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Research Article

Gum and Resin Production and Marketing: Implications for Pastoral Livelihood in Adadle District, Somali Region, Ethiopia

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Both locally and nationally, Ethiopia's gum resin sector has a substantial economic impact. Even though collecting and selling gum and resin is one of the main livelihood activities in Ethiopia's remote pastoral areas, there are few case studies that adequately reflect national realities. Therefore, the goal of this study is to pinpoint and evaluate gum and resin production and sale, as well as any implications for pastoral livelihood, in the Adadle district of the Somali Region. Both purposive and random sampling techniques were employed. The primary data gathering technique used were household surveys, key informant interviews, focus groups, market surveys, direct observation, and surveys of community-based organizations. Multiple response tests, one-way ANOVA, and descriptive statistics were used in SPSS Version 26 to statistically analyze the collected data. The study discovered many *Acacia*, *Boswellia*, and *Commiphora* tree species that are employed in the production of gum and resin. It was also found that natural oozing and artificial tapping were the methods used for collecting and harvesting gum and resin. The average amount of gum and resin/frankincense harvested annually by each family was 219.82 kg and 58.27 kg, respectively, with gum harvesting being substantially higher (p 0.05) than resin harvesting. The recurrent drought, season, and awareness level of harvesters on taping were the factors affecting the quantity and quality of production. The average annual household income from gum and resin/frankincense was 18,684 Ethiopian Birr and 43,704 Ethiopian Birr, respectively. The mean annual income from resin was substantially larger (p 0.05) than that of gum. The gum and resin market chain in the area comprises eight actors with five market channels. The research also demonstrates that the income made by selling gum and resin was used to pay for basic necessities for the family, save money for health care and medications, and pay for social concerns and educational expenses. Recurrent drought, lack of market access and market expertise, lack of institutional cooperatives, and lack of infrastructure and facilities were all determined to be obstacles to the production and sale of gum and resin. Generally, resources should be conserved and interventions should be done to ensure the sustainability of the resource base and improve production potential. Proper tapping techniques should be introduced to enhance production potential, and access to market information should be ensured to maximize primary producers' income share insured for maximizing the income share of primary producers.

1. Introduction

In the Horn of Africa, it has long been customary to use tree resin and gum for various purposes [1]. Dry forests and woods in sub-Saharan Africa are fragile, yet they nonetheless have a variety of ecological and economic advantages to humanity because of the region's abundant biodiversity [2]. Several sub-Saharan African countries employ a variety of species to produce gum and resin products, and the drylands of East Africa are particularly well known for their potential and long history of extraction and commercialization of natural gum and resin products [3]. When considering the resource potential of gum and resins, it greatly outpaces global output, and Sudan also produces a significant amount of gum arabic, more than 80% of the world's total production [4]. Gum arabic had an annual export potential of

100,000 tons from African nations up until 2017, and its demand was anticipated to reach 150,000 tons yearly by 2020 [4]. Ethiopia contributes just 0.9% to the global market, whereas nations like Chad, Nigeria, and Sudan make up over 97% of it. Around 7,000 tons of karaya gum from *Sterculia setigera* Del. are needed worldwide, and Senegal is the top exporter in Africa [5]. Ethiopia, Kenya, Somalia, and Eritrea are the principal exporters of 3,000, 2,361, 1,200, and 400 tons of aromatic resins [3].

Natural shrub and tree species that produce gum and resin are well recognized, and they are most frequently found in the drylands of Ethiopia [3]. This is because nearly all dryland settings are home to species that contribute significantly to the land mass through the production of gum and resin [6]. Current estimates of the area of well-stocked dry forests and woodlands for the production of gum and gum resins in Ethiopia vary from 28,550 km^2 to 43,350 km^2 [7]. Potential producers of commercial gum and gum resins include species like *Acacia* and *Commiphora*. In particular, *Myrrha* and *Opopanax* were derived from the *Commiphora* species, frankincense from several *Boswellia* species, and gum arabic from *Acacia* species ([3, 7]).

Particularly in the drylands of East Africa, the extraction and commercialization of natural gum and resin products are noted for their potential and lengthy history [3]. For 60% of rural residents who are classified as poor, the dry woods serve as a significant resource base for economic growth and livelihoods. To fulfill their basic needs, some 320 million people rely on products from dry forests [8]. Non-timber forest products other than timber provide 20–60% of the overall family income and are reported as a contribution even surpassing agricultural activity [9] and also serving as a complementary income to other livelihoods [10]. The gum and resin industry contributes significantly to the nation's economy both locally and nationally [11]. Forest harvesting is a traditional source of income and sustenance for rural families [12]. Gums and resins support local lives by providing both financial flow from selling goods to customers and subsistence value [7]. Plant resins are regarded for their use in the creation of adhesives, varnishes, and food glazing agents as well as their worth as raw material for the production of other chemical compounds and as scent- and incense-related substances. Plant resin was utilized for the first time in Southern Africa during the late Middle Stone Age as an adhesive for hafting stone tools [13]. The abundance of tree species in Ethiopia's dry forests, which provide the gums and resins that are the most valuable export products from the country's forestry industry, is a significant characteristic of those areas [7].

Despite the high potential of the resource base, Ethiopia now produces and exports very little gum arabic each year [8]. This is a result of inadequate output, acceptable tapping methods, a lack of infrastructure facilities, appropriate institutions, a dearth of cooperatives, and challenges in gaining access to markets, market knowledge, and reasonable market prices [14]. Additionally, there are gaps in or limitations in knowledge regarding the production and gum quality from different tree sources, the ideal age trees for tapping, establishment techniques, silvicultural management, and phenological record needs of the species [15]. Inconsistent marketing volumes over time and limited production range, lacking in a marketing structure, and institutional shortcomings decline benefits required from gums and resin production [7]. The main reason for the decline in production volume and potential is a low gain of producers from gum and resin due to very low prices for their products [16]. Due to a lack of producer organization in cooperatives, the percentage of producers' portion in the marketing margin decreases [16]. Institutions (government and non-government) can support extension services and support the development of a supply chain that might increase the amount of money the working poor can earn. This could only be accomplished by developing and improving pertinent mechanisms for the resource management and usage that is sustainable for gum and resin [17].

In Ethiopia's rural regions, gathering and selling gum and resin is a substantial source of revenue; however, few case studies have been conducted. Gum and resin resources have the potential to support rural development in general and climate change adaptation in vulnerable pastoral, agro-pastoral, and farming communities, in particular, but this potential has not yet been fully exploited at the national level [18, 19]. Concerning the study area, information on the state of the resources for woody plants that produce gum and resin, production systems, and marketing strategies has not been studied. Studies on the livelihood implications of gum and resin production are also either scanty or completely lacking. Therefore, this study analyzes the gum and resin production system, assesses the gum and resin marketing strategies, and establishes the gum and resin marketing implications in order to ascertain the livelihood consequences of gum and resin production and marketing in the study area.

