in which villagers interact with their natural environment in their daily livelihood strategies. They are based on local needs and values of communities with respect to forest resources.

b. Migration to Agricultural Frontiers

Given the menace of resource degradation, which threatened traditional land use practices, responses received at the household level and focus group discussions showed that community or collective reactions to cope with the changing environmental circumstances include the abandonment of settlements in order to migrate to agricultural frontiers (Ghimire 1994). Facts distilled from the analysis undertaken at the household level revealed that because of prolonged drought in 2006, many pastoralists had been forced to migrate long distances with herds in search of pasture. To survive the rugged arid and semi-arid conditions, herders usually move from place to place, taking their cows and other livestock to where there is water. Mobile lifestyle, resilience of local community and strong social networks were observed as coping strategies that help community cope with and adapt to the environment. This result concurs with the findings of Rioba et al. (2000) who also reported that the people of Wajir practise distress migration in times of hardship. Droughts have long contributed to human migration, cultural separation, population dislocation and the collapse of prehistoric and early historic societies (Pandey et al., 2003). It was observed that before taking such an extreme step to migrate, most households seek to adjust to changing socio-economic circumstances associated with resource degradation by suppressing subsistence levels, seeking wage employment, managing productive resources better and reducing their dependence on forest.

c. Consumption Coping Strategies

Local people adopted a number of consumption coping strategies in response to resource degradation by reducing food intake (twice instead of three daily meals); switching to lower-quality, cheaper cereals; seeking gifts of food; and relying on relatives, social support and humanitarian assistance. Without money from their livestock to buy essentials like maize, tea, sugar and soap, herdsman also turn to traders for credit. In good times this is rarely a problem, but when debtors have little chance to pay back what they owe, shopkeepers cut off credit lines. Across some parts of northern Kenya, locals have reported that even shops had closed.

d. Increased Dependence on Non-Agricultural Activities: The Importance of NTFPs and the Uses of *Boswellia* and *Commiphora* Resources

Diversified and integrated production systems using *Boswellia* and *Commiphora* species on small farms offer subsistence and an economic base of many forest-dependent poor in north-eastern Kenya, often serving as a buffer and safety net. These natural products play an important role in providing a large variety of goods, including products for household consumption, for direct sale or for manufacturing in household or village level. The role of

these trees to contribute to income generation is also very important, not only through the sale of fuel and construction material, but also through the sale of varieties of NTFPs, e.g. resins and honey. In addition, forests provide a home and a means of livelihood for large numbers of people, both traditional forest dwellers and those who find employment in extracting and harvesting commercial forest products (FAO 1985). The respondents identified many uses of *Boswellia* and *Commiphora* species, which help local people, remain competitive, endure land use and cultural transitions, as well as provide environmental amelioration with attendant societal benefits and livelihoods. The following paragraphs explain the uses of these tree species.

Interview results showed that the most important NTFPs are aromatic resins, i.e. frankincense and myrrh. They are part of almost every aspect of rural life and offer a range of possibilities to earn an income (Fig. 7). They are a traditional source of income for poor people in the rural area, especially the nomadic pastoralists. Frankincense is used for fumigation of houses to get rid of bad smell caused by urine from children's clothes and beddings, and in worship places as incense. Results also indicate that it was used for spiritual purposes by burning in mosques and as chewing gum. The bark was chewed to treat stomach disturbances and frankincense was burnt as mosquito repellent among other uses.

Results indicate that dry branches and trunks of *B. neglecta* were used for firewood; however, it was not used for charcoal production because of its low energy efficiency. The firewood problem, formerly mainly affecting women, has become a national issue affecting every member of the family. Information from respondents revealed that women spent an average of one to two hours collecting firewood. To solve the problem of firewood, in terms of quality, quantity and scarcity, farmers have planted trees on borderlines to act as boundary markers and at the same time provide firewood through pruning (Gondo and Kitheka 2000).

