Sudan University of Science & Technology

Collage of Graduate Studies Scientific Research

Assessment of the Impact of Gum Arabic Research Results Applied on Improving and Developing Gum Arabic Belt in Sheikan and UmRuwaba Localities, North Kordofan State, Sudan

تقييم أثر نتائج بحوث الصمغ العربى المطبقة على تحسين وتنمية حزام الصمغ العربى فى محليتى شيكان وام روابة- ولاية شمال كردفان فى السودان

By

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In 2021

DEDICATION

To soul of my father

My mother

My wife, Children

My brothers, sisters, relatives and Colleagues

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First and last, I am very thankful and indebted to my creator for the gifts of health and strength he gave me throughout of my study.

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ABSTRACT

This study was conducted in Sheikan and Um Ruwaba localities, North Kordofan State, Sudan from 2017 to 2021. It aimed to assess impact of some results of applied gum Arabic research on improving and developing of gum Arabic belt in Sheikan and Um Ruwaba localities. The focus is on production, marketing, quality aspects, adoption of innovated tools and agro-forestry. It also aimed to investigate to what extent the research centers performed their roles in passing results of these researches to the beneficiaries in the study area. Moreover, to know how these researches helped the beneficiaries in improving and developing their gum produced and quality. It also investigated gaps in gum Arabic research results and to design a conceptual model for how beneficiaries maximize their benefit from results of implemented research. Data were collected using a stratified random sampling where 265 gum Arabic producers were interviewed. Secondary data were obtained from relevant sources. With the aid of Statistical Package for the Social Sciences (SPSS), descriptive statistics, frequency, chi square and Likert Scale test were adopted. Statistical analysis revealed that percentages of respondents who applied what they have gained regarding agro-forestry, tapping with sunki, tapping direction, packing, pickings duration were 61.5%, 54.0%, 63.0%, 64.2% and 61.9% respectively. Chi- square test explained that there is significant relationship between gum Arabic production techniques applied and increasing production and quality of gum produced, in terms of tapping with sunki **(**0.005**)**,tapping direction east and west **(**0.094**)**, time of first picking after tapping (0.029) and time between the picking and second one **(**0.017**).** Likert scale test (2.00) showed weak and insufficient respondents attitude opinions towards gum Arabic production techniques that produced by FNC in term of agro-forestry (2.7), tapping practice (2.7), picking (2.7), packing (2.7) and

marketing (2.5). Likert scale test (3.00) showed that respondent's attitude opinions effectiveness of gum production techniques results between weak and not enough in developing and improving of gum belt, in terms of tapping directions **(**3.0**)**, packing containers (3.0), gum storing (2.8) and picking interval (3.0). The study recommended that sufficient training for gum producers is highly required to enable them to acquire skills and to build-up their capacity for more benefits from research output.

المسنخلص

اجريت هذه الدراسة بمحليتى شيكان وام روابة بولاية شمال كردفان – السودان من -2017 – 2021 . بهدف تقويم اثر بعض نتائج بحوث الصمغ العربى المطبقة على تحسين وتنمية قطاع الصمغ العربي فى محليتى شيكان وام روابة. وانصب التركيزفى انتاج الصمغ العربى , التسويق , جوانب النوعية , تبنى ادوات مبتكرة , والزراعة الغابية. كما هدفت إلى معرفة مدى أداء المراكز البحثية لأدوارها في توصيل نتائج هذه الأبحاث إلى المستفيدين في منطقة الدراسة. علاوة على ذلك، لمعرفة كيف ساعدت هذه الأبحاث المستفيدين في تحسين وتطوير الصمغ المنتج وجودته. ايضآ تحرت فى الفجوات فى نتائج بحوث الصمغ العربي وتصميم نموذج مفاهيمي لتعظيم منفعة المستفيدين من نتائج البحوث المنفذة.جمعت البيانات باستخدام العينة العشوائية الطبقية حيث تمت مقابلة 265 منتجاً للصمغ العربي.جمعت المعلومات الثانوية من المصادر ذات الصلة. تم استخدام الحزمة الاحصائية للعلوم الاجتماعية (SPSS), الاحصاء الوصفى, التكرار, مربع كاى واختبار ليكرت. اوضحت التحاليل الإحصائية المستهدفين طبقوا المعلومة فيما يختص بالزراعة الغابية ، الطق بالسونكى، اتجاهات الطق شرق وغرب ، الاوانى التى يعبىء فيها الصمغ والفترة بين اول لقطة والطق(61.5%),(54 %),(63 %), (64.2%) و (61.9%) على التوالى. اوضح تحليل مربع كاى انه هنالك علاقة زمنية بين تطبيق تقنيات انتاج الصمغ العربى و زيادة انتاج ونوعية الصمغ المنتج, فيما يختص تطبيق الطق بالسونكى (0.005), اتجاهات الطق شرق وغرب (0.094), زمن اول لقطة بعد الطق (0.029) والفترة بين اللقطة والتى تليها (0.017). اوضح مقياس ليكرت(2.00) اتجاهات آراء المستهدفين فى ضعف وعدم كفاية تقنيات انتاج الصمغ التى قدمت من الهيئة القومية للغابات فيما يتعلق بالزراعة الغابية (2.7), عملية الطق (2.7), اللقيط (2.7) , التعبئة (2.7) والتسويق (2.5). كما اوضح مقياس ليكرت(3.00) اتجاهات آراء المستهدفين فى فعالية نتائج تقنيات بحوث الصمغ العربى فى تطوير وتنمية قطاع الصمغ العربى بين ضعيفة وغير كافية, فيما يتعلق باتجاهات الطق (3.0), اوانىء التعبئة (3.0) تخزين الصمغ (2.8) و الفترة الزمنية للقيط (3.0). اوصت الدراسة بالتدريب الكافي لمنتجي الصمغ مطلوب بشدة لتمكينهم من اكتساب المهارات وبناء قدراتهم لتحقيق المزيد من الفوائد من مخرجات البحث.

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ACRONYMS

IGARDS: Institution of Gum Arabic Research and Desertification Studies

FNC: Forests National Corporation

ARC: Agricultural Research Corporation

NGOs: None Governmental Organizations

GAPAs: Gum Arabic Producer Associations

GAPs: Gum Arabic Producers

WSARP: Western Sudan Agricultural Research Project

GRD: Gum Research Division

EARC: Elobeid Agricultural Research Corporation

GARC: Gum Arabic Research Center

JECFA: Joint Expert Committee on Food Additive

ECsM: Elobeid Crops Market

GA: Gum Arabic

GABR: Gum Arabic Belt Rehabilitation

FAO: Food Agricultural Organization

WHO: World Health Organization

UK: United Kingdom

CHAPTER ONE
INTRODUCTION

1.1 Background:-

Sudan is the third largest country in Africa. It is located between latitudes 8 and 22 degrees north and longitudes 22 and 38 east, in the northeastern parts of Africa. The Sudan is bound by Egypt, the Red Sea, Eretria, Ethiopia, Republic of South Sudan, Central African Republic, Chad and Libya, with an estimated surface area 1.882 million km2. Sudan has an estimated 2019 population of 42.81 million. The 2020 UNDP Human Development Index ranks Sudan at 170 out of 189 countries. Poverty estimates indicate that about 15 million people are considered poor. The poverty rate is significantly higher in rural areas (58%) than in urban areas (26%) and varies markedly by states (Colm, et al, 2021). Over 80% of Sudan's employment takes place in the agricultural sub-sector of the economy, the majority of the populations are farmers and pastoralists living on subsistence farming and livestock herding in a nomadic way of live (Badri, 2012). In Sudan the gum belt denotes the area of central Sudan between latitudes 9 and 15ↄ N together with minor protrusions. The gum belt is estimated to cover 520,000 square kilometers 52 million hectares, which is one- fifth the area of the country. It spans over five sectors: Eastern, Central, Kordofan, Darfur and Blue Nile. It covers parts of the clay and sandy plains. The clay plains are found in South Kassala, South Blue Nile, South White Nile, Northern Upper Nile and South Kordofan (Fadlamola, 2003). Sudan has around 68.2 million hectares of arable land (approximately 183.3 million feddans), which makes up about 36.2% of the country (FAO 2018a). However, only around 29% of this land (20.0 million ha) is cultivated.

Gum Arabic is one of the main products of the rain fed agricultural sector in Sudan. It is a main forest product mainly produced from *Acacia senegal* trees. Small-scale farmers in traditional rain fed farming areas mostly produce gum Arabic. They represent up to 20 percent of Sudan's population and are among the poorest. The effect of the current gum Arabic marketing policy has not been encouraging to this group. This has led to reduced production and accordingly exports, diminishing for the past forty years at an average rate of 2.2 percent per annum (The World Bank. 2007). The World Bank 2007. Sector Policy Note Export

Marketing of Gum Arabic from Sudan. Multi Donor Trust Fund-National. Technical Secretariat.

Many multifaceted factors contributed to the deterioration of Gum Arabic production apart from drought, desertification and mismanagement.
Gum Arabic production in Sudan has suffered from a number of policy and institutional failures including a government monopoly on gum exports — reduced the price paid to producers in the early 2000s to around 10% of the world market price. This led many farmers to stop harvesting gum, which had a clear negative effect on the natural resource base, as many gum trees were also felled for charcoal production.

The high level of mistrust between smallholder producers and gum buyers. Another more complex problem was the inequity within smallholder producer groups. Gum tapping and collection require pre-financing for inputs such as jute bags and for hiring additional labor (Elhassan et al, 2020).

It contributes by an average of 12% to the gross domestic product of the country. Tapping is practiced during two different periods. Early tapping is conducted from October until the end of November. Late tapping is done only for trees in agro- forestry system where *Hashab* trees were grown and the crops were cultivated between the trees, or for those trees in water collecting sites, from December till the end of February. The tools of tapping *Hashab* trees were the traditional axe and the developed '*Sunki* (Adam *et al*, 2016). Gum Arabic plays an important role as a cash crop produced in the traditional rain-fed areas of North Kordofan in Western Sudan as indicated by El Dukheri, 1997, and Mohamoud, 2004.

Being of the most African countries affected by desertification, Sudan mainly the Gum Arabic belt has witnessed a considerable deterioration in several aspects of the natural resources, this could be explained in low farm productivity, low standard of living, increasing rates of poverty, unemployment and vagabonds. (Institution of Gum Arabic Research and Desertification Studies, IGARDS, 2016). Desertification is one of the most important environmental destructive calamities in the arid, semi-arid and semi humid eco-zones, attributed to natural factors such as drought and climate change, manmade factors such as irrational utilization of natural resources. This led to soil depletion, water scarcity, deterioration

of vegetation cover, conflict over resources and harsh socioeconomic impacts (IGARDS, 2016).The recent droughts had affected the Gum gardens of Northern Kordofan and led to the breakdown of the Gum Acacia agro-forestry system, reduced gum production and threatened the stability of the agricultural soils (Khalid, 1985). The densities of plant species have been greatly altered, and mostly reduced, (Taha, 2004). It contributes by an average of 12 percent to the gross domestic product of the country. Gum Arabic plays an important role as a cash crop produced in the traditional rain-fed areas of North Kordofan in Western Sudan (El Dukheri, 1997). The year 1958 was the beginning of organized scientific research and establishment of gum researches division in forest administration where Mr. Vaydal Hool was nominated as the manager of this division, it was responsible for two jobs, the first one is research conduction in chemistry of gum Arabic with coordination with one's of Universities of European or United State of America, aimed to diversity and increasing of gum uses. The second job was conducting of field researches in different gum aspects, as a goal of improving and increasing of gum production (Siefeldin, 2015).

In addition to that, there was nationally a number of Gum Arabic research Institutions and Centre's for the same job, the Gum Arabic Research Institution and Centre's include:

- Institution of Gum Arabic Research and Desertification Studies (IGARDS), in 2014, which formerly known as Gum Arabic Research Centre (GARC)- University of Kordofan
- Gum Arabic Research Centre, Sudan University of Sciences and Technology
- Gum Arabic and Forest Products Research Centre 2009 - University of West Kordofan
- Gum Arabic Research Centre and Gum Arabic Board Sudan.

In 2011, Gum Arabic Board sited an ambitious programming and planning, focusing on different fields, representing in opening new markets of Gum Arabic in China, Malaysia, India, Korea and anther Eastern Asia Countries, beside of processing of applied researches coordination, cooperation with new Gum research Centre's in China, gum Arabic research Centre in United Kingdom and gum Arabic

research in Malaysia with objectives of creation of new products based on international research results (GAB, 2011).

1.2 Problem Statement:-

Despite the great area of Hashab trees in the Gum Arabic belt since long time and accumulates of gum Arabic researches conducted, yet there is fluctuation in gum production and productivity, the production process are practiced by traditional tools. The developed tapping tools still not yet adopted by the majority of gum producers. Producers and traders did not yet follow the quality aspects. Many trees per feddans up to 250 trees nonetheless few of them produce gum. This study conducted to tackle the issue of researches conducted and its results impact on the improving and developing the gum Arabic sector in Sheikan and Um Ruwaba Localities - North Kordofan, Sudan.

1.3The research importance:

Despite of the plenty of Hashab trees in the Gum Arabic belt for long time and plenty of gum Arabic researches were conducted, still there are information gaps in gum production and productivity, quality aspects, marketing and adoption of innovations tools and their impact in gum Arabic producers, there for come this research to tackle this issue.

1.4 Research Objectives:-

The general objective of the study is to assess the impact of gum Arabic researches' results applied in improving and developing the gum Arabic belt of Sheikan and Um Ruwaba Localities - North Kordofan State, Sudan.