2. Materials and Methods

2.1. Description of Study Area. This research was carried out in Ethiopia's Somali Region's Adadle district, Shabelle Zone (Figure 1). It is one of the nine districts in the Shabelle Zone, which is located 600 and 1228 kilometers from Addis Ababa city and Jigjiga town, respectively. Adadle may be found in the lowlands of the Somali Regional State of Ethiopia's Wabi Shebelle River subbasin (latitudes: 5°38′10″ to 6°24′14″N; longitudes: 42°43′9″ to 43°54′29″E). The highest and lowest temperatures are 31.7°C and 21.6°C, respectively, and there is around 44.6 mm of rainfall on average per year. The long rainy season is from October to December, while the primary rainy season is from March to May.

According to the Central Statistical Agency of Ethiopia's (CSA) 2007 Census, there are 83,260 people living in this woreda, including 48,166 men and 35,094 women. While 5,584 people, or 6.71%, live in cities, 33,192 people, or 39.87%, are pastoralists. The current estimated population of the district is 112, 000 of which 64, 555 are males and 47, 445 are females. The inhabitants of the district, 75% pastoral with 99.9% being Muslim, belong to the Somali ethnic group. The district, located in the center of rangelands, spans 719,755 acres. The primary source of income for villages and

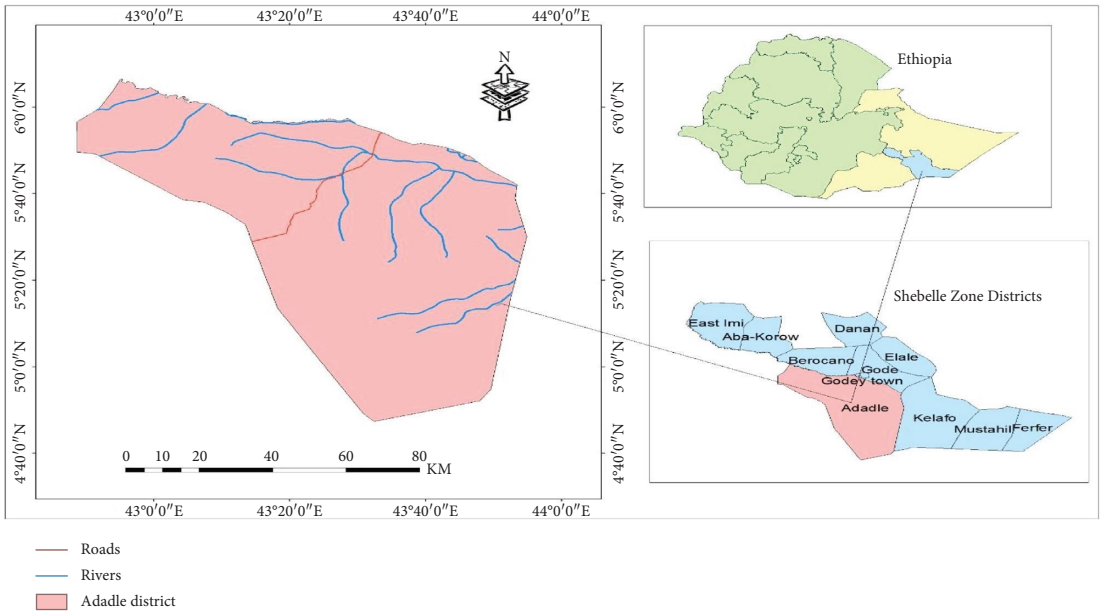


Figure 1: Map of study area.

nomadic pastoralists is animal husbandry. There are 112,850 livestock in the study area, with camels making up 34,750, cattle accounting for 20,850, goats for 34,350, and sheep for 22,900 [20].

2.2. Research Design. This section provides a summary of the study's research methodology, including the primary datasets used, their sources, kinds, and data analyzing techniques. Cross-sectional reconnaissance/preliminary survey was used to design the methodology and sampling techniques for the study. The production and marketing of gum and resin, as well as their effects on pastoral life, were identified using purposive random sampling procedures, which incorporated qualitative and quantitative data. Field observations, focus groups, key informant interviews, and tree identification collection were also used to generate and explore in-depth information, and field observation and tree identification collection also were used.

2.2.1. Sampling Techniques and Sample Size Determination. Purposive and stratified random sampling techniques were employed for the selection of study districts, kebele (smallest administrative unit), and respondents. Therefore, a reconnaissance survey was conducted in the study area before data collection. According to the results of the reconnaissance survey, the Adadle district was purposefully chosen based on its potential for producing and marketing resin and gum [14]. Secondly, the total kebele in the district was stratified into two rural and urban strata. Following this, six rural kebeles, Haben, Alihuley, Kulmil, Dabagali, Toxopo, and Elbied, were intentionally selected because they depended on the collection and sale of gum resin. The total household was stratified into two strata as participants and non-participants in the production and sale of resin and gum. Following this, 1,524 households who have been involved in the production and selling of gum and resin were identified from six kebeles, and 150 respondents were selected randomly through the lottery method by taking 25 households from each kebele.

2.2.2. Data Collection and Species Identification. The field observations, focus groups, meetings with key informants, respondent surveys, and identification of tree species by guided field walk with informants and market surveys were the main techniques applied. In general, data gathering involved a sequential exploratory technique [21] in which qualitative data were added to quantitative data collecting and analysis [22]. As a result, respondent interviews (surveys) were conducted, and data regarding the varieties of gum and resin were obtained; the species from which they are tapped, the collection techniques, and other topics were acquired using a semi-structured questionnaire. Additionally, it is utilized to collect information on the collecting period, the expected yearly revenue from the sale of gum and resin, the proportion of money used for sustaining households, local or domestic applications, therapeutic benefits, and other significant socioeconomic data. In addition to this, detailed information was explored through detailed conversations and discussions with key informants (KIs) and focus group discussions (FGDs). KIs were selected through the snowball method [23], mostly local people who had lived a long time in the locality and who have first-hand knowledge and know very well the history of the area. Participants in FGDs were 6–8 individuals who included kebele administrators, youth, women, and elders living in these gum and resin hotspot areas.

Guided field walks and observations were also done in the production and marketing areas. It was utilized to triangulate the information gathered from other sources and identify and catalog the main tree species in the research area

that are used to produce gum and resin. Scientific names of the plants recorded were identified by using taxonomic keys, the flora of Ethiopia and Eritrea [24]. Finally, the market survey was undertaken to record the types and names of gum and resins supplied to the market preference for different types and other aspects of gum and resin sold in the local markets in the study area. Therefore, semi-structured interviews were conducted with gum and resin sellers and buyers and local cooperatives engaged in gum and resin collection and marketing based on a semi-structured questionnaire checklist following methods used in [18, 25]. For further information, discussions were held with the district administrators and experts and trade and industry offices of the Adadle district to have basic information for analyzing its value chain.