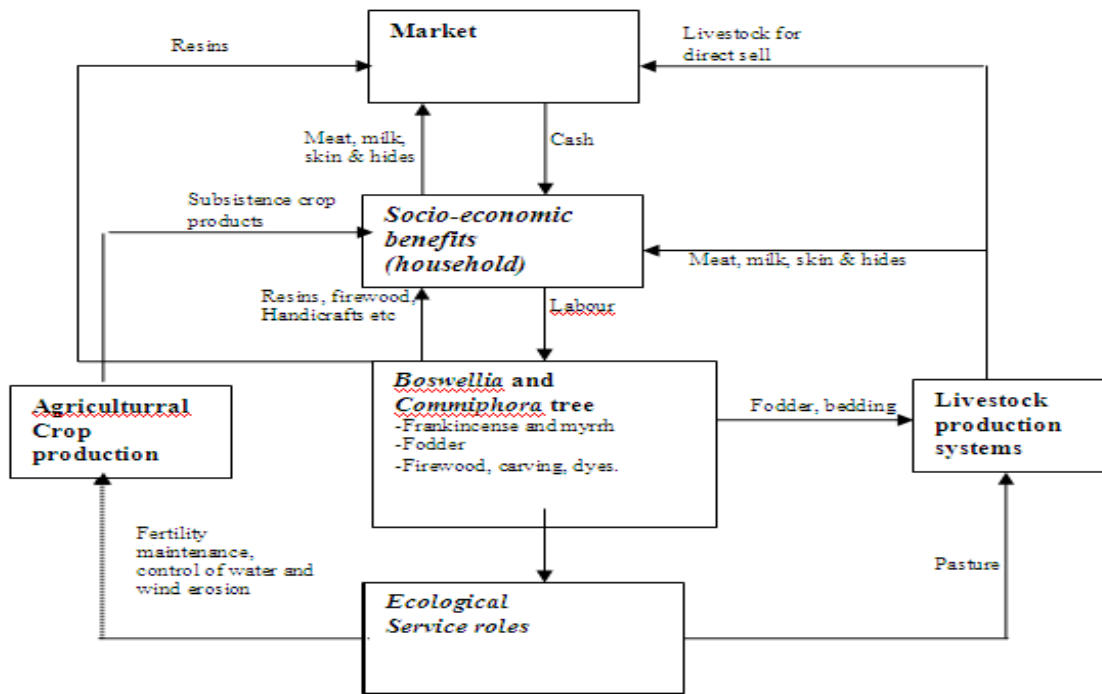
The research findings indicate that, pastoralism was the dominant mode of life in the district and the majority of Wajir District's population was dependent on livestock for their livelihood. The *Boswellia* and *Commiphora* species in the study area were very important sources of fodder for livestock. Leaves and seeds of the species were highly valued as fodder for goats and other livestock. The succulent stem was also used as fodder during the dry season. Mobile pastoralism is arguably the most efficient method of exploiting rangelands; and pastoral activities are practiced all over the district. According to Lemenih et al. (2002), the family of *Burseraceae* is known for its provision of nutritious fodder, and virtually all the *Burseraceae* are palatable to livestock, particularly in the dry season.

Honey and beeswax are two important NTFPs that have strong relationship with plants. Trees also provide much needed shade for keeping

hives cool under hot tropical climatic conditions. The long flowering period from October to February was helpful for bee forage. Bees are responsible for the pollination of many flowering plants and are therefore important in sustaining biodiversity (Luvanda et al. 2007).

Results indicate that dye was highly used in Wajir District in handcraft production. The bark of *Boswellia* and *Commiphora* species provided cheap dyestuff for carvings (see Fig. 7) and acted as a tanning agent for skin and hide processing, as well as colouring wooden household furniture.

Fig. 7. The Interaction Between *Boswellia/Commiphora* Tree Species And Other Components In Wajir District Farming System.



