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**CENTER FOR ETHIO- MINES DEVELOPMENT (CEMD)**

**ADDIS ABABA INSTITUTE TECHNOLOGY (AAiT)**

***APPLICATION OF LAPIDARY TECHNOLOGY FOR SUSTAINABLE  
GEMSTONE RESOURCE DEVELOPMENT IN ETHIOPIA***

**By: TSION SHUMALEM MEKONEN**

*Presented in partial fulfillment of the requirements for the degree of Master of Engineering in  
Mineral Engineering*

**OFFICE OF GRADUATE STUDIES**

**ADDIS ABABA UNIVERSITY**

**September, 2023**

**Addis Ababa, Ethiopia**

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*A Graduate Project Work Submitted To the Center for Ethio-Mines Development  
(CEMD), Addis Ababa Institute of Technology (AAiT)*

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## **DECLARATION OF ORIGINALITY**

I declare that this graduate project work entitled *-Application of lapidary technology for sustainable gemstone resource development in Ethiopia*, is my own work and has not been submitted to any university for similar purposes. The project is my own original master's degree work under the supervision of my advisor, Dr. Abubeker Yimam Ali, School of Chemical and Bio Engineering, AAIT of Addis Ababa University, and co-advisor, Mrs. Aselefech Mitiku (MSc). The references used in this study are duly recognized by proper citations.

Tsion Shumalem Mekonen

Name of Student

Signature

Date

## APPROVAL SHEET

*“Application of lapidary technology for sustainable gemstone resource development in Ethiopia”*, submitted in the partial fulfillment of the requirements for the Degree of Master of Engineering in Mineral Engineering, complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

### Approved by board of examiners:

<b>Name</b>	<b>Signature</b>	<b>Date</b>
Examiner _____	_____	_____
Advisor _____	_____	_____
Co-Advisor _____	_____	_____

## **ACKNOWLEDGMENT**

First of all, I would like to thank God for giving me the ability to carry out this work. This project work is a contribution towards finding lasting solutions to revamping the Ethiopian gemstone industry, particularly the lapidary sector.

I wish to express my gratitude to my advisors, Dr. Abubeker Yimam Ali and Mrs. Aselefech Mitku, for their assistance, advice and support throughout the entire work of this project.

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## **DEDICATION**

To My Son Fsehatsion Biniyam

## ABBREVIATIONS

ASM	Artisanal and small-scale mining
ETB	Ethiopian Birr (Currency)
MOM	Ministry of Mines
UN	United Nations
GDP	Gross Domestic Product
GIA	Gemological Institute of America
Gems	Gemstone
GSE	Geological Survey of Ethiopia
USGS	United States Geological Survey

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## **ABSTRACT**

Ethiopia is renowned for its mineral abundance and more than 40 varieties of gemstone resources. With the artisanal and small scale miners controlling the production, the phase of the gemstone path abruptly came to a halt, with just a few rough dealers and a few gem cutters remaining, resulting in a very low economic benefit from the sector. The purpose of this study is to look into the function of lapidary technology for sustainable gemstone resource development in Ethiopia. The paper focuses on identifying the country's gemstone resource development challenges, the stages of the lapidary process and colored gemstone value chains, lapidary technology and the economic and social importance of lapidary technology in creating various jewelry and decorations using the new technology. In this study, interviews, literature reviews, lapidary work on a selected sample (gemstone from Wegel Tena, Amhara Regional State, Ethiopia), and an economic analysis of rough and value-added gems are conducted to analyze the role of lapidary technology on the industry. Furthermore, it is designed to comprehend the stages of the supply process and gem value chain, as well as to investigate the economic and social ramifications of modern lapidary technology on the development of sustainable gemstone resources. The impact of lapidary on increasing the value of rough gemstones is enormous. An economic analysis made of agate, crystal quartz, obsidian, jasper, and opal found that there is an increase between 400 and 70,000 folds due to the effect of lapidary technology and value added on the rough gemstone. The study's findings revealed that the fragmented character of the gemstone business attributed to its lag behind other mining industries. Moreover, the study indicated that the gemstone industry in Ethiopia lacks technology, finance, lapidary expertise and a controlled market system. Enabling legislation should be put in place to ensure that the necessary economic return from gemstone resources is attained in order to protect the business and support a successful gemstone cutting and polishing industry.