2.3. Data Analyses. Data were processed, stored, organized, checked, and categorized into quantitative and qualitative categories, encoded into Excel sheets, and transferred to the SPSS program. SPSS Version 22 was used to statistically evaluate quantitative data. Several statistical studies using one-way ANOVA were conducted to investigate the function that gums and resins play in rural livelihoods. Descriptive statistics were employed to describe the various variables. Text analyses were used to analyze qualitative data through the way of condensing and summarizing qualitative information.

3. Results and Discussion

3.1. Gum and Resin Production and Collection

3.1.1. Gum and Resin-Producing Tree Species. Several gum and resin-bearing tree species identified in the study area were *Acacia oerfota*, *Acacia stuhlmannii*, *Boswellia frereana*, *Boswellia neglecta*, *Boswellia ogadensis*, *Commiphora erythraea*, *Commiphora guidotti*, *Commiphora myrrha*, and *Commiphora ogadensis* which are the most commonly known gum and resin trees species in the study area (Table 1).

According to the response from the respondent, two *Acacia* species, *Acacia oerfota* and *Acacia stuhlmannii*, were used for the production of gum. These tree species are characterized by their drought-tolerance potential, and most of them are small-leaved trees and shrubs.

3.1.2. Methods of Collecting and Harvesting. Gum and resin products are produced or harvested via both artificial tapping and natural oozing. Based on the response of respondents, 48.0% and 16.0% of respondents prefer and use natural oozing and tapping for the harvesting of products, respectively (Figure 2), whereas 36.0% of respondents revealed that they prefer and use both natural oozing and artificial tapping for harvesting gum and resin. Harvesting through natural oozing is undertaken by gathering the naturally oozed substance from the tree's trunk and branches and dropped/failed gum and resin products below the canopy of the trees. Artificial tapping was done by specially designed axes and other metal tools. After tapping, they wait for a week to collect the gum and resin from the tapped tree.

Responses of respondents revealed that most of the time natural oozing was mainly used for the collection of resin as it is used for the collection of products from natural exudates. Artificial taping is revealed as it is not used for the collection of resin because it affects the quality of the resin products. This is because during taping there is a wounding tree and there is the mixing of other compound exudates due to the tree wound and these compounds may mix and affect the quality of the resin. Regarding this, respondents show that the loss of quality due to mixing with other products affects the market value as buyers in the cooperative throw out resin products mixed with other compounds during the sorting process in the market area. Because of this, they only use natural oozing for the collection of resin to keep the quality of products. But in contrast to this, Getahun and Kebede [26] found that tapping enhances the quality of resins.

The process of artificially injuring tree stems and branches to produce gums is known as tapping, according to responses, which brings oozing of exudates through the openings of wounds. They revealed that they use only taping for the production of gum in addition to natural oozing because they believe that even if there is a quality decline of products, the taping has the potential to increase the amount of gum collected per day. Key informants and participants in the focus group discussion revealed that after tapping the tree, they left it for 4–6 days to get back to collect products. In line with this, the authors of [27, 28] found that tapped trees yielded more yield than untapped trees, and tapping improved the productivity of gum arabic by 77.42% when compared to natural oozing.

3.1.3. Gum and Resin Harvesting. The mean daily, monthly, and annual harvesting of gum and resin in kilos by household and the daily average harvesting of each individual were calculated. To do this, the number of families engaged in harvesting, the number of days per month allocated for gum and resin collection, and active harvesting months/seasons were considered. Following this, two individuals from each household on average were considered engaged for 15 days in each month and 6 months which are active collection times in the year. Based on this, the overall mean daily harvesting of gum was (1.22 ± 0.30) and (2.44 ± 0.60) kilograms by individual and household, respectively. As a result of this, the mean monthly and annual harvesting of gum was (36.64 ± 8.99) and (219.82 ± 53.95) kilograms per household, respectively (Table 2). The amount of gum being harvested was significantly more (p 0.05) than that of resin when compared with it, with a 5% confidence interval (Table 2). This means the mean monthly and annual harvesting of resin was only (9.71 ± 3.00) and (58.27 ± 17.98) kg per household, respectively (Table 2).

The amount of gum and resin collected varied more, with the average annual collection of gum being three times greater than the average annual collection of resin (Table 2). Regarding this, respondents revealed that the difference was

Table 1: Identified gum and resin-bearing tree species.

Scientific name	Vernacular (local) name (Somali)	Family	Product
Acacia oerfota (Forssk.) Schweinf.	Gumaro, Guure	*Fabaceae*	Gum
Acacia stuhlmannii Taub.	Gahaydher	*Leguminosae*	Gum
Boswellia frereana Birdw.	Dhidin/Malmal	*Burseraceae*	Resin
Boswellia neglecta S.	Muqlay/Murafur	*Burseraceae*	Gum
Boswellia ogadensis Vollesen	Gended	*Burseraceae*	Resin
Commiphora erythraea (Ehrenb.) Engl.	Hagar	*Burseraceae*	Resin
Commiphora guidotti Chiov.	Hadi	*Burseraceae*	Gum
Commiphora myrrha (Nees) Engl.	Myrrhor	*Burseraceae*	Resin
Commiphora ogadensis Chiov.	Murfur	*Burseraceae*	Gum

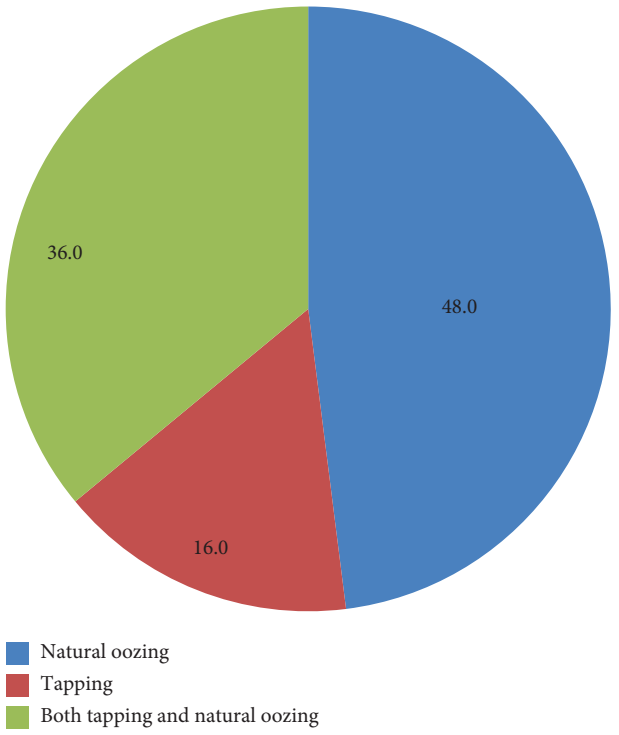


Figure 2: Collection and harvesting methods of gum and resin (%).

mainly due to the availability of products; the density of trees and the method of the collection were the major factors that contributed to the harvesting of both products. The first reason is that the more abundant tree species in the area were gum-producing (Table 1). The other reason is that from the two methods identified (Figure 2), as used for production and collecting gum and resin, gum was collected through both artificial tapping and natural oozing, and in them, tapping was commonly used. Respondents revealed that artificial taping has the potential to increase the amount of gum to be collected, whereas resin was collected only through naturally oozing exudate substances on the stem and branches of trees and sometimes from the ground below the canopy of trees. In addition to this, natural exudate products need time and season of production, and collectors and harvesters wait for the readiness of products and the time of collection. These factors reduce the amount of resin to be collected than gum.