1.4.1 Specific objectives:-

Analyze the applied researches' results in the field of gum Arabic production, marketing, quality aspects, adoption of innovation tools and agro- forestry services.

Investigate to what extent the research centers performed their role in conducting the results of these researches to the beneficiaries in the study area.

Measure to what extend these researches helps the beneficiaries in improving and developing their production and quality.

Find out the gaps in gum Arabic researches conducted results of priority researches.

Design ways for how the beneficiaries benefit from the results of implemented researches.

1.5 Variables of the Study:-

1.5.1 Table of the study variables:-

Independent variable	**Dependent Variable**
Results of applied researches in the area of:- Production Quality aspects Marketing and marketing information Adoption of innovation tools Agro-forestry services	-Improving gum Arabic production -Developing gum Arabic quality

1.6 Overall hypotheses:-

Applied researches results of Gum Arabic research, centers and institution, have no significant effect in improving and developing the Gum Arabic sector in Sheikan and Um Ruwaba Localities-North Kordofan state.

1.7 Research Questions:-

Are the results of applied researches in the field of gum Arabic production, marketing, quality aspects and innovation conducted to the beneficiaries?

Are the Researches Centers contributed to improving and developing gum Arabic sector?

Are there still gaps in gum Arabic researches results, in the priority fields?

How to achieve optimal benefits of the conducted researches in various aspects of gum Arabic?

1.8 Research organization:

This research is organized in five Chapters:

Chapter one includes the research introduction which consists of:

Background, problem statement, Research importance, Research objectives, variables of the study, overall hypotheses, Research Questions and Research organization

Chapter two consists of:

Literature review, which include: Actors involved in the gum Arabic production, gum Arabic producers' Associations and organizations.

The results of gum Arabic researches conducted, Gum Arabic production, gum Arabic definition, gum tapping and tapping tools, definition of Sunki, tapping date, annual average yield per tree, the first time of gum picking, gum collection, advantages of using sunki compared with an axe, land tenure and management practices, agro-forestry system, tapping direction, gum Arabic marketing system.

Chapter three consist of:

Research Methodology which include, The study Area, climate, soil types, sampling procedure, sample size, data collection Method , Study Tools, Data analysis procedure, permission for data collection, interview

Chapter four consist of:-

Data analysis, results and discussion

Chapter five consist of:-

Summary of the results, Conclusions and recommendations

References……and Appendix

CHAPTER TWO

LITERATURE REVIEW

This chapter is composed of three main sections, the first one focuses on the gum Arabic sector Sheikan and Um Ruwaba Localities - North Kordofan state. Section two is the gum Arabic researches institutions and centers performed their role in conducting the results of these researches to the beneficiaries in the study area. Section three is a review of the results of gum Arabic researches conducted in the field of gum Arabic production, marketing, quality aspects and innovation.

2.1 General Information about *Acacia sengal* (Hashab tree)

Shrubs or small trees 2-12 m high, Bark yellow to light brown or grey, rough, young branch lets with horizontal slit-like lenticels; stipules non-spinescent; prickles at nodes in threes, 2 lateral pointing upward or forward and one central pointing downward or backward, 4-7 mm long; dark brown with a grey base. Leaves 1-6 cm long; pinnae 2-6 pairs, 0.5-3 cm long; leaflets 8-18 pairs, linear to elliptic oblong, 1-6× 0.5- 2 cm. Inflorescence spicate, 2-10 cm long on peduncles 0.7-2cm long; flowers white or cream, sessile; sepals 2× 0.7 mm, pubescent; petals 2.5 × 0.3mm, glabrous; steams 4-7 mm long, glandular. Fruit flat straight oblong membranous dehiscent pods 3-24× 1- 3.3 cm, pale brown to straw-colored; seeds vertical in pod, orbicular, compressed, 8-12 mm across, yellow or pale brown; areoles crescent-shaped, central, 1.5-6 × 2.5-5 mm; funicles 7.5 mm long, Flowers Nov. - Feb.; fruits Jan. - April. (El Amin, 1990).

Hashab trees on sandy and clay plains, in short grass savanna forming a continuous belt from east to west in central Sudan. More common on the western sand plains of Kordofan and Darfur as pure stands associated with *Acacia mellifera.* (El Amin, 1990).

Acacia senegal (L.) Willd produces a high quality gum Arabic that is an important cash crop, which contributes significantly to the economies of a number of African courtiers (Fadl and Sheikh 2010). More than 80% of the total gum Arabic worldwide is collected from *Acacia senegal* which grows naturally in the gum belt of Sudan (Fadl and Sheikh 2010). This annual trade is worth around 45 million USD (Bashir 2001; Beshai 1984;

Larson and Bromely 1991). The average gum production in Sudan declined from 46,000 t in the 1960s to 28,000 t in 1990s Elmgvist 2003.

A. senegal in Sudan grows naturally in the gum belt (10°and 14°N). This broad ecological region represents a complex and diverse environment with regard to climate, soils, vegetation, animals and human activities (Ballal 1991, Siefeldin 1984).These factors were reported to have an impact on gum yield. The species is grown successfully in the semi-arid environment of Kordofan, Darfur and western White Nile and in the central clay plains (Ahmed 1986; Badi et al. 1989; Hussein and Sulieman 1999). In addition to producing gum, *A. senegal* is useful as a windbreak, its pods and foliage provide good fodder for livestock and the tough wood of its tap root and stem is used for making tool handles. Strong fibers can be obtained from the long and flexible surface roots, and the dense wood yields excellent charcoal (NAS 1986). *A. senegal* is an important multipurpose leguminous tree species for ~~a~~afforestation in the arid and semi arid regions. It plays an important environmental role in combating desert encroachment and minimizing soil erosion. An important characteristic of this woody legume is its ability to fix atmospheric nitrogen in symbiosis with rihzobium in root nodules (Zhang et al. 1992).

Europeans named Gum Arabic as ‘gum Arabic’ for the Sudanese gums, because it was obtainable from Arabian ports such as Jeddah and Alexandria (Karl – Hermann, 1997). It was described as ‘a hardened latex material which solidifies after oozing from a tree’ (Adamu, Nasiru and Oguntunde, 2008) or rather, it is a dried exudates obtained from the stems and branches of Acacia senegal (L) Willdenow or closely related species (Anon, 2004 in Abdullahi, 2004). It has been observed that the acacia tree is made up of several species. (Domdain and Philips stated in Nasir, 2005) that the Acacia genus has about 11000 – 12000 identified species which produces gum of various grades. Out of these numerous species, only one, *Acacia senegal* is identified as producing the best quality gum in commercial quantity (Aghughu, 1998). Gum Arabic has several industrial, social and other uses. The industrial uses include its use in food, pharmaceuticals and textiles industries (Giroh et al., 2010). It is also useful in beverages and cosmetics industries (Gwary et al., 2013). It is socially an important revenue earner for the producing countries and employer of labor for

rural people who are engaged in production and gum collection. In countries bordering the Sahara, the plants have proved useful as windbreaks and shelter belts against desert encroachment. Their canopies intercept raindrops while the root systems are effective in reducing soil erosion, thereby stabilizing soils.

2.2 Extension Services

2.2.1The Chemistry of Gum Arabic research

Research on chemistry of gum Arabic is being carried out at the University of Edinburgh, UK. Sample of bulk gum, single nodules and all sorts of gum have been sent to Edinburgh by the GRD for many years. The purpose has been to investigate the physical and chemical properties of gum Arabic, the most important of which are those related to its use in foods especially its effects in human health.

Globally, because it's often used as an ingredient rather than simply an additive, confectionery is the biggest end use application for gum Arabic in Europe than in the United States. The same author reported that gum Arabic is used to stabilize oil in water emulsion where, for example, citrus oil is employed as flavor component. In flavor encapsulation it prevents evaporation and protects the flavor from oxidation and absorption of water. The use in textiles, paint and adhesive including the traditional office glue and postage stamps has declined considerably over the years and now accounts for only very small quantities of gum Arabic (John, 1999).

2.2.2 under the Gum Research Division (GRD)

The GRD was involved for several years in widespread extension campaigns aimed at improving gum gardens, their protection against fire and the use of the new tapping tool (*Sunki*). The extension mainly covered the former provinces of Kordofan and Darfur, but to a lesser extent the White Nile, Blue Nile and Kassala provinces as well. In these campaigns, the GRD obtained generous support from province authorities, rural councils and the leaders of the native administration in the areas. As a result of these extension campaigns the GRD was able to influence gum production to a great extent. For example, gum production in Darfur jumped from 7,489 tons in 1967/68 season (a record year) to 9,858 tons in 1968/69 season, in spite of very poor rains in the latter

season GRD, 1968/69.Tapping tools were distributed to many villagers, and in particular to the local blacksmiths to make them locally available. In general, the new tapping tool (*Sunki*) seems to have been better received in newly opened up areas such as South Kordofan and South Darfur than in the areas where gum production is a well established tradition. In Darfur alone in 1973 some of 761 villages were covered, 9,234 farmers were contacted and 350 tapping tools were distributed (GRD, 1973/74).

2.2.3 Gum Research Section of Western Sudan Agricultural Research Project (GRSWSARP)

More extension work, (researches Hashab tree) was done under the GRD than at present because of the separation of the activity and its assignment to ill-equipped agricultural extension departments. Recently the agricultural extension services in the different areas are run by the Regional Ministries of Agriculture in co-operation with the Central Agricultural Extension Administration in Khartoum, (Gum Arabic Belt Rehabilitation, 1989).

2.3 Gum Arabic Uses

Uses of gum Arabic fall in three main categories, food, pharmaceutical as well as technical and miscellaneous (FAO, 1995 and Chikamai, 1996).Gum Arabic is exudates from Acacia trees, mainly from *A. senegal* and *Acacia seyal*. Sudan is considered the world's largest producer of gum acacia. Gum Arabic is the oldest and best known of all the polysaccharide plant exudates. It was used by the Ancient Egyptians in their paintings as an adhesive for mineral pigments and as an adhering agent to make flaxen wrapping for embalming mummies.

2.4 Chemical Composition of Gum Arabic

Gum Arabic is a true gum, that is, water-soluble polysaccharide. It is tasteless, odorless and forms a weekly acidic solution in water. On hydrolysis it breaks down to its component sugars: galactose, arabinose, rhamnose and glucuronic acid in the approximate proportions 44: 25: 14: 17. Identification tests usually involve the detection of these sugars to distinguish it from other natural and synthetic gums. The protein content is low, usually around 2% but is believed to play an important role in

determining the emulsifying properties of gum Arabic (John, 1999). Menzies *et al*., 1992 found that the optical rotation of the gum Arabic is (ca-30) and content of rhamnose (12- 14%), arabinose (24- 29%), galactose (36 -42%), glucuronic (16 – 17%), Nitogen (0.327 – 0.365%) and protein (2.16 – 2.41%). Gum Arabic is composed of salts of an acidic arabino – galactan protein complex. As gum Arabic has been used as foodstuff, it's safely and energy value as a food additive was tested. Gum Arabic is free from toxic materials and hence can be used in small quantities as a food additive. However, it can also be used as a major ingredient. The energy value of gum Arabic, as accepted by FAO and WHO in 1982, is 4Kcal/g. It also accounts for about 15.3% and 10% of the household income of gum producers and other farmers in the Sudanese gum belt respectively (El Amin and Ballal, 1989).The report of the IIED/IES, 1989 describes very thoroughly the importance of gum Arabic production to the economy of the Sudan .Gum Arabic is a product of the trees *Acacia senegal* (gum Hashab), that offers two broad-based benefits to the people of the Sudan. In many parts of Kordofan, the collection of gum significantly improves the livelihood of the sedentary agriculturist population.

2.5 Environmental aspects of Hashab

The gum trees provide invaluable environmental benefits to this large area of the Sudan. They also provide fodder and fuel wood and contribute to the increase in crop yield through nitrogen fixation. Moreover, they offer protection to soils against desertification, which is a phenomenon of a perpetual declining soil productivity hazard resulting from climate variation and human use of the land (Taha, 2004).

2.6 Socio-economic aspects of Hashab

Gum Arabic from *Acacia senegal* (Hashab) trees is a major product of rain fed agricultural sector in Sudan. It contributes significantly to household income of gum farmers and foreign exchange earnings of the country. Hashab trees provide fodder, fuel wood and diverse valuable social-environmental benefits, (Taha, 2004). The vital role of forests to the Sudanese economy and the welfare of its population can be indicated in several ways (Bayoumi, et al, 2000). The main sources of fuel are firewood and charcoal. They constitute about 85% of the total energy

used annually, and about 93% of the domestic consumption. *Acacia senegal* (Hashab tree) is multi-purpose tree. Each part of the tree (roots, root nodes, bark, wood, leaves, flowers, gum, pods and seeds) is used in special traditional or medicinal use. There were more than forty uses for the *Acacia senegal* parts. People use different parts of *Acacia senegal* as food, drink, medicine, culture, believes and norms, (El Tahir, 2013).