**Keywords:** Ethiopia, Gemstone, Challenges, Rough, Lapidary, Technology, Supply chain, Value-add, Jewelry.

# CHAPTER 1- INTRODUCTION

## 1.1. BACKGROUND

Ethiopia is recognized for its mineral abundance and a variety of gemstones. A gemstone or gem is a piece of attractive mineral that is used to make jewelry or other adornments when cut and polished. The most obvious and attractive feature of gemstones is their color (Teshome and Kolhe). As reported in the Journal of Gemology in 2018, over 40 varieties of colored gemstone deposits, including emerald, tourmaline, opal, aquamarine, jasper, agate, chrysoprase, peridot, and amethyst, are now found in the country. New discoveries are also on the rise, including the especially exciting discovery of the color-changing chrome grossular green garnet. The top three gemstones for which Ethiopia is known in the international market are Opal, emerald, and sapphire (Kyngdon-McKay, Jorns et al. 2016).

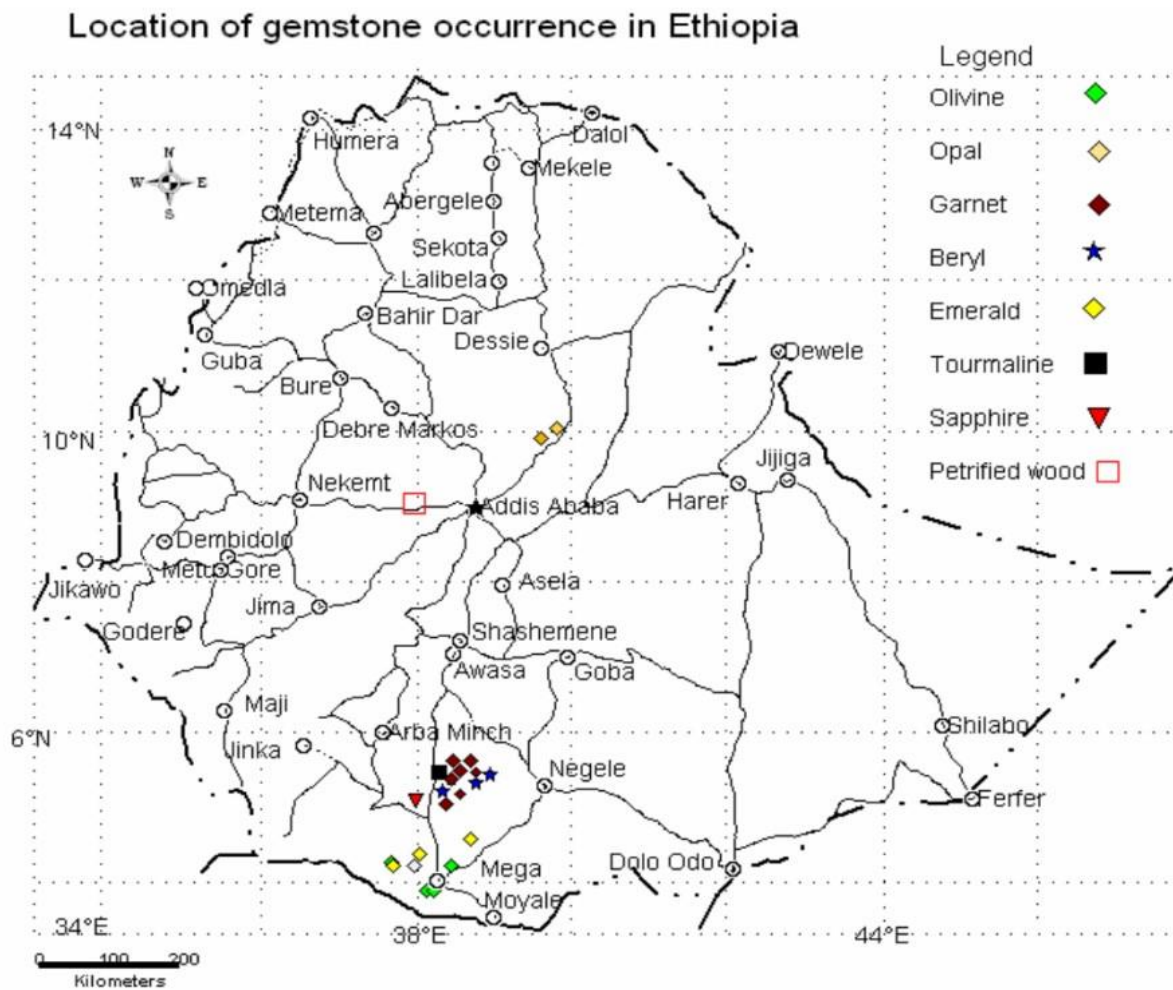
The term “rough” often refers to gemstone material that has not been substantially cut and polished. In its raw and uncut form, a gemstone can look like a pebble or a dazzling sparkle on a grey rock (Lee 2021),(Brandao, de Alencar Naas and Neto 2021). Cobbed material is rough material that has been softly hammered to remove fragile, fragmented material (Teshome and Kolhe) . The act of cutting, shaping, and polishing gems is known as gem cutting or lapidary, and the person who performs it is known as a lapidary (sometimes lapidarist). The term "lapidary" is derived from the word "lapidaries," which were medieval 'treatises' on alchemy, mineralogy, chemistry, and other fields (Edsall-kerwin 2010).