3.1.4. Factors Affecting the Quality and Quantity of Gum and Resin. The respondents identified a number of elements that adversely affect the quantity and quality of gum and resin products. From these, recurrent drought, the season of production, post-harvest handling, lack of awareness of taping and collection methods, the topographical situation of the area, and contaminants were factors affecting both the quality and quantity of products (Figure 3).

Dry seasons, mostly from October to March, are the best times for production and harvesting, while wet seasons are not advised because they degrade the quality of the goods. Similarly, the quantity and quality of gum and resin products were found to be much higher during the dry season because it makes the tapping and collection procedure simple, according to research in [29] which also indicated that seasonal variation affects production and quality of these products. Because the recurrent drought affects the regenerative potential of trees, drought was revealed as one of the major factors which affect the quantity of product. According to the respondents, if there was no drought, trees would start to regrow and replenish the injured parts formed through tapping production and they grow both physiologically and morphologically and build up their production potential during the normal rainy season. But recurrent drought affecting both the physiological and morphological growth of trees leads to less quantity production. This is in agreement with Berhanu et al. [30] who discovered that harvesting and production are seasonal, taking place during the dry season, and that refueling and wounding last until the start of the wet season.

Respondents and cooperative members in the market area revealed that post-harvesting handling of gum and resin was also a factor that affects the quality of products. This is because the majority of collectors were herders and shepherds who did not have enough know-how to store products after harvesting. In addition to this, during harvesting, they have no proper materials to collect and they use what they find on the roads and production areas including old plastic bags and clothes. This shortage of awareness always affects the quality of products, mostly resin, because it is collected with much moisture and has the potential to retain dust and other substances. Similar to this, finding from [30] confirms that most collectors were cattle herders, they have no training in methods, and they developed experience from their parents. Respondents also show that as a producer, the

Table 2: Mean monthly and annual harvesting of gum and resin.

Type of product	Daily harvesting (kg/individual) Mean ± SD	Daily harvesting (kg/HH) Mean ± SD	Monthly harvesting (kg/HH) Mean ± SD	Yearly harvesting (kg/HH) Mean ± SD
Gum	$1.22^{a} \pm 0.30$	$2.44^{a} \pm 0.60$	$36.64^{a} \pm 8.99$	$219.82^{a} \pm 53.95$
Resin/frankincense	$0.32^{b} \pm 0.10$	$0.65^{b} \pm 0.20$	$9.71^{b} \pm 3.00$	$58.27^{b} \pm 17.98$

Two family members were engaged in collection for an average 15 days/month for each product type and only six months/year as active collection time. Different superscript letters (a and b) in the same column indicate significant difference.

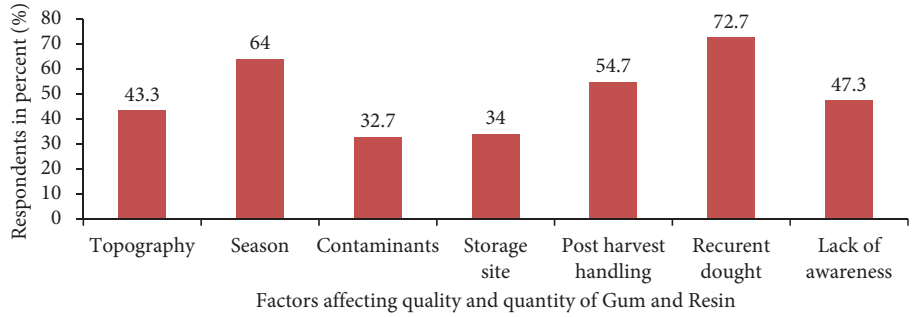


Figure 3: The variables influencing the quantity and quality of produced gum and resin.

topography is also a factor affecting the quantity of gum and resin. This is because the gum and resin-bearing tree species prefer to grow on flat land than in hilly areas and trees grown on flat land have more potential for the production of gum and resin.

3.2. Marketing and Market Chain Analysis

3.2.1. Gum and Resin Market Chain Actors. The study revealed that the gum and resin market chain comprises eight different actors playing their own roles in the marketing chain in each stage from production/harvesting to different consumers (Table 3).

Responses gained from collectors, personnel in the cooperative and agents, and field observations show that gum and resin producers/harvesters are pastoralists who produce and/or harvest gum and resin for production. The local village traders are pastoralists who have small capital and are engaged in buying a product from producers and/or collectors. A cooperative is a system created by persons in the Adadle district who collect and buy gum and resin from collectors and local village traders and transport and sell a product to agents in Gode city and exporters from Somaliland. They have permission from the government in the district and pay taxes to the government every year. Agents were engaged in collection, cleaning, sorting, weighing, and buying from village traders and cooperatives, tax-paying to the government and transporting to Jigjiga and Harar city, and selling to retailers and exporters. In this stage, there are two actors, daily laborers and sometimes intermediaries. Daily laborers engaged actors by doing activities such as cleaning, sorting, and repacking in the hands of agents and loading gum and resin to a truck for transportation. In line to this finding, study of [16] shows that daily laborers are involved in the loading and unloading and sorting, cleaning, and grading work for agents. Sometimes when new retailers and exporters come to agents and cooperatives for buying products, intermediaries serve through mediating and creating agreements between agents and new retailers and exporters on the price and collecting information about the price on local market and other market situations. Retailers were small traders who performed their business independently in shops and commodity trading areas in the market by selling it to the final consumer through retail. The final consumers in the marketing chain actors were the end of the value chain and final product consumer types. These are households, churches, and sometimes factories in the national market, and from them, factories and industries use goods from the international markets while families and churches are customers in the local and national marketplaces.

3.2.2. Market Channels and Marketing Chain Mapping. Gum and resin goods are moved along the marketing chain from manufacturers and/or collectors to ultimate customers with the assistance of the value chain actors mentioned in Table 3. By combining the responses from respondents and observations from the district, five main gum and resin market channels were developed based on the actors in the market chain and shown on market chain mapping (Figure 4).

Channel 1 ≥ producers and/or collectors ⟶ cooperative ⟶ agents ⟶ retailors ⟶ consumers

Channel 2 ≥ producers and/or collectors ⟶ cooperative ⟶ exporters ⟶ retailors ⟶ consumers

Channel 3 ≥ producer and/or collectors ⟶ village trader ⟶ cooperatives ⟶ Agents ⟶ retailors ⟶ consumers

Table 3: Gum and resin marketing chain actors and their activities.