- Collection/Harvesting of Frankincense

Some households and communities in north-eastern Kenya diversify their livelihood sources due to climate change. For instance, collection or harvesting of *Boswellia* rather than cultivating crops when confronted with climatic risk is a diversification strategy. The results indicate that it is *only Boswellia* that is available for local people during the dry season when no crop is growing. The study also shows that pastoralists and other community groups in Wajir District, such as IDPs, agro-pastoralist and villagers collect frankincense and myrrh. Women and children of the nomadic pastoralists mainly do the collection of frankincense. According to results, local people in the study area tap *commiphora myrrha* but not *Boswellia neglecta*. In order to

obtain frankincense for *Boswellia neglecta*, physical damage by goats, wildlife or insects has to be inflicted to *Boswellia neglecta* to enable exudates to drip from the tress and be collected. The stem wood of *B. neglecta* has thin bark layer which is easily wounded by goats, wildlife and insects. Limited quantities are collected from wounds on the tree trunk where the inner bark has been removed. The resin drips to the ground and with air contact, the resin dries and hardens, after which the local people, particularly women and children (occasionally men), collect it from the ground during the dry season (see Fig. 8).

Fig. 8. Local Men Collecting Frankincense Under *B.Neglecta* Tree in the Study Area (Photo: Badal A. Hassan)



Results also showed that tapping is not made during the rainy season owing to washing off of the gum-resins by the rain and consequent gum resins' deterioration. Information obtained from group discussions revealed that animals do not engage in tree scratching in the rainy seasons owing to fodder availability. A similar study by Lemenih et al. (2003) in Liban region of eastern Ethiopia also showed that collection is performed on natural exudations often simultaneously with herding.

- Collection/Harvesting of Myrrh

Two commercial resin producing species of *Commiphora* were found in the study area, namely *C. myrrha*, producing real myrrh (important one) and

C. holtziana which produces medicinal type opoponax called hagar in Somali. Based on the information gathered during the group discussion, myrrh is mainly collected by men but also occasionally widows to generate household income to enhance their livelihood. Responses received from an informer who is a ship owner indicate that myrrh harvesters take tea, sugar, oil rice etc. from gum and resin storeowners in the form of loans, and travel to the field for many days. This activity is locally known as "Arah". They normally stay in the field for about one month. After harvesting or collection is completed, the resin products are brought to the market for sale. Depending on the initial contract, harvesters are obliged to sell their resin products to the investors who provided them with loans. Myrrh and frankincense have been valued since Pharaonic times when the ancient Egyptians regarded it as an essential ingredient for the preparation of mummies (Chikamai and Odera 2002).

- *Financial Return of Frankincense and Myrrh*

In north-eastern Kenya, farmers and pastoralists often sell frankincense and myrrh as an adaptation measure when faced with climate risk. Responses received from group discussion, indicate that the harvesting of frankincense and myrrh takes place in summer and winter each year for about four weeks per harvest. Respondents revealed that myrrh fetched the best price on the market, while frankincense fetched the least price. Myrrh was generating an average annual income of Ksh 24,375, an equivalent of US\$ 380.80 per household, while frankincense Ksh 1,312, being approximately, US\$ 20.50, per household. A possible explanation is that frankincense from, as an example, *B. neglecta*, has more cultural value than economic significance in Wajir District. However, myrrh offers significant financial returns. This information concurs with the findings of Luvanda et al. (2007) who studied market prices in north-eastern Kenya of *olibanum* and found that it was fetching an average of Ksh 20 at the local market and retailed at Ksh 30, while *malmal* was purchased at Ksh 72 and sold at Ksh 84.

A similar study carried out by Lemenih et al. (2003) in Liban, found that oleo-gum resins (including frankincense and myrrh) supply significant cash income, on average US \$ 80.00 per household per year; an income which was reported to be three fold greater than the contribution from crop farming, the paper added that, the income from oleo-gum resins, cover one third of the pastoral household annual subsistence. The same authors also reported that, the economic incentive provided by the oleo-gum resins could have wider economic and ecological implications for households living in arid and semi-arid lowlands like Liban. It diversifies the economy and potentially minimizes the risks associated with frequent crop and fodder failures due to recurring droughts (Lemenih et al.2003).

e. Major Buyers of Frankincense and Myrrh in Wajir District and Employment Opportunity