2.7 Agro-forestry system:

(Kamal, E. M. F. 2012) cited that *A. senegal* trees had a beneficial effect on crop performance and yield as well as gum yield, under titled Influence of *Acacia senegal* agro-forestry system on growth and yield of

sorghum, sesame, roselle and gum in north Kordofan State, Sudan. Hammad, 2014 mentioned that traditional shifting cultivation, agro-forestry, which is the dominant crop production system practiced in the tropics Oba et al., 2002, is the typical *Acacia*-based farming system in the gum belt of Sudan. Hammad, 2010**,** refer to the agro-forestry practices have a significant effect (α .05) in improving some soil physical properties, namely bulk density, porosity and permeability, as well as they increase N, P, Ca, Mg, Cl and HCO3 content of the soil. Hammad et al., 2014 cited that tree planting and husbandry has existed in the Sudan for several millennia, during which time gum Arabic has been a prized export commodity. Local socioeconomic conditions determine land tenure practices. Noticeable variations in land tenure with regard to different parts of the country necessitate common regulations: allocating land holding to households by the village leader (sheikh), regulating the *Acacia*-based farming system according to environmentally sound principles, and assessing agricultural and gum Arabic yields.

2.8 Historical Background of tapping tools

Gum Arabic Belt Rehabilitation in Sudan (GABR, 1989), carrying out of all extension services needed by and advice to:

Gum Arabic producers on the technical side of production; provincial commissioners on protection of gum areas and problems such as water provision, transport of gum, etc; the gum Arabic Company with regard to forecast of yield and other related issues, provincial technical staff with regard to dissemination of technical knowledge for management of the

Forests Department gum reserves, management of all Forests Department gum reserves both natural and planted, mainly act as a buffer stock.

Research on gum Arabic was formally started in 1957/58 when the division was created. Before then, sporadic attempts were made to solve some of the main problems related to gum Arabic. For example, attempts to establish gum plantations date back to 1911, followed by some in mid-1920s and again in the mid-1930s. All these attempts, however, lacked continuity or follow-up due to changes in the plans of the Forest Service and interruptions by major incidences such as World War11 Hall, 1961. The Gum Research Division (GRD) has experienced administrative changes. In 1975, it was put under the umbrella of the Agricultural Research Corporation (ARC) so that it benefits from the multi-disciplinary interactions and focus only on research and extension. In 1982 it was absorbed in the Western Sudan Agricultural Research Project (WSARP) which is part of the Gum Research Division (ARC). (Bayoumi, et al, 2000).

2.9 Gum Tapping and Tapping Tools:-

Gum tappers use small axes for tapping Hashab trees. Tapping is usually done on younger branches and rarely on the main trunks because the latter produces gum of rather poor quality. The use of the axe frequently damages the wood making them be more susceptible to attack by borers which might eventually kill the branch or even the whole tree (Gum Arabic Belt Rehabilitation GABR 1989). Because of this several tapping tools (Appendix 2) were tested to find a suitable alternative to the axe. The Gum Research Division (GRD) with the help of a local blacksmith finally evolved an alternative tool (Sunki). Campaigns were launched to train gum producers in the use of the new tapping tool. The response, however, was not very encouraging especially in the traditional gum production areas. This was due to the tendency among farmers to stick to their old and proven tools, as they had more uses for the axe than the new tool. To tap a gum tree, the blade of a small axe or a "*Sunki*" (bayonet) is pushed under the bark of the branch. The blade is pulled back causing a wound about 2.5cm wide and up to one meter long. The developed tapping tool *Sunki* is widely used in White Nile, North Kordofan and

south Darfur. However, in Blue Nile, south Kordofan and North Darfur the small bladed axe is more commonly used.

The average life of the tree is significantly decreased as a result of the injury caused by the axe. For example the gum tree was found to die at the age of 7 to 14 years in the areas using the traditional axe rather than the *Sunki* (Ballal, 1991).

2.10 Gum Tapping and Collection

2.10.1 Definition of Tapping

Tapping refers to scratching the bark of the stem and/or branches of the tree, while avoiding damaging the cambium layer, in order to accelerate gum exudation. Like other acacias, *A. senegal* produces gum either naturally or following scratching of the bark. Traditionally, the natural exudates from *A. senegal* are often collected by local people in both Kordofan and Darfur regions, Sudan. Different local tools are used by gum tappers in Sudan for tapping *A. senegal* trees for gum production. For example, axes are traditionally used for tapping the stems and/or branches of *A. senegal*. Another tool that is used is called a Makmak, which is also used for tapping Hashab trees. Makmak, weighing 0.50-0.75kg with a15cm blade and a 7-10cm sharp edge, is designed for tapping gum trees, for example *A. senegal*, by pushing the blade upward into the bark, the two tools are mentioned are not recommended, as it is difficult to control the depth of the incisions made in the stem and/or branch of the tree, The tapping tool "*Sunki*" or "Bayonet" 20cm in length and weighing 0. 25-0.50 Kg is used for tapping *A. senegal* (Ballal et al., 2005). In Sudan, is the only tool recommended for tapping this tree species. The *Sunki* has to be pushed under the bark and pulled back.

2.10.2 Tapping Calendar

The *Acacia senegal* tree ripe for tapping after a dormancy period following the growing season after the end of the rainy season, the exact time depends on whether the rains end early or late. The best time for tapping is usually judged by the shedding of leaves and changes in the color of the bark of the tree (Ballal, 1991).

2.10.3 Tapping date:-

The weather temperature has a considerable influence as to when the gum season starts, if the weather is hot enough directly after October/November; the leaves will start falling, which is a signal to start tapping the *A. senegal* trees. Idris, 2011 announced that the best time for tapping gum Arabic trees is October and November. Tapping of *A. senegal* trees on the 1st October increased the total gum yield by 63% compared with the total yield obtained from 1st November and 1st of December (Fadl, *et al* 2013).

2.10.4 Tapping direction:-

(Idris Musa et al., 2009) cited that a highly significant difference between tapping direction ($P \leq 0.001$) was obtained, the gum yield increased by 60 % when the tapping was on the eastern and western sides towards direct sun light

2.10.5 Marketing:-

Gum Arabic Project programme, (2010) cited that several years ago the Sudanese gum sector witnessed a serious decline. Gum Arabic prices fell and small-scale gum producers only received a tiny percentage of the export price. Farmers started to cut down the Acacia trees in order to expand food and cash crop cultivation. Mahmmoud et al., (2014) cited that the gum Arabic (GA) producers, as major stakeholders, do not often exist physically at Elobeid Crops Market (ECsM), the gum Arabic companies do not show up directly at the auction market.

2.10.6 Gum Arabic production:-

Gum Arabic is a non-wood tree product whose sustainable production depends on the perpetuity of the bush-fallow system whereby millet is obtained from the cultivated plots while gum Arabic is obtained from the trees of *A. senegal* that grow on the fallow land. The peasant farmers always ensured regeneration, tending and protection of their gum gardens because the income derived from sales of gum Arabic was more than 50% of family revenue, which amounted to 40-50% of gum export prices. Not only that but also the tree, being a legume, restore soil fertility while

growing on the fallow land and provide fuel wood when clear-felled for re-cultivation (Seif el Din 1986, El siddig et al, 2007).

There are a lot of previous researches and studies conducted in gum Arabic production filed. It contributes by an average of 12% to the gross domestic product of the country. Gum Arabic is natural exudates obtained from the stem and branches of *A. Senegal* and closely related species such as *A. seyal* (Joint Expert Committee on Food Additive JECFA, 1999).

2.10.7 Tapping Method

Tapping is injurious to the tree branches. *A. senegal* tree is tapped when it reaches a height of about 1.2 to 3m, with a main stem of about 10cm, or more, in diameter. Such a growth is attained in a period of 3-7 years. Tapping is carried out using a sharp tool, which peels off part of the bark creating a small wound as stated by (Ballal, 1991).

2.11 Definition of sunki

Sunki is advanced tapping tool, which was developed by the gum research program for tapping *A. senegal* Hashab tree, while the axe is the traditional tool for tapping the gum Arabic trees (Fadl and Gebauer, 2004). Also (Hall, 1961) sated that Gum researchers have developed a new hand tool called the '*Sunki*' which is easier and faster in use as well as being less injurious to the tree.

2.11.1 Advantages of using the Sunki compared with an axe:

- The *Sunki* is a spear-like blade and has many advantages over the axes: It does not damage the tree
- It regulates the width of the bark removed
- It enables tapping of branches and from any direction, and
- One person can tap more trees in a shorter time, obtaining of pure gum free from impurities, reaching the higher branches that could not be tapped by using an axe, saving time and reducing labor, *Sunki* could be used in gum collection, increasing the productive age for the tree (Ballal, 2014).

2 .12 Gum Arabic Producers Association, (GAPAs)

Gum Arabic Producers' Associations (GAPAs) are established by the Forests National Corporation (FNC), in line with the cooperative laws in Sudan, which were started during the period of the Sudanese Socialist Union party, 1971 and amended in 2003. The GAPAs are mandated to provide tangible benefits for improving producers' access to services such as credit, training and extension, and community development projects like constructing water reservoirs, gum Arabic stores, schools and mosques. This study looked at the role of GAPAs across Sheikan and Um Ruwaba Localities - North Kordofan state.

2.12.1 Why and when are cooperative societies established?

Cooperative societies are created when markets fail to provide the goods and services that people need, at reasonable prices and with an acceptable quality.

2.12.2 Types of cooperative societies according to the activity nature:

Consumer cooperative societies, productive cooperative societies and workers' cooperative societies

2.12.3 Types of cooperative societies according to the type of activity:

Supply cooperatives and processing and marketing cooperatives, (Suzan, 2020)

2.12.4 Principles of collaborative work:

Voluntary and open membership, democratic member control, the economic participation of the members, autonomy and independence, learning, training and information and cooperation between cooperative societies, (Suzan, 2020)

2.12.5 Care for society.

Gum Arabic producers Associations, the number of cooperative societies in the state: 260 societies, of which 21 are women. Most of these associations, are based in the northern part of the state

2.12.6 Emergence of the gum Arabic Producers associations:

The idea of establishing and forming associations of gum Arabic producers came in the third phase in 1992, the experiment began in North Kordofan State with 20 associations according to the project document until 1995, the authority continued activities related to establishing and forming associations in North Kordofan State, and the number increased to 35 by the end of 2002, in the year 2002, the commission invited all the agriculture ministers and forest managers in the producing states to attend a seminar to assess the association's experience and the possibility of circulating it in the producing states, the seminar's recommendation came as a tribute to the experience that it should be circulated to the states that produce glues (Suzan, 2020).

2.12.7 Goals of the gum Arabic Producers associations:

A major goal is to establish the principle of self-reliance among rural communities by organizing farmers and producers of gum Arabic in groupings that are easy to deal with, reconstructing the belt and increasing the area planted with hashab by establishing popular and individual nurseries**,** increasing production and productivity by applying different technologies, raise the capabilities and competencies of members of organizational, administrative, negotiation and marketing societies, fight against the Shell system, middlemen, brokers, and beneficiaries, providing basic services in coordination with organizations and bodies working in various development fields, (Suzan, 2020).

2. 13 Gum producers or collectors:-

Gum Arabic producers defined as the rightful owner of a gum orchard or plantation, or a shareholder in the cropping system of the gum product. Their main job is to establish, maintain and market gum, to acquire land, plant naturally regenerated gum trees, tend to, protect, tap and collect the gum Arabic, and finally sell it as raw, green natural gum, ideally through official channels (auction markets) but often through 'middlemen' (Mahmoud, 2004).

2. 14 Gum Arabic researches institutions and centers

2.14.1 Institution of Gum Arabic Research and Desertification Studies (IGARDS) University of Kordofan

Desertification is one of the most important environmental destructive calamities in the arid, semi arid and semi humid eco-zones, attributed to natural factors such as drought and climate change; manmade factors such as irrational utilization of natural resources. This led to soil depletion, water scarcity, deterioration of vegetation cover, conflict over resources and harsh socioeconomic impacts. This circumstance necessitated revitalizing research visions in the field of gum Arabic, desertification and environment to guarantee sustainable supply of these vital aspects. A new scope of problem oriented academic research institutions like the Institute of Gum Arabic Researches and Desertification Studies (IGARDS) depending on scientific consideration, training, documentation is of crucial importance. To meet these new transformations, University of Kordofan, the pioneer academic institution in Western Sudan, revised and redesigned the mandate of the Gum Arabic Research Center (GARC) to be the Institute of Gum Arabic Researches and Desertification Studies (IGARDS), which have been approved in December 2014, (IGARDS annual report, 2018).

2.14.1.1 IGARDS vision

Towards optimum supply of gum Arabic and environment

2.14.1.2 IGARDS mission

Leading research in gum Arabic, desertification and environment

2.14.1.3 Objectives of IGARDS

Training and qualifying different stakeholders, designing, implementing and coordinating researches and studies, conducting postgraduate programs in the fields of gum Arabic, desertification and environment, initiating scientific platform among relevant national and worldwide institutions, organizing and coordinating conferences, workshops and seminars, documenting and promoting indigenous knowledge and disseminating recent technologies and publishing IGARDS findings and providing technical consultancies.

2.14.1.4 Stakeholders*:*

Research centers and institutions, active parties in environment and desertification issues, gum Arabic producers and institutions, interested individuals in knowledge of related fields, school pupils and relevant technical college students, scientific organizations in and outside the country and students and researchers concern with gum Arabic desertification and environment.

2.15 Elobeid Agricultural Research Corporation (EARC)

Research on gum Arabic was formally started in 1957/58 when the division of Elobied Agricultural Research was created. Before then, sporadic attempts were made to solve some of the main problems related to gum Arabic. For example, attempts to establish gum plantations date back to 1911, followed by some in mid-1920s and again in the mid-1930s. All these attempts, however, lacked continuity or follow-up due to changes in the plans of the Forest Service and interruptions by major incidences such as World War11 (Hall, 1961). The Gum Research Division (GRD) has experienced administrative changes. In 1975, it was put under the umbrella of the Agricultural Research Corporation (ARC) so that it benefits from the multi-disciplinary interactions and focus only on research and extension. In 1982 it was absorbed in the Western Sudan Agricultural Research Project (WSARP) which is part of the Gum Research Division (ARC).