Market chain actors	Activities of each value chain actor
Producers/collectors	Tree-tapping, collecting, sorting, and packing gum and resin, bringing it to cooperative and village trade areas, and selling it for the Adadle district's cooperatives and traders according to their preferences
Village traders	Sorting, weighing, buying, and collecting gum and resin from producers/collectors and selling for cooperative in the Adadle district and agents in Gode city
Cooperative	Buying from producers and village traders, cleaning, sorting, repacking, weighing, transporting to Gode city, and tax-paying for government and selling for agents and exporters
Agents	Buying from village traders and cooperative, cleaning, sorting, repacking, weighing, tax-paying, transporting to Jigjiga and Harar City, and selling for retailers and exporters
Daily laborers	Cleaning, sorting, repacking in the hand of agents and loading gum and resin on a truck, and making ready for transportation to the marketing area
Intermediary (but not common)	Mediating and creating agreement agents and new retailers and exporters on the price and serving value chain governance part through collecting information and situation of the market
Retailers	They were small traders and performed their business independently by buying gum and resin from agents and finally selling it to the final consumer
Exporters	International marketing of gum and resin by exporters especially from Somaliland
Consumers	Final users of product buying from retailers and exporters

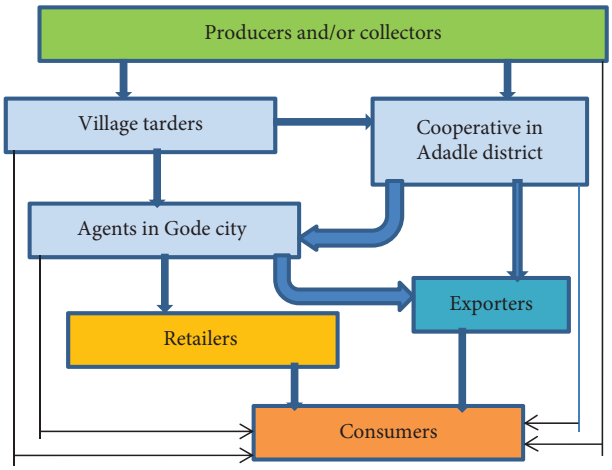


Figure 4: Marketing chain mapping of gum and resin.

Channel 4 ≥ producers and/or collectors ⟶ village trader ⟶ cooperatives ⟶ Agents ⟶ Exporters ⟶ consumers

Channel 5 ≥ producers and/or collectors ⟶ village trader ⟶ cooperatives ⟶ Exporters ⟶ consumers

In channel one, producers and/or collectors collect the product from the production area and sell products to organized cooperatives. Cooperatives in this channel buy products from the producers and collectors, then keep products in their store in the district and sell them to agents in Gode city. Following this, agents in Gode city sell their products to retailers that come from Jigjiga and Harar city, and the retailers sell them to final consumers. In this channel, the market chain is finalized on a national basis. But in channel two, the cooperative in this channel sells products to exporters from Somaliland. Following this, exporters sell it to retailers and/or final consumers. In this channel, the market chain is finalized in international marketing.

Finally, in channel five, organized cooperatives sell products directly to the exporters. In channels four and five, there is international marketing of cooperatives in the district and agents sell products to the exporters who come from Somaliland. The majority of the time, organized cooperatives and agents keep products in storage for a while since doing so gives them a higher opportunity of maximizing their profit.

3.2.3. Value Distribution and Value Addition Systems of Gum and Resin. According to the response of respondents and cooperatives from the Adadle district, collectors sell one kilogram of gum and resin to an average of 85 and 750 Ethiopian birrs, respectively. In addition to this, members of the cooperative and agents in the district and Gode city exposed that there are also costs related to sorting, cleaning, repacking, loading, tax payments, and transportation and storage sites. Based on this, the distribution of gum and resin in the district is done by taking only one national marketing channel which is from the Adadle district to Harar city. For this case, the average annual harvesting per household which is 219.82 kg gum and 58.27 kg resin (Table 2) was used with their average values of 18,684, and 43,704 Ethiopian birrs (Table 4) with 15 days per month and 6 potential harvesting months per year.

A preliminary marketing margin analysis for the shorter marketing channel from Adadle to Harar was done, and the different gums and resins exhibit variations in market price and marketing margins for different actors in the value chain. The value distribution shows that the percentage share of producers in the final price was 21.25% and 50% for gum and resin, respectively (Table 5). This indicates that the percentage share of the final price of resin was higher than

Table 4: Mean daily, monthly, and annual income from sale of gum and resin.

Type of product	Daily income (birr/individual) Mean ± SD	Daily income (birr/HH) Mean ± SD	Monthly income (birr/HH) Mean ± SD	Yearly income (birr/HH) Mean ± SD
Gum	$103.80^{b} \pm 25.48$	$207.60^{b} \pm 50.96$	$3114.06^{b} \pm 764.36$	$18684.36^{b} \pm 4586.16$
Resin	$242.80^{a} \pm 74.94$	$485.60^{a} \pm 149.87$	$7284.0^{a} \pm 2248.12$	$43704.00^{a} \pm 13488.71$

For each type of product, two family members engage in collection on average for fifteen days per month, with only six months per year being used for active collection. Significant differences are indicated in the same column by several superscript letters.

that of gum. For the value chain actors of gum, the retailers have a greater share of the final price, and producers, cooperatives, and whole sellers have fewer shares in gum value distribution. The results indicated that producers did not necessarily benefit from harvesting and selling gum. Similarly, cooperative bodies in the district have only 5.91% of the final price share. This indicates that the share of producers and cooperatives in the final price of gum tended to be lower than that of wholesalers. This is because they have no market information and the values are only decided by retailers and depend on the agreement of the whole sellers who buy products from them. Less number of cooperatives in the area and a lack of cooperation with producers affect the number of their share benefits from the total margin. This is in line with Kassa et al. [31] who found that particularly long marketing channels and a lack of organization of producers and cooperatives affect the percentage share of producers. Regarding these, Te Velde et al. [32] also indicated that better association among producers and more organized value chain governance could result in more organized production and higher profits for value chain participants upstream.

The study found that there is no value addition process for harvesting and collecting gum and resin in the hands of pastoralists as their families engaged in collecting and harvesting without any cost or product process. The value addition system of gum and resin was started at the hands of a cooperative in the district through the process of sorting, weighing, and buying a product from collectors and harvesters because of the costs pained for sorting and weighing. The value related to transporting products from Adadle district to Gode city was also the value added to the hands of cooperatives in the district. The agents who buy products from cooperatives undertake different additional work. These are the cost of buying a product from a cooperative, cleaning, sorting, repacking, and loading gum on a truck and the cost of transportation. In addition to these, costs sometimes were related to the intermediary in mediating and creating an agreement with agents who serve as value chain governance, and the value relationships to the selling of products for retailers and exporters and consumers were the different values added in the marketing of gum and resin in the study area.