The main buyers of the resin product in Wajir District were local businessmen who owned gum and resin stores. There were few other buyers, including locals, who were buying for local consumption. *Malmal* appeared as the major product in the market. The market in *Boswellia* products remains underdeveloped. Across northern Kenya the source of commercial frankincense was *B. nelecta* with limited export market at low prices. The market chain consists of collectors, assemblers (retailers), stockists (wholesalers) and exporters. Trade in gums and resins can be classified as monopolistic, characterised by many buyers and sellers of gums and resins. There are three aromatic market chains: Collector-Consumer; Collector-Retailer-Consumer; and Collector-Retailer-Wholesaler-Stockists-Consumer. Results from key informants revealed that during the peak season, Wajir District transports about 180 tons of various gums and resins per month, while during low season between 70-80 tons were transported outside the district. There were about three big gum stores, one of them named Hamdi Gum Store. According to available records, the owner of Hamdi Gum Store had been trading *malmal* and *hagar* since 1968. The store had four permanent employees, a manager (son of the owner) and three casual workers. The internal market outlets for the district's frankincense and myrrh are Mombasa and Nairobi, while external outlets are Eritrea and Djibouti. In the past, the community used to export frankincense and myrrh to Somalia but it is currently not possible due to political instability. Resins constitute an integral part in the regional, national and rural economies and play an essential role in earning foreign exchange in the horn of Africa (Mulugeta et al. 2003). Myrrh contributes about 30% of the national potential in Kenya i.e. MT 1050 (Luvanda et al. 2007). Commercialization of resin diversifies the economy and potentially minimises the risks associated with frequent crop and fodder failures. The markets and end-users for the resins are classified into three main sectors: fragrance (chiefly incense in many social ceremonies and religious rituals such as Orthodox, Roman Catholic, Muslim (Coulter 1987; Farah 1994; FAO 1995); flavour (mainly '*maid*i' for chewing and chewing gum industry, but with some minor uses of the oils as flavouring agents (CARE and MNKAL 2010) in bakeries and other food industries that produce milk products and various alcoholic and soft drinks); and as a raw material in pharmacology (ointment formulation, tumours, vomiting, dysentery, fevers, leprosy, cancer, ingredient for wound plasters, laxative, toothpaste and mouthwash), cosmetics, an ingredient of lotions, soaps, detergents and creams and oriental powder based perfumes, floral perfumes, citrus colognes, spice blends, male fragrances and other scented preparations), paints, adhesive, fabrication of vanishes, fumigation powders, dye manufacturing,

beverage (Tadesse et al. 2002; Habte 2002). In the Wajir District and Somalia, local terms are used to distinguish between different types of resin. Frankincense is known as *maid* or *beyo* according to its source (CARE and MNKAL 2010). Other important uses of the species include poles and timber, fodder, craft products, honey production, traditional medicine from leaves, roots and bark and in the rehabilitation of degraded lands.

Conclusions

The impact of climate change is a major concern for northeastern Kenya as related particularly to livelihood security, natural resources, and, most importantly, rain-fed agriculture. Uncertainty in production due to fluctuations in total rainfall and changes in its distribution as well as decrease in relative productivity in rainfed lands affect the livelihoods of many poor and marginalised farmers, and make them more vulnerable to climate-related shocks. In addition, mounting pressure on the area's natural resources due to mounting rise in overgrazing, drought and deforestation, has resulted in large-scale degradation of its environment and ecosystem, calling for immediate attention for seeking newer approaches in farming systems to meet the basic needs of its people.

Facts distilled from the analysis at the household level revealed that the community is well-endowed with natural capital, especially livestock, land, and high value trees, notably *Boswellia* and *Commiphora* species. The community adopts different adaptation measures when confronted with climate related shocks, such as mobile lifestyle and diversification of livelihood sources. Farming systems survey and analysis as shown in summary of results clearly show the great potential and challenge of agroforestry in Wajir District. Adoption of agroforestry on a wide range of land in Wajir District and integration of multipurpose trees in the existing farming/cropping system was seen as an apt option to achieve the objectives. The most preferred species in the study area were *Commiphora* and *Boswellia*. The main products from *Boswellia* and *Commiphora* were frankincense and myrrh, respectively. The resins market was still underdeveloped as constraint by technical, policy and socio-economic factors. Therefore, the situation demands empowering the local communities through formation of community based associations to coordinate trade in gums and resins, public awareness creation on quality and standards and product development (packing and advertising).

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