2.15.1 Agricultural Research under the Gum Research Division (ARGRD)

The Gum Research Division (GRD) with the help of a local blacksmith finally evolved an alternative tool (Sunki).

2.16 Forests National Corporation, (FNC)

Forests National Corporation (FNC) is one of the most important bodies that targets environment protection issues. The FNC Act, 1989 amended by the Forests and Renewable Natural Resources Act 2001, set out the functions of the FNC to:

Lay down the general policies,

Make the rules and methods which secure the good utilization and development of forests

Achieve full protection of the environment;

Propose laws which achieve the implementation of the approved policies for the development of forests

Supervise technically all forests of the country

Disseminate awareness about forests

Conduct studies and forest planning; increase the reserved forest areas up to a minimum of 20% of the area of the country

Intensify tree plantation and supply seedlings

Develop Gum Arabic and other minor forest products; and coordinate with other bodies to implement forest policies particularly project combating desertification (Abdel Magid and Sharif, 2018).

In the meantime, it ensures direct management of the forest sector and supervises most of the gum Arabic projects.

2.16.1 Efforts of National Forests Authority to develop gum Arabic sector:-

The authority has very great efforts working to develop the supplier base and produce gums in general and gum Arabic in particular. These efforts are as follows:

2.16.1.1 Providing and distributing seedlings and seeds

There are (13) central nurseries in the state, the production capacity ranges between (15-500) thousand seedlings, covering almost all the state's localities and producing seedlings of various types, focusing on Hashab seedlings 80% of these nurseries produce Hashab seedlings.The state is considered one of the sources of seeds in Sudan, where 100 tons of seeds were collected, the most important of which are Hashab, Talh, Ard and other important and rare seeds.

2.16.1.2 Counseling and training

Forests provide extension services to producers, training of producers on accounting systems, book keeping, and design of small projects,

organizing the producers into associations of gum Arabic and other gum Arabic producers and supporting people's efforts to develop production and improve quality (Suzan, 2020).

2.16.1.3 Providing financing

The National Forest Authority has attracted and attracted some projects to develop the production of gum Arabic, example of the Sudanese project to promote the production and marketing of gum Arabic and other projects

2.16.1.4 Protection and legalization of holdings

Forests contribute to protecting the Hashab tree, based on the Forests and Natural Resources Law of 2002. Forests are the only authorities authorizing producer holdings Suzan, 2020.

2.16.1.5 Exchange visits of the producers

Forests of West Kordofan State carried out an exchange visit for the producers of acacia gum in the state of Sennar, with the aim of exchanging experiences, changing some concepts, and implementing production and quality. Supporting the idea of establishing popular forests and private forests (Suzan, 2020).

2.17. Diffusion and adoption of agricultural innovation:

An innovation according to Rogers (2003) is seen as (an idea, practice or object that is perceived as a new by an individual or other unit of adoption. Also Vanden& Howkins**, (**1999) reported that innovation is an idea, method or object regarded as new by an individual but which is not always the result of recent research. Technological innovations usually have two components, a hardware aspect, the tool product, and a software aspect, how to use the hardware, (Poostichi, 1986) reported that: The purpose of most innovation for rural households, rural people farmers and their families is to develop techniques that enable them to do their work more effectively.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area:-

North Kordofan state situated at the centre of the gum belt area of Sudan. The state lies between latitudes 12° 15′ and 16° 32′ North and longitudes 27º and 32º east. The region is situated within the Gum belt strip dominated by sandy soil. The state consists of eight localities: Sheikan, Elrahad, Um Ruwaba, Bara, West Bara, Um Dam, Sodari and Gabra, (Mahmoud et al., 2014). Bordered by six states northern state from the north, Khartoum State and White Nile from the east, South Kordofan in the south, South Darfur from the south-west and North Darfur in the west, North Kordofan state covers an area of 244, 700 square km meters, equivalent to 139 square miles and 58.8 million acres of land. The study was conducted in Sheikan and Um Ruwaba Localities in North Kordofan State, which is situated in the heart of the gum Arabic belt. North Kordofan State is located in the central part of Sudan, (F.Net, 2013) arid and semi–arid zones that cover the largest part of this State (Hamad, 2018). It lays between latitudes 12º 10'and 16º 30'N, longitudes 27º and 32º 35'E is divided into eight localities (Zein elabdein, et al, 2015).The average annual rainfall is about 300-mm, consisting of storms of short duration between July and September with the highest rainfall generally occurring in August (Makki and Musa, 2011). The soil of the site lies within the sand dune area locally known as “Goz” soil. The site is naturally dominated main grasses include namely Huskneet (*Cenchrus biflorus*), Shuleny (*Zorniaglo chidiata*) and Bigual (*Blepharis linarifolia*). Such tree as Humied (*Sclerocarya birrea*), Higlig (*Balanites sp*),Arad (*Acacia etbaica*) and Sider (*Zizuphus spina*). The Shrubs include Kursan (*Bosciase negalensis*), Usher (*Calotropis sp*), Mereikh (*Polygala eriotera*) and Aborakhus (*Andropogon gayanus*) according to MAWF, 2009, Ishag, 2013 the major crops grown are millet and sorghum (food crops), groundnut and sesame (cash crops) on the other site Gum Arabic production and forest and Non Timber Forest Products (NTFPs) contribute significantly to livelihood. Animal raised are mainly sheep, camels, and goats (Hamad, 2018).

3.2 The study population:-

The total population selected for the study was 2040 gum producers, which represented by two localities, namely sheikan and UmRuwaba localities. As the result of homogeneity of the study members we selected five (5) and (4) four gum Arabic producers associations from Sheikan (1134) producer and UmRuwaba (906) producer respectively, namely:- Elgrewid Mima, Eldamukyia, Faragella, Elbinia Salama and Umsomama from Sheikan and Umsiraiha Abdel Raheem, Samandia, Umjgzeera and Amanalla from Um Ruwaba locality.(see table 3.1) below

3.2.1 Sample size and selection procedure:

Stratified sample selection procedure was applied all through the sample selection for the study, where two localities (Sheikan and UmRuwaba) were selected out of (9) localities composing North Kordofan State (the study area). The gum Arabic producers in the state are organized into associations, called Gum Arabic Producers Associations (GAPAs). In the selected two localities there were (36 associations) out of which nine associations (5 from Sheikan and 4 from UmRuwaba) were randomly selected for conducting the study. 265 gum producers was the sample selected randomly for interview. The sample represents 13% of the 2040 producers of the total population composing of the selected associations.

It based on the sample size calculator technique (**http://www.surveysystem.com/sscalc.htm**), following the techniques of sample size calculator and the sample size formula as shown below:

Determine sample size:-

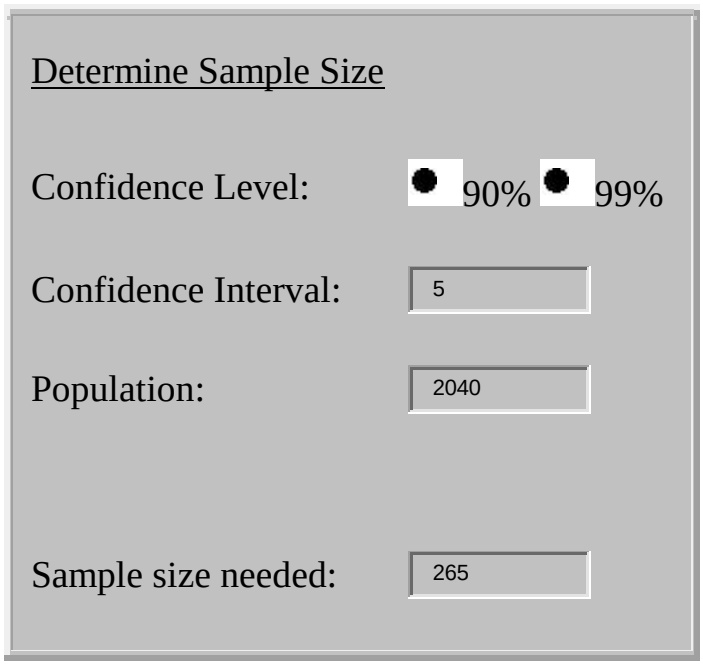

Table (3.1) showed Sheikan and Um Ruwaba localities associations and producers number in each association

Sheikan associations	Producers No	UmRuwaba associations	Producers No	Total
Elgrewid Mima	215	Umsiraiha Abdel Raheem	272	
Eldamukyia	269	Samandia	224	
Faragella	205	Umjgzeera	207	
Elbinia Salama	207	Amanalla	203	
Umsomama	238			
Total	1134		906	2040

3.2.2 Sample Size:-

The sample size was 265 gum Arabic producers, which was calculated out from the total members of Gum Arabic Producers Association 2040, in Sheikan and UmRuwaba localities North Kordofan State gum Arabic

producers Associations, Elobied Forests Corporation Office, Gum Arabic Producers Associations, (2017). (See table 3.2) below

Table (3.2) showed sample size selected from each association, (13%)

Association	Sample size
Elgrewid Mima	13/ 100× 214 = 28
Eldamukyia	35
Faragella	27
Elbinia Salama	27
Umsomama	31
Umsiraiha Abdel Raheem	35
Samandia	29
Umjgzeera	27
Amanalla	26
Total	265

3.3 Methods of Data Collection:

The social survey method was used to collect study data, primary data were collected, selected stratified simple random sample by using a questionnaire appendix No (1). The researcher obtained 265 valid questionnaires to conduct the statistical study.

The research relied on the questionnaire as a primary tool for obtaining primary information. The researcher relied on the questionnaire for its multiple advantages represented in the following:

- Ability to applying for information from a number of individuals.

- Low cost and ease of application.

- Easy to put questions and words.

- Provides time for the respondent and gives him an opportunity to think.

To achieve the purposes of the previous questionnaire, the researcher designed a questionnaire for assessment of impact of gum Arabic research results applied on improving and developing of gum Arabic sector in Sheikan and Um Ruwaba Localities - North Kordofan State, Sudan.

The research questionnaire composed of the fallowing sections:

1. Part one: demographic data :Age, educational level, and Social status

2. Part two: gum Arabic production

3. Part three: gum Arabic production quality

4. Part four Marketing and marketing information

5. Part Five: adoption of innovation tools

3.3.1 Permission for data collection

Official permission letter was written from the Manger of Forests Natural Corporation, and then it was coped and distributed to the study areas departments.

3.3.2 Interview

The interview was conducted according to the following procedures and sampling techniques. It was conducted with Gum Arabic Producers Associations (GAPAs). There are 265 gum Arabic producers association members. This means that 265 producers were randomly selected out of 2040 of total number of Gum Arabic producers associations.

3.4 Data analysis procedure:

In data analysis SPSS program was used for, descriptive the study population by using the frequency and percentage

- Using Chi square for hypothesis test.-

- Using likert scale test:- to measure the attitude of the research community towards the role of research centers.

CHAPTER FOUR
RSELUTS and DISCUSSIONS

This chapter represents the results of the study in term of tables, figures and charts. It also presents the interpretation and discussion of the results.

4.1 Demographic characteristics and social data:-

4.1.1: frequency distribution according to education level

Table 4.1.1: frequency and percentage distribution of respondents by education level

Education level	Frequency distribution	%
Illiterate	70	26.4
khalwa	61	23.0
Before university	133	50.2
University	1	0.4
Total	265	100.0

Source: field survey 2020

Table 4.1.1 explained that the educational level of the respondents is low. 52% of them had only attended primary, secondary and higher education. Only few received university education, while 26.4% of the respondent's illiterate. This indicated that uneducated people mainly practice gum Arabic production. Formal education has the potentials for enhancing communication of the gum research results, and conceivably has positive effects on other variables, including attitudinal and behavioral characteristics of respondents.

4.1.2: frequency distribution according to family size:-

Table 4.1.2: frequency and percentage distribution of respondents by family size

Family size	Frequency distribution	%
2-3 members	26	9.8
4 - 6	72	27.2
7 - 9	103	38.9
>10	64	24.1
Total	265	100

Source: field survey 2020

Table 4.1.2 showed frequency distribution and percentage of the respondent's according to family size, 38.9% of respondents family size range between 7- 9 persons, this indicated that high rate of family members which might be an indicator to availability of labor in future.

4.1.3: frequency distribution according to marital status:-

Table 4.1.3: frequency distribution and percentage of respondents by marital status

Marital status	Frequency distribution	%
Married	258	97.4
Single	7	2.6
Total	265	100

Source: field survey 2020

Table 4.1.3 showed frequency distribution and percentage of the respondent's according to marital status, the table indicated that 97.4% of the respondents are married

4.1.4: frequency distribution according to gender:-

Table 4.1.4: frequency distribution and percentage of respondents by gender

Gender	Frequency distribution	%
Male	265	100
Female	0.0	0.0
Total	265	100

Source: field survey 2020

Table 4.1.4 showed frequency distribution and percentage of the respondent's according to gender. The table clearly showed that all (100%) of the respondents in the study area are male, this indicated that gum Arabic production occupation is practiced by male.