3.2.4. SWOT Analysis for Harvesting and Marketing of Gum and Resin. A SWOT analysis was done to identify internal and external factors that might affect gum and resin production and market practice in the study area (Table 6).

3.3. Livelihood Implications of Gum and Resin Production

3.3.1. Income from Gum and Resin Production. Based on the local market practice of both gum and resin, the total daily average income earned per individual and mean daily, monthly, and annual income per household were identified and expressed in Ethiopian birr. Based on this, the average prices of both gum and resin were 85 and 750 Ethiopian birr/kg, respectively. Based on these, the mean monthly and annual income of (3114.06 ± 764.36) and (18684.36 ± 4586.16) Ethiopian birr was gained from gum per household, respectively, whereas $(7{,}284.0 \pm 2{,}248.12)$ and $(43{,}704.00 \pm 13{,}488.71)$ were gained from resin per household, respectively (Table 4). These show that the income earned from selling resin was significantly higher ($p < 0.05$) than that of gum.

This study found that the average annual income from gum and resin was 18, 684.36 Ethiopian birr (357.53 USD) and 43704 Ethiopian birr (836.28 USD), respectively. The result supports the idea that many pastoral households are highly dependent upon income from gum and resin for their livelihoods. Respondents and KIs demonstrate that these sales and production diversify economic activities and lessen the hazards associated with recurrent droughts, such as livestock losses owing to feed and water shortages. KIs and participants in FGDs revealed that during the drought years of 2015 and 2016, pastoralists took advantage of the collecting and marketing of gum and resin. This provides cash income which is complementary to other kinds of income, acting as a financial safety net during times of drought and as part of a drought adaptation strategy. In line with this finding, Berhanu et al. [30] discovered that the current methods of production in pastoral communities make frankincense a key source of revenue, diversify the economic activities, and lower the dangers connected with drought.

3.3.2. Livelihood Role of Income Earned from Gum and Resin. Money earned from the selling of resin and gum is allocated to different uses and expenses for livelihood. According to the response of 98% of respondents, more of the income was allocated to fulfilling family basic needs such as purchasing food, buying clothes, and construction and maintenance of houses for shelter. 79% of the respondents revealed that the income generated was also assigned to buying additional livestock and purchasing supplementary feed for them. The other remaining amount of income was also expensed with medicine and health care, saving for other unexpected events, social, cultural, and religious events, and school expenses (Table 7).

Table 5: Value distribution of gum and resin.

Gum	Producers (219.82 kg/HH)	Cooperative in the district	Whole sellers (Gode town)	Retailers (Harar town)	Consumers in Harar town
Selling price	18,684.34 Ethiopian birr	26,378.4	54,955	87,928	87,928
Marketing cost (transport, cleaning, sorting, repacking, tax, loading, etc.)	—	2,500	3,500	4,000	—
Marketing margin	—	7,694.06	21,981	32,973	—
Net margin	—	5,194.06	18,481	28,973	—
Share of final price in (%)	21.25%	5.91%	21.02%	32.95%	—
Resin	*Producers (58.27 kg/HH)*	*Cooperative in the district*	*Whole sellers (Gode town)*	*Retailers (Harar town)*	*Consumers in Harar town*
Selling price	43,702 Ethiopian birr	49,529.5	69,924	87,405	87,405
Marketing cost (transport, cleaning, sorting, repacking, tax, loading, etc.)	—	2,000	3,500	2,000	—
Marketing margin	—	5827.5	20,394.5	17,481	—
Net margin	—	3,827.5	16,894.5	15,481	—
Share of final price (%)	50%	4.38%	19.33%	17.71%	—

Table 6: SWOT analysis of harvesting and marketing of gum and resin.

Strengths	(i) Pastoralists' experience in the harvesting process (ii) Suitability of area for gum and resin tree growth (iii) Good access to transport
Weakness	(i) Lack of good tapping experience and knowledge (ii) Shortage of market and market information and poor value chain governance (iii) Insufficient availability of cooperatives and non-functionality of cooperatives due to lack of continued follow-ups and support by the government (iv) The decline in quality due to poor handling and storing practices and lack of value-additive activities
Opportunities	(i) Enough labor force (ii) Increase of interest in local, national, and international markets (iii) Rise in prices of gum and resin in the market (iv) Availability of one cooperative with legally binding rules and regulations
Threats	(i) Extreme climate events which are recurrent drought (ii) Human activities such as cutting trees for fences and other uses (iii) The decreasing number of potential gum and resin-bearing tree species due to recurrent drought

Table 7: Importance of income earned from gum and resin.

Area of expense of money earned from gum and resin	$N = 150$ Frequency	%
Household basic needs (food, cloth, and shelter)	147	98.0
Medicine and health care	89	59.3
School expense	50	33.3
Saving for unexpected events	78	52.0
Social, cultural, and religious events	61	40.7
Livestock production and livestock feed	119	79.3

The sum of frequency and percentage are more than N and 100%, respectively, because of multiple response test analysis.

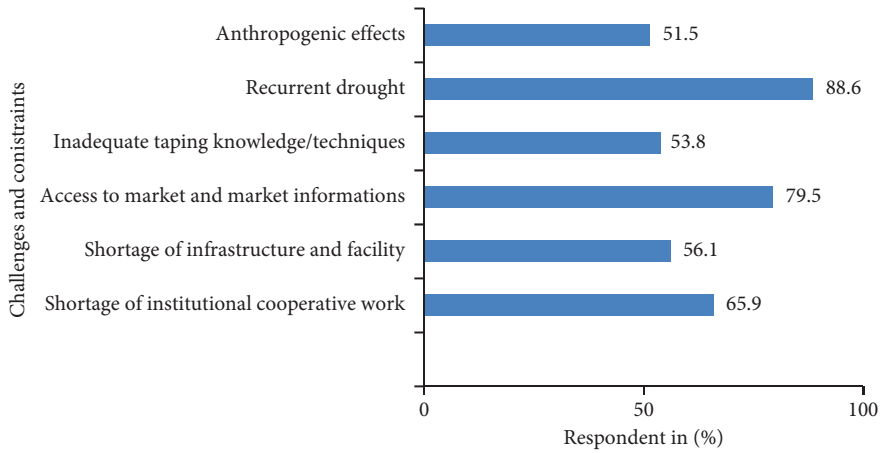
During the drought, gum and resin functioned as a safety net because the cost-related livelihood of pastoralists was mainly fulfilled from the income obtained. Key informants show that the income generated from selling gum and resin supports families during recurrent drought times. Additionally, it is crucial for pastoralists who lost their livestock during drought time because some pastoralists who lost their livestock due to drought hazards increased their post-drought livestock numbers and assets. Therefore, it serves as a mitigation and adaptation strategy for climate change. In line with this study, Hido and Alemayehu [14] found that the primary source of income for the pastoral community was the collection and sale of gum and resin products, which also contributed significantly to the food purchases of households. The cost of health care and medication for humans and livestock, savings, school expenses, and costs related to participating in different social-cultural issues were covered by the income earned from selling gum and resin products. In line with this, Worku et al. [19] reported the only source of revenue for women and schoolchildren, and the third most significant source of subsistence after crop and honey production was income from the manufacturing of gum and resin [29].