4. 1.5: frequency distribution according to occupation of the respondents

Table (4.1.5) frequency distribution and percentage of respondents by occupation

Main occupation	Frequency distribution	%
Agriculture	28	11.6
Animal grazing	3	1.1
Merchant	5	1.9
Employee	3	1.1
Gum production	222	83.8
GP and animal grazing	2	0.8
GP and merchant	2	0.8
Total	265	100

Source: field survey 2020

Table 4.1.5 showed frequency distribution and percentage of the respondent's according to main occupation. The table clearly showed that 83.8% of the respondents their main occupation is gum Arabic production and 0.8% practice gum Arabic production and animals rising. This result confirmed that the gum Arabic is the main source of income for the respondents in study area.

4. 1.6: frequency distribution according to owing hashab garden

Table (4.1.6) frequency distribution and percentage of respondents by their hashab area owned

Owing hashab garden/ Mokhams	Frequency	%
0 - 0 Mokhams	6	2.3
1 - 10	71	26.8
11 -20	65	24.5
21 -30	30	11.3
>30	93	35.1
Total	265	100

Source: field survey 2020

Table 4.1.6 showed distribution and percentage of the respondents according to hashab garden area owned. The table showed that 35.1% of the respondents owned Hashab garden more than 30 mokhams, only 2.3% of respondents not owned Hashab garden. This confirmed that the gum Arabic producers in the area have possibility and opportunity to produce gum in their own gardens.

4. 1.7: frequency distribution according to area of hashab garden for farming:

Table (4.1.7) frequency distribution and percentage of respondents by their used hashab garden for farming

Hashab garden for farming	Frequency	%
0.0 Mokhams	12	4.5
1 -10	149	56.3
11 -20	43	16.2
21 -30	18	6.8
>30	43	16.2
Total	265	100

Source: field survey 2020

Table 4.1.7 showed distribution and percentage of the respondents according to hashab garden area owned used for farming. The table confirmed that 56.3% of the respondents explained that they owned (1-10) mokhams use it for farming.

4.1.8: frequency distribution according to area of hashab garden for tapping:

Table (4.1.8) frequency distribution and percentage of respondents by their used hashab garden for tapping

Hashab garden for tapping	Frequency	%
0.0 Mokhams	5	1.9
1 -10	120	45.3
11 -20	61	23.0
21 -30	19	7.2
>30	60	22.6
Total	265	100

Source: field survey (2020)

Table 4.1.8 showed distribution and percentage of the respondents according to hashab garden area owned use for tapping. The table showed that 45.3% of the respondents explained that they owned (1 – 10) mokhams use it for tapping, while 1.9% not owned hashab garden. This confirmed that the gum Arabic producers in the area have possibility and opportunity to produce gum in their own gardens.

4.1.9: frequency distribution according to tapping experience:-

Table (4.1.9) frequency distribution and percentage of respondents by their years of experience in tapping hashab trees

Experience in tapping/ years	Frequency	%
0.0 years	1	0.4
1 - 10	78	29.4
11 - 20	49	18.5
>20	137	51.7
Total	265	100

Source: field survey (2020)

Table 4.1.9 showed that more than half 51.7% of the respondents their experience in tapping operation more than 20 years while only 0.4% of the respondents have no experience in tapping. This confirmed that the

gum Arabic producers in the area have possibility and opportunity to produce great amount and high quality of gum Arabic.

4.1.10: frequency distribution according to tapping tools used:-

Table (4.1.10) frequency distribution and percentage of respondents according to their tapping tools

Tapping tool used	Frequency	%
Sunki	142	53.6
Small axe	62	23.0
Small axe and makmak	37	14.0
Sunki and small axe	24	9.4
Total	265	100

Source: field survey 2020

Table 4.1.10 showed distribution and percentage of respondents according to their tapping tool used. The table revealed that 53.6%of respondents used sunki in tapping, this result on line with Ballal et al., 2005 that the Sunki in tapping increases the gum yield. While 9.4% of respondents used sunki and axe, the researcher agree with this group that tapping with sunki and axe because of the diversity of hashab trees.

4.1.11: frequency distribution according to tapping direction:-

Table (4.1.11) frequency distribution and percentage of respondents according to their direction of tapping

Direction of tapping	Frequency	%
East and west	195	73.5
North and south	6	2.3
All directions	64	24.2
Total	265	100

Source: field survey 2020

Table 4.1.11 showed distribution and percentage of respondents according to their direction of tapping. There were 73.2% of respondents confirmed that tapping hashab in east and west direction, this result agree with Idris et al., 2009 that tapping in east and west direction increased gum yield. Adoption of tapping direction east and west by the

respondents reflected positively in improving and developing of gum Arabic sector in study area, by applied research.

4. 1.12: frequency distribution according to picking time

Table (4.1.12) frequency distribution and percentage of respondents by their time of first picking

Time of first picking in days	Frequency	%
25 days	50	18.9
45	84	31.7
35	50	18.9
50	8	3.0
15	73	27.5
Total	265	100

Source: field survey 2020

Table 4.1.12 revealed that 31.7% of the respondents confirmed that 45 days the best time for first gum picking and this result match with Abdel Magid et al., 2014, the first picking begins 45 days after tapping. The result revealed that the gum Arabic research institution and centers have poor role in conducting gum Arabic techniques to producers, must produce more extension packages to producers in practicing first picking to increase adoption rate.

4. 1.13: frequency distribution according to second picking time:-

Table (4.1.13) frequency distribution and percentage of respondents by their second picking time

Time of second picking in days	Frequency	%
7 days	7	2.7
10	21	7.9
14	132	49.8
21	105	39.6
Total	265	100

Source: field survey 2020

Table 4.1.13 revealed that about fifty percent (50.0%) of the respondents confirmed that the second picking take place at 14 day after the first picking. 50% of the respondents followed well practicing of second

picking operation. The result revealed that the gum Arabic research institution and centers must produce more extension packages to gum producers in practicing second picking to increase adoption members.

4.1.14: frequency distribution according to method of picking gum

Table (4.1.14) frequency and percentage of respondents by their method of picking the gum

Method of picking	Frequency	%
Hand	115	43.5
Sunki	24	9.1
Axe and hashasha	20	7.5
Hand and sunki	60	22.5
Hand and axe	46	17.4
Total	265	100

Source: field survey 2020

Table 4.1.14 indicated distribution and percentage of the respondents according to their method of picking gum. The table revealed that 43.5% of the respondents picking gum by their hand,

4.1.15: frequency distribution according to type of bags used of collection gum

Table (4.1.15) frequency and percentage of respondents by their bags used for gum collection

Bags used for collection	Frequency	%
Cortala	52	19.6
Plastic bucket	115	43.5
Plastic bag	27	10.2
Palm basket	51	19.2
Cortala and plastic bucket	20	7.5
Total	265	100

Source: field survey 2020

Table 4.1.15 indicated distribution and percentage of the respondents according to their bags used in collecting gum. 43.5% of the respondents confirmed that collecting the picking gum in Plastic bucket, and this result are negatively with the gum Arabic quality aspects, while 19.6% collecting the picking gum in Cortala, and this result positively with gum

Arabic production quality. 53.7% of the respondents used wrong practicing in gum Arabic collection, and they need more extension information's about recommended collection method to adopt.

4.1.16: frequency distribution according to Place of marketing gum

Table (4.1.16) frequency distribution and percentage of the respondents by their marketing place

Place of marketing	Frequency	%
Village merchant	172	65.0
Umdawarwar market	32	12.1
Auction or/ and town market	31	11.6
Village merchant and town market	30	11.3
Total	265	100

Source: field survey 2020

Table 4.1.16 indicated frequency distribution and percentage of the respondents according to their place of sell gum. 65.0% of the respondents confirmed that they sold their gum to village merchant. The result revealed that most of the respondents are poor and consumed their gum retain immediately and they not owned ways of transportation.

4.1.17: frequency distribution according to time of selling gum

Table (4.1.17) frequency distribution and percentage of the respondents by their time of selling gum

Time of selling gum	Frequency	%
Immediately	250	94.2
End of season	10	3.8
On rising prices	5	2.0
Total	265	100

Source: field survey 2020

Table 4.1.17 indicated frequency distribution and percentage of the respondents according to time of sell gum. 83.0% of respondents confirmed that sold their gum immediately and only 2.0% sold their gum when prices rising. The result showed that most of the respondents are poor and consumed their gum return immediately.

4.1.18: frequency distribution according to workshop and training gained:-

Table (4.1.18) frequency distribution and percentage of respondents by their workshop and training gained

Workshop and training gained	Frequency	%
Gained	59	22.2
Not gained	206	77.8
Total	265	100

Source: field survey 2020

Table 4.1.18 indicated distribution and percentage of the respondents by workshop and training they gained. 77.8% of the respondents confirmed that not gained any workshop and training, only 22.2% of the respondents they had. The result reveals that adoption of gum Arabic techniques production affected by the training. This finding emphasizes the weak role of institutions and centers of gum Arabic research.

4.1.19: **frequency distribution according to place of training gained**:-

Table (4.1.19) frequency distribution and percentage of the respondents by their place of training

Place of training	Frequency	%
No training gained	206	77.8
Institution of gum Arabic research &desertification studies IGARDS	15	5.8
Elobied research station	6	2.3
Forests National Corporation	26	10.2
Organizations	12	3.9
Total	265	100

Source: field survey 2020

Table 4.1.19 indicated distribution and percentage of the respondents by their place of training. 76.2% of the respondents confirmed that they not gained workshop and training, while 10.2% of respondents gained training in Forest National Corporation. The result reveals that adoption of gum Arabic techniques production affected by the Training. This finding emphasizes the negative role of institutions and centers of gum Arabic research.

4.1.20: frequency distribution according to agriculture Extensionests as source of knowledge and to what extent depend on it

Table (4.1.20) frequency distribution and percentage of respondents by agriculture Extensionests as source of knowledge

Agricultural Extensionests	Frequency	%
Depend on it completely	70	26.4
Depend on it some time	83	31.3
Not depend on it	112	42.3
Total	265	100

Source: - field survey 2020

Table 4.1.20 showed that 42.3% of the respondents clarified that agricultural Extensionests is not depend on it as source of knowledge transfer. While 26.4% of the respondents confirmed that agricultural Extensionests depend on it completely as source of knowledge transfer.

4.1.21: frequency distribution of accumulative knowledge's as source of knowledge and to what extent depends on it

Table (4.1.21) frequency distribution and percentage of respondents by accumulative knowledge's as source of knowledge

Accumulative knowledge's	Frequency	%
Depend on it completely	228	86.0
Depend on it some time	27	10.2
Not depend on it	10	3.8
Total	265	100

Source: field survey 2020

Table 4.1.21 showed frequency distribution and percentage of the respondents according to accumulative knowledge as source of knowledge transfer. The table showed that 86.0% of the respondents clarified that accumulative knowledge depends on it completely as source of knowledge transfer. Only 3.8% of the respondents clarified that not depend on accumulative knowledge as source of knowledge transfer. This result clarified that low education rate of the respondents.

4.1.22: frequency distribution according to educated area as source of knowledge and to what extent depend on it

Table (4.1.22) frequency distribution and percentage of respondents by educated area source of knowledge

Educated area	Frequency	%
Depend on it completely	52	19.6
Depend on it some time	86	32.5
Not depend on it	127	47.9
Total	265	100

Source: field survey 2020

Table 4.1.22 showed frequency distribution and percentage of the respondents according to educated area as source of knowledge transfer. The table showed that 47.9% of the respondents clarified that educated area not depends on it as source of knowledge transfer. While 19.6% of the respondents confirmed that depend on educated area completely as source of knowledge transfer.

4.1.23: frequency distribution according to radio as source of knowledge and to what extent depend on it

Table (4.1.23) Frequency distribution and percentage of respondents by the radio source of knowledge

The radio	Frequency	%
Depend on it completely	119	44.9
Depend on it some time	81	30.6
Not depend on it	65	24.5
Total	265	100

Source: field survey 2020

Table 4.1.23 showed frequency distribution and percentage of the respondents according to radio as source of knowledge transfer. The results showed that, 44.9% of the respondents confirmed that completely depend on the radio as source of knowledge transfer. While 24.5% of the respondents clarified that not depend on radio as source of knowledge transfer. This result reflected that respondent's low education level is only

affected by grandfather's ideas, this affected negative on adoption rate of innovations.

4.1.24: frequency distribution according to information gained and applied gum production techniques

Table (4.1.24) frequency distribution and percentage of respondents by information gained and applied agro-forestry, tapping with sunki, tapping east and west, sunki in tapping increase productive tree age and sunki in tapping faster than axe

Information gained and applied agro-forestry services					
Gained information	Frequency	%	Applied	Frequency	%
Gained	163	61.5	Applied	163	61.5
Not gained	102	38.5	Not applied	102	38.5
Total	265	100.0	265	265	100.0
Information gained and applied tapping with sunki					
Gained inform	171	64.5	Applied	143	54.0
Not gained	94	35.5	Not applied	122	46.0
Total	265	100.0	Total	265	100.0
Information gained and applied sunki taps increase productive tree age					
Gained	171	64.5	Applied	145	54.7
Not gained	94	35.5	Not applied	120	45.3
Total	265	100.0	Total	265	100.0
Information gained and applied sunki in tapping faster than axe					
Gained	170	64.2	Applied	140	52.8
Not gained	95	35.8	Not applied	125	47.2
Total	265	100.0	Total	265	100.0

Source: field survey 2020

Table 4.1.24 showed frequency distribution and percentage of the respondents according to their gained information and applied agro-forestry services, tapping with sunki, sunki in tapping increase productive tree age and sunki in tapping faster than axe. 61.5% and 61.5% of the respondents confirmed that gained and applied agro forestry services, 64.5% and 54.0% of respondents gained and applied tapping with sunki, 64.5% and 54.7% of respondents gained and applied tapping with sunki increase productive tree age and 64.2% and 52.8% of the respondents gained and applied sunki in tapping faster than axe. The results indicated

that above of 50% of the respondents gained information and applied these gum Arabic techniques productions above. This reflected positive in helping the respondents in increasing and improving their gum Arabic production and quality in study area.