3.4. Challenges and Constraints on the Production and Marketing of Gum and Resin. The production and marketing of gum and resin in the study area are not free to access and not without challenges; there are different societal, institutional, and environmental (ecological) challenges and constraints. Regarding this, respondents reported that recurrent drought, lack of access to market and market information, lack of institutional cooperatives, shortage of infrastructure and facilities, inadequate tapping knowledge and techniques, and different anthropogenic activities are challenges that constrained the proper production and marketing of gum and resin in the study area (Figure 5).

The study found that drought and shortage of rainfall due to climate change and variability were the major factors that threatened the gum and resin-bearing tree species because the seasonal growth of the plants was affected due to a shortage of rainfall and extreme temperatures (Figure 5 and Table 6). Drought also affects the regeneration of tree species in the grazing land and is going to affect the sustainability of tree species. The field observation also shows that only large trees were available in the area and overgrazing was due to a shortage of livestock forage and feed. This is because recurrent drought causes the loss of palatable and browser species and it diverts browsers' livestock to rely on gum and resin-bearing trees and becomes a threatening factor for some browsing gum and resin trees. Funding was agreed with the study of [33, 34] found that recurrent droughts and related overgrazing greatly affected gum production and cause the death of many gum-resin tree species and causes ecological disturbance and overgrazing has a deleterious effect on the natural regeneration of plants that produce resin.

Lack of access to market and market information and shortage of competitive market areas for selling collected products were the major constraints for the production and marketing of gum and resin (Figure 5 and Table 6). This is because producers have no clear and enough market access and market information and the only cooperative body in the district is in operation to collect and buy products from collectors. Regarding this, respondents exposed that they had no interference in the buying and selling process and prices were solely decided by cooperatives in the district. According to key informants, the lack of another competitive cooperative body to buy the product from producers affects the freedom to decide on the price and negotiate with buyers on the prices. In this case, respondents show that if there was more than one cooperative engaged in buying products in the district, we may have the freedom to decide on the price and come into agreement on the value and to have decisions on prices.

The other anthropogenic factors were also major human-induced factors that threatened the sustainability of these valuable tree species (Figure 5 and Table 6). Responses from KIs and participants in FGDs revealed that cutting trees for the construction of fences around the home was the major anthropogenic effect or the threat to gum and resin trees. This is because some tree species such as *Boswellia frereana* and *Commiphora myrrha* have potential to propagate vegetatively and pastoralists cut and construct life defenses around and in front of their homes from such trees. Similarly, Lemenih and Kassa [7] found that human-related disturbances such as overgrazing, forest fire, and intensive removal of trees for lumber for building and fuel have a major negative influence on gum-resin tree species. A lot of damage to some of the resources through poor and excessive tapping due to inadequate tapping knowledge and techniques was also another challenge to tree resources. It not only affects the quality of the product but also affects the sustainability of tree species. Respondents demonstrate that continuously taping a single tree, cutting and injuring trees, disposing of trees to insects, infecting trees, and killing trees during extended drought times all have a significant negative impact on tree development. Similarly, the study in [30] found that the attempt to improve yield through negligent tapping and frequent, strong wounding was shown to be damaging to the trees. Deeper wounds during the dry season caused longer healing times, which led to tree death since poor growth circumstances prevented speedy recovery.



Note. Percentage of multiple response tests

Figure 5: Challenges and constraints of gum and resin production.

4. Conclusion and Recommendations

In Ethiopia's rural areas, particularly in the drylands, one of the main livelihood activities is the collecting and selling of gum and resin. In this study, the gum and resin manufacturing system, gum and resin marketing tactics, and the impact of gum and resin production and marketing on local residents' livelihoods are all identified. The study found that products from gum and resin were collected and harvested through natural oozing and artificial tapping. The mean annual harvested gum was significantly higher than the mean annual harvested/collected resin. The gum and resin market chain comprises eight actors with five market channels. Even though the average yearly harvest of gum was larger, the average annual income from resin was much more than the average annual income from gum. The income gained from gum and resin was allocated to fulfilling family basic needs, medicine and health care saving, and social issues and school expenses. The problems and limitations to the production and sale of gum and resin were recurrent drought, lack of market access and market intelligence, and lack of institutional cooperatives, infrastructure, and facilities. The research comes to the conclusion that the production and commercialization of gum and resin significantly improve household livelihood and act as risk avoidance, adaptation, and mitigation strategies for climate change variability such unpredictable rainfall and drought. Finally, the study suggests that local governmental bodies and local communities also should work jointly to ensure the sustainability of species of gum and resin-producing trees. Timely delivery of market information should be ensured and market access, infrastructure, and availability of enough institutional cooperatives should also be improved. Awareness should be created through short- and long-term training for producers and cooperative members. It is advised that the marketing chain and resource access be properly governed.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Disclosure

This study was conducted as part of the authors' employment at Kebri Dehar University.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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References

[1] Y. M. S. Salah, *The Role of Indigenous Gums and Resins in Pastoralists' Livelihood Security and Climate Change Adaptation in Garba Tula Area of Northern Kenya*, Early Career Fellowship Programme, Brighton, UK, 2014.

[2] A. Abtew, J. Pretzsch, L. Secco, and T. E. Mohamod, "Contribution of small-scale gum and resin commercialization to local livelihood and rural economic development in the drylands of Eastern Africa," *Forests*, vol. 5, no. 5, pp. 952–977, 2014.

[3] W. Tadesse, T. Dejene, G. Zeleke, and G. Desalegn, "Underutilized natural gum and resin resources in Ethiopia for future directions and commercial utilization," *World Journal of Agricultural Research*, vol. 8, no. 2, pp. 32–38, 2020.

[4] Ngara, "Overview and framework of priorities 2017-2030. The network for natural gums and resins in Africa," *The Network for Gums and Resins in Africa*, vol. 40, 2017.

[5] B. Chikamai, M. Tchatat, J. C. Tieguhong, and O. Ndoye, "Forest management for non-wood forest products and services in Sub-Saharan Africa," *Discovery and Innovation*, vol. 21, no. 3, 2009.

[6] W. Tadesse, G. Desalegn, and R. Alia, "Natural gum and resin bearing species of Ethiopia and their potential applications," *Investigación Agraria: Sistemas y Recursos Forestales*, vol. 16, no. 3, pp. 211–221, 2007.

[7] M. Lemenih and H. Kassa, "Opportunities and challenges for sustainable production and marketing of gums and resins in Ethiopia," , 2011.