4.1.25: frequency distribution according to information gained and applied gum production techniques

Table (4.1.25) frequency distribution and percentage of respondents by information gained and applied tapping direction, picking time and packing

Information gained and applied tapping direction east and west					
Gained information	Frequency	%	Applied	Frequency	%
Gained	176	66.4	Applied	167	63.0
Not gained	89	33.6	Not applied	98	37.0
Total	265	100.0	Total	265	100.0
Information gained and applied time of first picking after tapping					
Gained	174	65.7	Applied	164	61.9
Not gained	91	34.3	Not applied	101	38.1
Total	265	100.0	Total	265	100.0
Information gained and applied bags packing gum Arabic on it					
Gained	170	64.2	Applied	164	61.9
Not gained	95	35.8	Not applied	101	38.1
Total	265	100.0	Total	265	100.0
Information gained and applied time of first picking and second one					
Gained	174	65.7	Applied	164	61.9
Not gained	91	34.3	Not applied	101	38.1
Total	265	100.0	Total	265	100.0

Source: field survey 2020

Table 4.1.25 showed frequency distribution and percentage of the respondents according to their gained information and applied tapping direction, time of first picking after tapping, bags packing gum on it and time of first picking and second one. 66.4% and 63.0% of the respondents confirmed that gained and applied tapping direction, 65.7% and 61.9% of the respondents confirmed that gained and applied time of first picking after tapping, 64.4% and 61.9% of the respondents confirmed gained and applied bags packing gum on it and 65.7% and 61.9% of the respondents

confirmed that gained and applied time of first picking and second one. The results indicated that above of 60% of the respondents gained information and applied these gum Arabic techniques productions above. This reflected positive in helping the respondents in increasing and improving their gum Arabic quality produced in study area.

4.2 Chi-square test:

This test used to measure the level of significance of the relationship between search variables that were included in the study hypotheses at the level of significance 0.05 as a measure of the relation through the parameter of degree of freedom.

4.2.1 Chi-square test on applied agro-forestry services

Table 4.2.1: Chi-square test between applied agro-forestry services and gum Arabic produced last 5 years

Applied agro-forestry services	gum Arabic produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		> 20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	163
Applied	15	71.4	70	66.7	13	46.4	10	40.0	50	68.5	5	38.5	61.5%
Not applied	6	28.6	35	33.3	15	53.6	15	60.0	23	31.5	8	61.5	102 38.5%
Significant Level	0.015												

Statistical analysis (2020)

The result of table (4.2.1) showed that there's significance of a relationship between applied agro forestry services and gum Arabic produced within the level of significant (0.015).This means that there is increasing of gum Arabic produced after respondents applied agro-forestry last 5 years. The result is in line with the Hammad, (2010).

4.2.2 Chi-square test on applied tapping by sunki

Table 4.2.2: Chi-square test between applied tapping by sunki and gum Arabic produced last 5 years

Applied tapping by sunki	Gum Arabic produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		> 20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	143
Applied	16		58		9		12		45		3		54.0%
Not applied	5	23.8	47	44.8	19	67.9	13	52.0	28	38.4	10	76.9	122 46.0%
Significant Level	0.005												

Statistical analysis (2020)

The result on table (4.2.2) showed that there's a significant relationship between applied tapping by sunki and gum Arabic produced at ($p = 0.005$).This means that there is increasing of gum Arabic produced after the respondents applied tapping by sunki last 5 years. The result is matches the result of Hussien et al., 2018.

4.2.3 Chi-square test on applied tapping direction east and west

Table 4.2.3: Chi-square test between applied tapping direction east and west and gum Arabic produced last 5 years

Applied tapping direction east and west	Gum Arabic produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		> 20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	167
Applied	16	76.2	66	62.9	13	46.4	12	48.0	52	71.2	8	61.5	63.0%
Not applied	5	23.8	39	37.1	15	53.6	13	52.0	21	28.8	5	38.5	98 37.0%
Significant Level	0.094												

Statistical analysis (2020)

The result on table (4.2.3) showed that there's no significance of a relationship between applied tapping direction east and west and gum Arabic produced (p= 0.094). This means that there is no increasing of gum Arabic produced after the respondents applied tapping direction east and west last 5 years. The result is negative with the result cited by Idris, 2011.

4.2.4 Chi-square test on applied taps with sunki increase productive tree age

Table 4.2.4: Chi-square test result between applied taps with sunki and gum Arabic produced last 5 years

applied tapping with sunki increase productive tree age	Gum produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		>20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	
Applied	16	76.2	58	55.2	10	35.7	11	44.0	46	63.0	4	30.8	145 54.7%
Not applied	5	23.8	47	44.8	18	64.3	14	56.0	27	37.0	9	69.2	120 45.3%
Significant Level	0.014												

Statistical analysis (2020)

The result (table 4.2.4) showed that there's a significance of a relationship between applied tapping with sunki increase productive tree age and gum Arabic produced last 5 years, within the level of significance (0.014). This means that there is increasing of productive Hashab tree age and gum Arabic produced after the respondents applied this technique last 5 years. The result is also in line with the result cited by Ballal et al., 2005.

4.2.5 Chi-square test on applied sunki in tapping is faster than axe

Table 4.2.5: Chi-square test between applied sunki in tapping is faster than axe and gum Arabic produced last 5 years

Sunki in tapping faster than axe	Gum Arabic produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		> 20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	140
Applied	16	76.2	57	54.3	10	35.3	10	40.0	43	58.9	4	30.8	52.8%
Not applied	5	23.8	48	45.7	18	64.3	15	60.0	30	41.1	9	69.2	125 47.2%
Significant Level	0.021												

Statistical analysis (2020)

The result (table 4.2.5) showed that there's a significant relationship between applied sunki in tapping faster than axe and gum Arabic produced within the level of significance (0.021). This means that there is increasing of gum Arabic produced after the respondents applied taps with sunki faster than axe last 5 years. The result matches also as the result cited by Ballal, 2014.

4.2.6 Chi-square test result of applied time of first picking after tapping and gum Arabic quality produced last 5 years

Table 4.2.6: Chi-square test on applied time of first picking after tapping and gum Arabic quality produced last 5 years

Time of first picking after tapping	Gum Arabic quality produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		> 20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	164
Applied	17	81.0	65	61.9	15	53.6	10	40.0	51	69.9	6	46.2	61.9%
Not applied	4	19.0	40	38.1	13	46.4	15	60.0	22	30.1	7	53.8	101 38.15
Significant Level	0.029												

Statistical analysis (2020)

The result on table (4.2.6) showed that there's a significance of a relationship between applied time of first picking after tapping and gum Arabic quality produced within the level of significance (0.029).This means that produced of high gum quality after the respondents applied time of first picking after tapping last 5 years. The result matches with the result cited by Abdel Magid et al., 2014.

4.2.7 Chi-square test result of applied time between first picking and second one and gum quality produced last 5 years

Table 4.2.7: Chi-square test on applied time between first picking and second one and gum quality produced last 5 years

The time between the picking and the second one	Gum Arabic quality produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		>20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	164
Applied	16	76.2	63	60.0	15	53.6	11	44.0	54	74.0	5	38.5	61.9%
Not applied	5	23.8	42	40.0	13	46.4	14	56.0	19	26.0	8	61.5	101 38.1%
Significant Level	0.017												

Statistical analysis (2020)

The result on the table (4.2.7) showed that there's a significant relationship between applied time between first picking and second one and gum quality produced, within the level of significance (0.017).This means that produced of high gum quality after respondents applied this technique last 5 years. The result matches with the result cited by Abdel Magid et al., 2014.

4.2.8 Chi-square test result of applied bags packing gum in it and gum quality produced last 5 years

Table 4.2.8: Chi-square test between applied bags packing gum in it and gum quality produced last 5 years

Bags packing gum in it	Gum Arabic quality produced last 5 years												Total
	0		0 -5		6 -10		11 – 15		16 – 20		>20		
	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	Fr	%	164
Applied	16	76.2	63	60.0	13	46.4	12	48.0	54	74.0	6	46.2	61.9%
Not applied	5	23.8	42	40.0	15	53.6	13	52.0	19	26.0	7	53.8	101 38.1%
Significant Level	0.026												

Statistical analysis (2020)

The result on the table (4.2.8) showed that there's a significant relationship between applied bags packing gum in it and gum Arabic quality produced, within the level of significance (0.026).This means that produced of high gum Arabic quality after respondents applied recommended packing bags last 5 years. The result matches with the result cited by (IGARDS annual reports, 2020).

4.3: likert scale:-

4.3.1 Likert scale to measure respondent's attitude to towards IGARDS role in transfer gum production techniques

Table 4.3.1: Likert scale to measure respondent's attitude towards agro-forestry, tapping, picking, packing and marketing techniques provided by IGARDS

Gum production techniques produced by IGARDS	scale
Agro-forestry service Tapping practice Picking practice Packing practice Marketing	2.3 2.5 2.5 2.4 2.2
Likert scale 2	

Statistical analysis 2020

Likert scale range:

Degree	Rank
Sufficient	4
Insufficient	3
Weak	2
Absence	1

Table 4.3.1 showed Gum Arabic Research and Desertification Studies (IGARDS) that produced agro forestry services (2.3), tapping practice (2.5), picking practice (2.5), packing practice (2.4) and marketing (2.2). Indicated that Likert scale results are weak towards the techniques provided from IGARDS. This result showed that overall (IGARDS) were weak (2) point in the likert measured scale.

4.3.2 Likert scale to measure respondent's attitude to towards ARC role in transfer gum production techniques

Table 4.3.2: Likert scale to measure respondent's attitude towards agro-forestry, tapping, picking, packing and marketing provided by ARC

Gum production techniques produced by ARC	scale
Agro-forestry service	2.3
Tapping practice	2.4
Picking practice	2.4
Packing practice	2.4
Marketing	2.2
Likert scale 2	

Statistical analysis 2020

Table 4.3.2 shows that Agricultural Research Corporation ARC that produced agro forestry services (2.3), tapping practice (2.4), picking practice (2.4), packing practice (2.4) and marketing (2.2). Indicated the Likert scale results are negatively towards the services provided from the ARC. This result showed that overall (ARC) were weak (2) point in the likert measured scale.

4.3.3 Likert scale to measure respondent's attitude towards FNC role in transfer gum production techniques

Table 4.3.3: Likert scale to measure respondent's attitude towards agro-forestry, tapping, picking, packing and marketing provided by FNC

Gum production techniques produced by FNC	scale
Agro-forestry service	2.7
Tapping practice	2.7
Picking practice	2.7
Packing practice	2.7
Marketing	2.5
Likert scale 2	

Statistical analysis 2020

The table 4.3.3 shows that Forests National Corporation FNC that produced agro forestry services (2.7), tapping practice (2.7), picking practice (2.7), packing practice (2.7) and marketing (2.5). Indicated the

Likert scale results are negative towards the services produced from FNC. This result showed that overall (ARC) were insufficient (3) point in the likert measured scale.

4.3.4 Likert scale to measure respondent's attitude towards Organizations role in transfer gum production techniques

Table 4.3.4: Likert scale to measure respondent's attitude towards agro-forestry, tapping, picking, packing and marketing provided by Organizations

Gum production techniques produced by Organizations	scale
Agro-forestry service Tapping practice Picking practice Packing practice Marketing	2.2 2.3 2.2 2.3 2.1
Likert scale 2	

Statistical analysis 2020

The table 4.3.4 shows the Organizations that produced agro forestry services (2.2), tapping practice (2.3), picking practice (2.2), packing practice (2.3) and marketing (2.1). Indicated the Likert scale results are negative towards the services that produced from the Organizations. This result showed that overall Organizations were weak (2) point in the likert measured scale.

4.3.5 Likert scale to measure respondent's attitude towards Associations role in transfer gum production techniques

Table 4.3.5: Likert scale to measure respondent's attitude towards agro-forestry, tapping, picking, packing and marketing provided by Associations

Gum production techniques produced by Associations	scale
Agro-forestry service Tapping practice Picking practice Packing practice Marketing	2.4 2.5 2.5 2.5 2.3
Likert scale 2	

Statistical analysis 2020

Table 4.3.5 shows the Associations that that produced agro forestry services (2.4), tapping practice (2.5), picking practice (2.5), packing practice (2.5) and marketing (2.3). Indicated the Likert scale results are negative towards the service produced from the Associations. This result showed that overall Associations were weak (2) point in the likert measured scale.

4.3.6 Likert scale to measure respondent's attitude towards effectiveness of agro- forestry, tree care and tapping

Table 4.3.6: Likert scale to measure respondent's attitude towards efficacy of agro- forestry services, tree care, tapping direction and position

Gum production research results techniques	Scale	Effectiveness
Agro- forestry services Tree care Tapping direction Tapping position	2.9 2.9 3.0 3.0	Not enough Not enough Not enough Not enough
Liker scale 4		

Statistical analysis 2020

The table 4.3.6 showed effectiveness of agro forestry services (2.9), tree care (2.9), tapping direction (3.0) and tapping position (3.0). Indicated the Likert scale results of respondents' effectiveness of gum Arabic research results and reflected the items effectiveness degrees, between enough and weak, but from the table indicated that the gum Arabic research results in agro forestry services, tree care, tapping direction and tapping position, and gross likert mean of items (3) degree, and this at not enough level from the scale indicated in the table. The result reflected that the gum Arabic research institution and centers have poor roles in transfer the gum research techniques to beneficiaries in study area. This result showed that overall agro- forestry, tree care and tapping were not enough (4) point in the likert measured scale.

4.3.7 Likert scale to measure respondent's attitude towards effectiveness of picking, packing, market and storing

Table 4.3.7: Likert scale to measure respondent's attitude towards effectiveness of picking, packing containers, entering auction market and gum storing

Gum production research techniques results	Scale	effectiveness
Picking containers Packing containers Entering auction market Gum storing	3.1 3.0 2.4 2.8	Not enough Not enough weak Not enough
Likert scale 4		

Statistical analysis 2020

The table 4.3.7 showed effectiveness of picking, packing containers, entering auction market and gum storing. Indicated the Likert scale results of respondents' effectiveness of gum Arabic research results and reflected the items effectiveness degrees, between enough and weak, but from the table indicated that the gum Arabic research results in picking, packing containers, entering auction market and gum storing, and gross likert mean of items (3) degree, this at not enough level from the scale indicated in the table. The result reflected that the gum Arabic research

institution and centers have weak roles in transfer the gum research techniques to beneficiaries in study area. This result showed that overall picking, packing containers, entering auction market and gum storing were weak and not enough (4) point in the likert measured scale.

4.3.8 Likert scale to measure respondent's attitude towards effectiveness of gum price and picking interval

Table 4.3.8: Likert scale to measure respondent's attitude towards effectiveness of gum price information, gum price determination, picking interval and duration between tapping and first picking

Gum production research techniques results	Scale	Effectiveness
Gum price information Gum floor price determination Picking interval Duration between tapping and first picking	2.8 2.4 3.0 3.0	Not enough weak Not enough Not enough
Likert scale 4		

Statistical analysis 2020

The table 4.3.8 showed effectiveness of gum price, gum floor price determination, picking interval and duration between tapping and first picking. Indicated the Likert scale results of respondents' effectiveness of gum Arabic research results and reflected the items effectiveness degrees, between enough and weak, but from the table indicated that the gum Arabic research results in gum price information, gum price determination, picking interval and duration between tapping and first picking, and gross likert mean of items (3) degree, this at not enough level from the scale indicated in the table. The result reflected that gum Arabic research institution and centers have poor roles in transfer gum research techniques to beneficiaries in study area. This result showed that overall gum price information, gum price determination, picking interval and duration between tapping and first picking were weak and not enough (4) point in the likert measured scale.

Likert scale range:

Degree of efficacy	Rank
Enough	4
Not enough	3
Weak	2
Absence	1

4.4 Priority research gaps according to study output

According to literature review, many research were conducted however, there are some gaps which represent in gum productivity of hashab tree in natural stands in comparison with managed hashab gardens. Concerning gum quality, research gaps are found in terms of packing, picking and gum collection. Research in the field of marketing system, pricing, grading and trade are highly required on systematic base and due to changing policies. In the field of planting, production and processing, innovations are urgently needed.

4.5 Figure Conceptual model for way of how beneficiaries benefit from the results of implemented research in the title

The model (4.5) explain that the research centre's (IGARDs, ARC) and Universities are consider as source of knowledge, Forests National Corporation and None Govern-mental Organizations are represented as supporting institutions of knowledge, in addition to that there is mutual relationship between gum Arabic research centers and FNC. Research centers, universities, FNC and NGOs introduce knowledge through training, field visits and media services to the gum Arabic producers associations, gum Arabic producers, farmers and Extensionests. The expected output from these services is high gum production, high gum quality, sustainable production, adoption of gum Arabic techniques and assuring environmental protection.

CHAPTER FIVE

Summary, conclusions and recommendations

5.1 Summary:

- 52.2% of respondents their education level before university, 38.9% of respondents family size range between 7-9 persons, 97.4% of the respondents are married, 100% of the respondents in the study area male, 83.8% of the respondents the main occupation gum Arabic production, 35.1% of the respondents owned Hashab garden area more than 30 mokhams, 56.3% of the respondents owned 1-10 mokhams use it for farming, 45.3% of the respondents owned 1-10 mokhams use it for tapping, 51.7% of the respondents their experience in tapping more than 20 years, 53.6%of respondents used sunki in tapping hashab trees.

- 73.2% of respondents tapping hashab in east and west direction, 31.7% of the respondents confirmed that 45 days the best time for first gum picking, 50.0% of the respondents confirmed that the second picking take place at 14 day after the first picking, 43.5% of the respondents picking gum by their hand, 43.5% of the respondents collecting the picking gum in Plastic bucket, 65.0% of the respondents sold their gum to village merchant, 83.0% of respondents confirmed that sold their gum immediately after collection, 77.8% of the respondents confirmed that not gained any training, while 10.2% of respondents confirmed that gained training in Forest National Corporation

- 42.3% of the respondents clarified that not depend on agricultural Extensionests' as source of knowledge transfer. 86.0% of the respondents clarified that depends on accumulative knowledge completely as source of knowledge transfer. 47.9% of the respondents clarified that not depends on educated area as source of knowledge transfer. 44.9% of the respondents confirmed that completely depend on the radio as source of knowledge transfer.

- 61.5% and 61.5% of the respondents confirmed that gained and applied agro forestry services. 64.5% and 54.0% of respondents gained and applied tapping with sunki. 64.5% and 54.7% of respondents gained and applied tapping with sunki increase productive tree age. 64.2% and

52.8% of the respondents gained and applied sunki in tapping faster than axe.

- 66.4% and 63.0% of the respondents confirmed that gained and applied tapping direction. 65.7% and 61.9% of the respondents confirmed that gained and applied time of first picking after tapping. 64.4% and 61.9% of the respondents confirmed gained and applied bags packing gum on it. 65.7% and 61.9% of the respondents confirmed that gained and applied time of first picking and second one.

- Chi-square test results there's significance of a relationship between applied gum Arabic production techniques and gum produced and gum quality, in terms of agro-forestry (0.015), tapping by sunki (0.005), tapping with sunki increase productive tree age (0.014), sunki in tapping is faster than axe (0.021), time of first picking after tapping (0.029), time between first picking and second one (0.017) and bags packing gum in it (0.026), and also Chi-square test results there's no significance of a relationship between applied gum Arabic production techniques and gum produced, in terms of tapping direction east and west (0.094).

Likert scale test (2.00) showed weak and insufficient respondents attitude opinions towards gum Arabic production techniques that produced by IGARDS with regard to agro-forestry (2.3), tapping practice (2.5), picking (2.5), packing (2.4) and marketing (2.2). For ARC, the test also showed weak and insufficient respondent's attitude with regard to agro-forestry (2.3), tapping practice (2.4), picking (2.4), packing (2.4) and marketing (2.2), Regarding FNC, Likert scale test also showed insufficient respondents attitude in term of agro-forestry (2.7), tapping practice (2.7), picking (2.7), packing (2.7) and marketing (2.5).

Likert scale test (3.00) showed that respondent's attitude opinions efficacy of gum production techniques results between weak and not enough in developing and improving of gum sector, in terms of agro-forestry **(**2.9**)**, tree care **(**2.9**)**, tapping directions **(**3.0**)**, tapping position **(**3.0**)**, picking containers (3.1), packing containers (3.0), gum price information (2.8), determination of gum floor price (2.4), entering auction market (2.4), gum storing (2.8), duration between tapping and first picking (3.0) and picking interval (3.0).

5.2 Conclusion:-

The study was based on the hypothesis applied research results of gum Arabic research centers and institution, have significant effect in improving and developing the gum Arabic sector in Sheikan and UmRuwaba Localities - North Kordofan state. The results of chi-square test between applied gum Arabic production techniques and gum Arabic produced and quality, showed that there are a significance of a relationship between applied gum production techniques and gum produced and quality. Likert scale to measure respondent's attitude opinions towards sufficient and effectiveness of gum Arabic production researches techniques results. The results reflected that the gum Arabic research institution and centers have poor roles in transfer the gum research techniques to beneficiaries in study area. Priority research gaps according to study output and conceptual model for way of how beneficiaries benefit from the results of implemented research.

5.3 Recommendations

Based on the findings and conclusions of this study, and upon the observation made by the author, the following recommendations would be helpful to the agencies concerned with development and improvement of gum Arabic producers in Sheikan and Um Ruwaba localities, North Kordofan State, and the adoption of producers of gum Arabic production techniques.

5.3.1 Recommendations for Development Projects in North Kordofan State:-

- Supporting public services and investment in rural areas in order to improve gum producers living and working conditions.
- Introduction of services such as education, health and drinking water.

5.3.2 Recommendations for gum Arabic research Institutions in Sheikan and Um Ruwaba localities, North Kordofan State:-

- Use of participatory approaches in extension and rural development programs, particularly those targeting gum Arabic producers.

- Arranging for allowing sufficient time for gum producers to engage in training in order to enable them to acquire skills.
- Linking extension with credit, and marketing services, especially in programs targeting gum Arabic producers.
- Researchers should invent a combine tapping tool (sunki and axe) for tapping hashab trees.
- Research institutions and centers should provide productive mother's hashab trees seeds.

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Appendix No (1)

Questionnaire:

Sudan University of Science & Technology

Department of Agricultural Extension & Rural Development

The postgraduate student Abdel Aziz Elsaied Hussien Hamad is attempting to collect data for his PhD Study under the title: Assessment of the Impact of Gum Arabic Research Applied on Improving and Developing of Gum Arabic Sector in North Kordofan, Sheikan and Um Ruwaba Localities. Your collaboration through selecting the right answer where appropriate would help in achieving the objectives of the research. Your answers will be highly confidential and will not be used in any other purpose.

Locality……..

Administrative unit ……..

Village……

1. Sex: Male ( ) Female ( )

2. Age: ……year

3. Marital status: - Married ( ) Single ( )

4. Family size: 2- 3 ( ) 4 - 6 ( ) 7 – 9 ( ) More than 10 ( )

5. Education level:- Illiterate ( ) Khalwa ( ) Elementary ( ) Secondary ( ) University ( )

6. Main occupation (Source of income)?

Agriculture ( ) Animal razing ( ) Merchant ( ) Employee ( ) Gum Arabic production

7. Second occupation:- Agriculture ( ) Animal razing ( ) Merchant ( ) Employee ( ) Gum Arabic production

8. How many Mokhams is your Garden? (5 – 10) (11 – 20) (21 – 30) more than 30 Mokhams

9. How many Mokhams of it used for farming? (5 – 10) (11 – 20) (21 – 30) more than 30 Mokhams

10. How many Mokhams of it used for Tapping? (5 – 10) (11 – 20) (21 – 30) more than 30 Mokhams

11. How many years in tapping gum Arabic production? (1 – 10) (11 – 20) more than 20 years

12. What is the source of information or knowledge transformation?

Sources of Knowledge	Depend on it as source of knowledge and information		
	Depend on it completely	Depend on it some time	Not Depend on it
Agricultural extensions			
Accumulative knowledge			
Educated of the area			
The Radio			

13. How many Hashab trees in Mokhams for your before 10 years? (5 – 20) (21 – 35) (36 – 50) more than 50 trees

14. How many Hashab trees in Mokhams for your last 5 years ? (5 – 20) (21 – 35) (36 – 50) more than 50 trees

15. In what time do you begin to fetish about the in formations to improve the production performance? (1 – 5) (6 – 10) (11 – 15) more than (15) years

16. How many Kilometers far your garden from your home? (5 – 10) (11 -20) (21 – 30) more than (30) kilometers

17. What is the labor used in tapping of gum Arabic production?

Rent ( ) family labor ( ) co operative ( ) other ( ) specify ( )

18. How many kantar of gum Arabic produced in prior season?

(1 – 5) (6 – 10) more than (10) kantar

19. What is the mean of gum Arabic in kantar of your village the prior season?

(5 -10) (11 – 15) (16 – 20) more than 20 kantar

20. How many pound of gum Hashab tree produced before 10 years? …….pound

21. How many pound of gum Hashab tree produced last 5 years ago? ……..pound

22. How many retain and increasing of income from gum Arabic last 5 years ago?

(5 – 10) (11 – 15) (16 – 20) more than 20 thousand Sudanese pound

23. How many retain of income from gum Arabic before 10 years?

(5 – 10) (11 – 15) (16 – 20) more than 20 thousand Sudanese pound

24. What is the cost of working day tapping in pound before 10 years? (100) (200) (300) (400) more than 500 Sudanese pound

25. What is the cost of working day tapping in Sudanese pound last 5 years ago?

(100) (200) (300) (400) Sudanese pound, more than 500 Sudanese pound ( )

26. Do you plant Hashab trees in the last 5 years ago? Yes ( ) No ( )

27. If the answer yeas, what is source of seedlings? Agricultural Research ( ) Institution of gum Arabic Research ( ) Forest National Corporation ( ) other ( )

28. What is the number of seedlings planted? (10 – 50) (51 -100) (101 -150) (151 – 200) more than 200 seedling

29. What is the area of seedlings planted? (5 – 10) (11 – 15) more than 15 Mokhams

30. Is there any migration of one number of your family to the towns?

Yes ( ) No ( )

31. I f the answer yes, how many individual migrated to the towns?

One individual ( ) two individual ( ) more than 2 individual ( )

32. What is the luxuries you owned?

Refrigerator ( ) television ( ) car ( ) other ( )