[8] W. Tadesse and G. Desalegn, "Sterculia setigera del Potential Dryland~ resource for the production of gum karaya ln," *Ethiopian Journal of Natural Resources*, vol. 11, no. 1, pp. 83–98, 2009.

[9] M. S. Suleiman, V. O. Wasonga, J. S. Mbau, A. Suleiman, and Y. A. Elhadi, "Non-timber forest products and their contribution to households income around Falgore Game Reserve in Kano, Nigeria," *Ecological Processes*, vol. 6, no. 1, pp. 23–14, 2017.

[10] C. Shackleton and S. Shackleton, "The importance of non-timber forest products in rural livelihood security and as safety nets: a review of evidence from South Africa," *South African Journal of Science*, vol. 100, no. 11, pp. 658–664, 2004.

[11] T. Wubalem, *Natural Gums and Resins: Potential Dryland Non Timber forest Products of Ethiopia Naturally African: In Support of African Natural Products Development and Marketing Sub-regional Consultative Workshop for Eastern Africa World Agroforestry Centre*, ICRAF, Nairobi, Kenya, 2009.

[12] B. Belcher, R. Achdiawan, and S. Dewi, "Forest-based livelihoods strategies conditioned by market remoteness and forest proximity in Jharkhand, India," *World Development*, vol. 66, pp. 269–279, 2015.

[13] P. R. Kozowyk, G. H. Langejans, and J. A. Poulis, "Lap shear and impact testing of ochre and beeswax in experimental Middle Stone Age compound adhesives," *PLoS One*, vol. 11, no. 3, Article ID e0150436, 2016.

[14] A. Hido and A. Alemayehu, "The social and economic significance of natural gum and resin in the woodlands of south omo zone, southern Ethiopia," *International Journal of Financial Research*, vol. 2022, Article ID 8742823, 10 pages, 2022.

[15] A. Alemu, Z. Yilma, A. Eshete, and T. Dejene, "Growth performance and gum Arabic production of *Acacia senegal* in northwest lowlands of Ethiopia," *Journal of Forestry Research*, vol. 24, no. 3, pp. 471–476, 2013.

[16] H. Kassa, B. Tefera, and G. Fitwi, *Preliminary Value Chain Analysis of Gum and Resin Marketing in Ethiopia*, CIFOR, Bogor, Indonesia, 2011.

[17] M. Adem, A. Worku, M. Lemenih, W. Tadesse, and J. Pretzsch, "Diversity, regeneration status and population structure of gum-and resin-bearing woody species in south Omo zone, southern Ethiopia," *Journal of Forestry Research*, vol. 25, no. 2, pp. 319–328, 2014.

[18] M. Lemenih, T. Abebe, and M. Olsson, "Gum and resin resources from some Acacia, Boswellia and Commiphora species and their economic contributions in Liban, south-east Ethiopia," *Journal of Arid Environments*, vol. 55, no. 3, pp. 465–482, 2003.

[19] A. Worku, M. Lemenih, M. Fetene, and D. Teketay, "Socio-economic importance of gum and resin resources in the dry woodlands of Borana, southern Ethiopia," *Forests, Trees and Livelihoods*, vol. 20, no. 2-3, pp. 137–155, 2011.

[20] Y. Osman, S. M. Ali, E. Schelling et al., "Integrated community based human and animal syndromic surveillance in Adadle district of the Somali region of Ethiopia," *One Health*, vol. 13, Article ID 100334, 2021.

[21] W. Creswell, *Research Design. Qualitative, Quantitative and Mixed Methods Approach*, SAGE Publications, Thousand Oaks, CA, USA, 2009.

[22] R. K. Yin, *Case Study Research: Design and Methods*, Vol. 5, International Professional Publisher Sage Publishing, Thousand Oaks, CA, USA, 2009.

[23] H. R. Bernard, *Research Methods in Anthropology: Qualitative and Quantitative Approaches*, Altamira Press, Walnut Creek, CA, USA, 3 edition, 2002.

[24] I. Hedberg, "Flora of Ethiopia and Eritrea," in *The Biodiversity of African Plants*, L. J. G. van der Maesen, X. M. van der Burgt, and J. M. van Medenbach de Rooy, Eds., Springer, Berlin, Germany, pp. 802–804, 1996.

[25] A. Eshete, D. Teketay, and H. Hulten, "The socio-economic importance and status of populations of Boswellia papyrifera (del) hochst," *Forests Trees and Livelihoods*, vol. 15, no. 1, pp. 55–74, 2005.

[26] A. Getahun and Y. Kebede, "Status, socio-economic contribution and conservation constraints of Gum and resin species in East Africa review," *International Research Journal of Biological Sciences*, vol. 9, no. 1, pp. 40–46, 2020.

[27] M. E. Ballal, E. A. El Siddig, M. A. Elfadl, and O. Luukkanen, "Relationship between environmental factors, tapping dates, tapping intensity and gum Arabic yield of an Acacia senegal plantation in western Sudan," *Journal of Arid Environments*, vol. 63, no. 2, pp. 379–389, 2005.

[28] C. Wekesa, P. Makenzi, B. N. Chikamai, J. K. Lelon, A. M. Luv, and M. Muga, "Gum Arabic yield in different varieties of Acacia Senegal (L) Willd in Kenya," *African Journal of Plant Science*, vol. 3, no. 11, pp. 263–276, 2009.

[29] Z. Mekonnen, A. Worku, T. Yohannes, T. Bahru, T. Mebratu, and D. Teketay, "Economic contribution of gum and resin resources to household livelihoods in selected regions and the national economy of Ethiopia," *Ethnobotany Research and Applications*, vol. 11, pp. 273–288, 2013.

[30] Y. Berhanu, P. Vedeld, A. Angassa, and J. B. Aune, "The contribution of frankincense to the agro-pastoral household economy and its potential for commercialization-A case from Borana, southern Ethiopia," *Journal of Arid Environments*, vol. 186, Article ID 104423, 2021.

[31] H. Kassa, T. Berihun, and F. Girmay, *Preliminary Value Chain Analysis of Gum and Resin Marketing in Ethiopia: Issues for Policy and Research*, Vol. 4, CIFOR, Bogor, Indonesia, 2011.

[32] D. W. Te Velde, J. Rushton, K. Schreckenberg et al., "Entrepreneurship in value chains of non-timber forest products," *Forest Policy and Economics*, vol. 8, no. 7, pp. 725–741, 2006.

[33] F. N. Gachathi and S. Eriksen, "Gums and resins: the potential for supporting sustainable adaptation in Kenya's drylands," *Climate and Development*, vol. 3, no. 1, pp. 59–70, 2011.

[34] A. Eshete, D. Teketay, M. Lemenih, and F. Bongers, "Effects of resin tapping and tree size on the purity, germination and storage behavior of Boswellia papyrifera (Del.) Hochst. seeds from Metema District, northwestern Ethiopia," *Forest Ecology and Management*, vol. 269, pp. 31–36, 2012.