33. What is situation of the agro-forestry? In increasing ( ) in decreasing ( )

34. What is situation of the garden fallow?

In increasing ( ) in decreasing ( )

35. What is type of the trees in and around the garden? Hashab trees ( ) Hashab and mixed of trees ( ) other ( ) specify ( )

36. How many retain from agriculture last 5 years? (5000) (10000) (15000) more than 15000 Sudanese bound

37. How many retain from charcoal and fuel wood last 5 years ago? (5000) (10000) (15000) more than 15000 Sudanese bound

38. How many retain from animals last 5 years ago? (5000) (10000) (15000) more than 15000 Sudanese bound

39. What is the funding source of the animals? Agriculture retain ( ) gum Arabic retain ( ) mercantile retain ( ) other ( ) specify ( )

40. What is the funding source of home expenditure? Agriculture retain ( ) gum Arabic retain ( ) mercantile retain ( ) other ( ) specify ( )

41. What is the type of land use of garden?

Owner- ship ( ) inheritance ( ) buying ( )

42. How many Mokhams is your Hashab garden? Small garden (5 – 10) mean garden (11 – 25) Large garden more than (25) Mokhams

43. What is the type of trees in your garden? Hashab trees ( ) Hashab and another type of trees ( ) Hashab and agriculture ( )

44. Mentioned the reasons of selecting of tapping tool that is more prevent to your produced gum? More quicker ( ) tapping the higher branches ( ) safety to tree ( ) other ( ) specify ( )

45. In what expenditure the increasing of income?

Expenditure items	Expenditure		
	yes	To some extend	No
Improving of livelihood level			
Health			
Education			
Saving			
Other			

(B) Tapping Technique:-

46. What are the directions you tapping the tree?

East and West ( ) North and South ( ) All the directions ( )

47. What is source of information? Agricultural research ( ) Institution of gum Arabic research ( ) Forest National Corporation ( ) Grandfathers ( ) other ( ) specify ( )

48. If the answer east and west, what is source of information? ARC ( ) IGARDS ( ) FNC ( ) Grandfathers ( ) other ( ) specify ( )

49. If the answer North and South, What is source of information? ARC ( ) IGARDS ( ) FNC ( ) Grandfathers ( ) other ( ) specify ( )

50. Where is the Hashab tree taps? Stem only ( ) branches only ( ) stem and branches ( ) not know and tap randomly ( )

(C) Picking Technique:-

51. How many days between tapping and first picking? (25) days ( ) (45) day ( ) (35) day ( ) (50) day ( ) other ( ) specify ( )

52. How many days between first picking and second one?

7 days ( ) 10 days ( ) 14 days ( ) other ( ) specify ( )

53. How is picking the gum from tree?

Hand ( ) Sunki ( ) Farar ( ) other ( ) specify ( )

54. In what is the picking gum collecting? Cortala ( ) plastic bucket ( ) plastic bag ( ) palm basket ( ) other ( ) specify ( )

55. In what the picking gum packing?

Jute bag ( ) plastic bag ( ) other ( ) specify ( )

(D). Marketing:-

56. Where is you sell your produced gum? Village merchant ( ) umdawarwar markets ( ) auction market ( ) other ( ) specify ( )

57. What is the time you sell your produced gum? After collection immediately ( ) after collecting to number of pickings ( ) end of season ( ) on rising prices ( ) other ( ) specify ( )

58. Do you storage the gum for rising prices? Yes ( ) No ( )

59. Is it the prices of gum in the last 10 years satisfied?

Satisfied ( ) not satisfied ( )

(E) Agro-forestry farming:-

60. Do you practicing Agro-forestry system? Yes ( ) No ( )

61. What is the type of crops farming in agro-forestry system? Hashab + ground nuts ( ) Hashab + sesame ( ) Hashab + sorghum ( ) other ( ) specify ( )

62. What is the efficacy of gum Arabic researches results on promoting and developing of gum Arabic sector in your area?

Technique / information	Take information		Applied			Efficacy				Information source
	yes	No	Applied	Not applied	why	very Efficacy	Efficacy	Efficacy to some extend	Not efficacy	
Agro-										

forestry services										
Tree husbandry										
Tapping with Sunki										
Direction of tapping (East and West)										
Taps by axe harmful to tree										
Taps with Sunki increase productive age of tree										
Sunki in taps is faster than axe										
Taps with Sunki prevent thieves										
Taps with Sunki harmless to tapper										
Time of first picking after tapping										
Time between picking and second one										
Information about picking tool										
Tools that picking										

gum on it										
Tools that packaging gum on it										
How to storage your produced gum										
How is transport the gum										
More harmful to tree and tapper when taps with axe										

63. Assessment efficacy of gum Arabic research results on developing and promoting of gum Arabic sector.

Gum Arabic techniques	Efficacy			
	Enough	Not enough	weak	absence
Agro-forestry services				
Tree husbandry				
Direction of tapping				
Place of tapping tree				
Tools that picking gum on it				
Tools that packaging gum on it				
Knowledge of gum prices				
assess of gum concentration price				
Entering to auction markets				
How to storing produced gum				
The picking tool				
duration between tapping and first collection				
duration between picking and the second one				

64 The information taken by producer through last 10 years ago:-

Do you gain information last 10	yes	No	If the answer no mentioned the reason				
			Weak of	Few	Modern	No	Other

years ago about gum production techniques			extension services	interest by extension techniques	techniques expensive	mass media	specify
Sunki tapping							
tapping directions							
axe tapping harmful to tree							
Tapping with Sunki increase productive age of the tree							
Sunki in tapping faster than axe							
Tapping with Sunki prevent the gum from thieves							
Less harmful to tapper when taps with Sunki							
duration between tapping and first collection							
duration between picking and the second one							
picking tool							
tools picking gum on it							
tools packaging gum on it							
knowledge of gum Arabic prices							
Entering to auction markets							
assess of gum concentration price							
How storage gum							

65. What is your personal opinion on agro-forestry services that produced the following institutions?

Institution	sufficient	Not sufficient	weak	Not know
IGARDS				
ARC				
FNC				
Originations				
Associations				
Other				

66. What is your personal opinion on tapping operation that produced the following institutions?

Institution	sufficient	Not sufficient	weak	Not know
IGARDS				
ARC				
FNC				
Originations				
Associations				
Other				

67. What is your personal opinion on picking operation that produced the following institutions?

Institution	sufficient	Not sufficient	weak	Not know
IGARDS				
ARC				
FNC				
Originations				
Associations				
Other				

68. What is your personal opinion on packaging operation that produced the following institutions?

Institution	sufficient	Not sufficient	weak	Not know
IGARDS				
ARC				
FNC				
Originations				
Associations				
Other				

69. What is your personal opinion on packaging operation that produced the following institutions?

Institution	sufficient	Not sufficient	weak	Not know

IGARDS				
ARC				
FNC				
Originations				
Associations				
Other				

(F). Training item:-

70. Do you taken any workshop in scope of gum Arabic production through the last 10 years ago? Yes ( ) No ( )

71. If yes, what is the source of information?

IGARDS ( ) ARC ( ) FNC ( ) Originations ( )

72. Do you taken any services in the area like digging well, storage buildings, machines? Yes ( ) No ( )

73. What is the source of services?

IGARDS ( ) ARC ( ) FNC ( ) Originations ( )

74. Do you think that gum Arabic areas increased in last 10 years ago? Yes ( ) No ( )

75. If yes, what is the reason of increasing? Planting of Hashab seedlings ( ) increasing of gum Arabic prices ( ) local care of gum and Hashab trees ( ) other ( ) specify ( )

76. How many Mokhams is the increasing of gum Arabic areas in last year's?

1 – 5 ( ) 6 – 10 ( ) 11 – 15 Mokhams ( ) > 15 Mokhams

77. If the areas decreased, what is the reason? Gum Arabic prices decreasing ( ) severe cutting ( ) lack of natural generation ( ) increasing of agriculture areas ( ) other ( ) specify ( )

78. Do you think that gum Arabic production increased in the last 10 years ago? Yes ( ) No ( )

79. Reasons of increasing of gum Arabic production in last 10 years ago Aare local care of gum and Hashab trees? Yes ( ) No ( )

80. Reasons of increasing of gum Arabic production in last 10 years ago are local care of gum Arabic prices? Yes ( ) No ( )

81. Reasons of increasing of gum Arabic production in last 10 years ago are companies made good share with gum Arabic producers?

Yes ( ) No ( )

82. Reasons of increasing of gum Arabic production in last 10 years ago are international concern with gum Arabic? Yes ( ) No ( )

83. For you how many kantar of gum Arabic increased in last 10 years ago? 1 – 2 kantar ( ) 3 – 4 kantar ( ) more than 5 kantar

84. Is there any foreigners in locality of gum Arabic markets?

Yes ( ) No ( )

85. Is the foreigners have role in increasing and improving prices?

Yes ( ) No ( )

86. Increasing of gum Arabic kantar prices in last 5 years ago is from……..Sudanese pound to…….. Sudanese pound

87. Are the foreigners have role in livelihood of gum Arabic producers?

Yes ( ) No ( )

88. Do you see any advanced or developed in planting and production operations of gum Arabic in the last 10 years ago?

Yes ( ) No ( )

89. What is the institution do you think participate in this progress and developing?

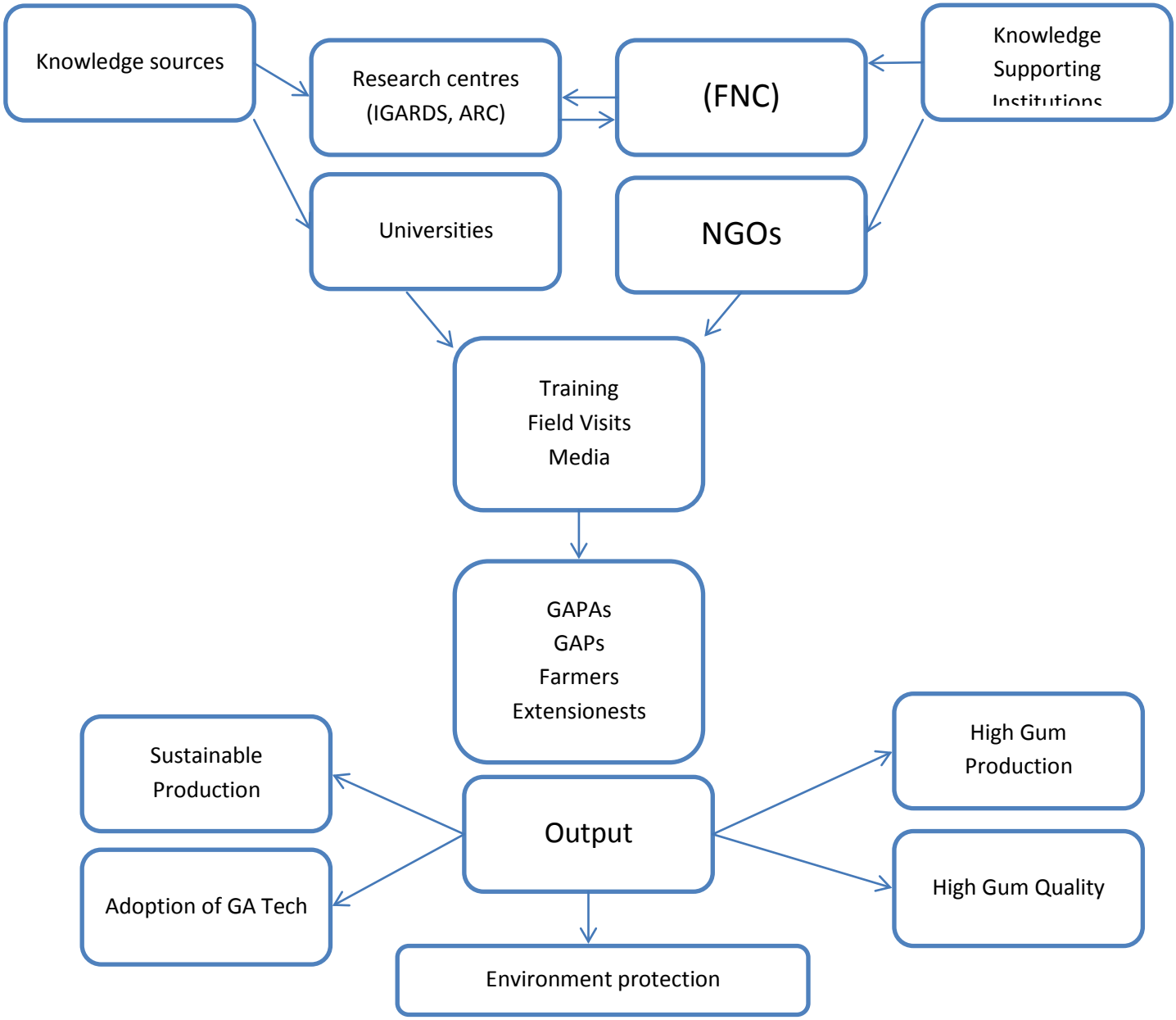
IGARDS ( ) ARC ( ) FNC ( ) Originations ( )

90. What are your own opinions in developing, promoting and progressing of gum Arabic sector? ……

Appendix No.2 Tapping tools for Hashab tree

The picture above showed the tapping tools: the first from above is an Axe, the middle is Makmak, and the last one is *Sunki*.

Appendix No. 3 Tapping of Hashab tree by *Sunki*



Appendix No.4 conceptual model for way of how beneficaries benefit from the results of implemented research