Lapidary work in the gemstone industry combines art and business. During production, the rough gemstone gets transformed into a radiant, shining geometric design, depending on the mineral properties and engineering features of the specific gemstone. A skilled artisan can create gemstones of any size, from those weighing hundreds of carats to those that are small enough to fit under a fingernail. The gemstone gets smaller as it progresses through the transition, yet its value improves along with it (Lee 2021).

The development of the concept of sustainability reveals a revolution in global thinking that forces organizations to reexamine how their actions are settled to enhance economic development, decreasing the negative effects on the environmental, social, and economic dimensions of the production of goods and services (Alves, Ferreira and Araújo 2021).

The presence of gemstone minerals and their consideration for development at the governmental level date back a decade, when one government organization called "The Ethiopian Mineral Recourse Development Corporation," in collaboration with the United Nations Industrial Development Project, established a gemstone workshop that had started its production on peridot and silica gems varieties like jasper and agate. In the history of Ethiopian mining industry, gemstones were not known as economic resource and were not part of the mining history for a long period of time. It was in the last decade that the world came to know that Ethiopia will be one of the gems producing country join gems market(Kyngdon-McKay, Jorns et al. 2016) .

Artisanal and small-scale mining is a widely applied method of mining for colored stone deposits worldwide.



**Figure 1 Location map of different Gemstone Occurrence in Ethiopia (GSE, 2009)**

Gemstone trade or business occurs anywhere in the nation, between miners, brokers (dealers),

and exporters of gemstones brought to major cities like Addis Ababa, where foreign purchasers can purchase and export. Rough gemstones are gem commodities exported abroad. Indians, Chinese, Sirilankan, are the main buyers of Ethiopian gemstones.

This study aims to shed light on various aspects of Ethiopia's colored gemstone supply/value chain, as well as assess the prospects and constraints of the present sector, the role of lapidary technology, and its economic and social importance for the sustainable development of the resources.

## **1.2. STATEMENT OF THE PROBLEM**

Ethiopia is one of the producers and exporters of colored gemstones. It was reported that over 40 types of gemstones are known to exist in different parts of the country, with opal, emerald, and sapphire being the top precious gemstones introduced by Ethiopia to the world market. These and other gemstones are mined and collected in the permitted way of mining (artisanal and small-scale mining), and the resources are exported mostly as rough gemstones. As a result, the economic benefit that can be gained through the application of modern lapidary technology and value addition is actually vanishing. The main reason behind this is the lack of modern lapidary technology, which forced miners to trade the rough gemstone.

## **1.3. OBJECTIVES**

### **1.3.1. GENERAL OBJECTIVE**

The general objective of this study is to examine the role of lapidary technology for sustainable gemstone resource development in Ethiopia.

### **1.3.2. SPECIFIC OBJECTIVES**

The specific objectives of this study are

- To identify the various stages of lapidary process
- To assay and introduce modern lapidary technology.
- To investigate the challenges of the Ethiopia's gemstone industry
- To advocate the economic and social importance of using lapidary

#### **1.4. SIGNIFICANCE OF THE STUDY**

This study will constitute a valuable contribution to the understanding of the role of lapidary technology in gemstone resource development. It will serve as an initial document for further study in investigating the opportunities and challenges faced by the gemstone industry in Ethiopia and identifying the economic, social, and technological importance of lapidary work.

#### **1.5. SCOPE OF THE STUDY**

This study is mainly about the applications of lapidary technology and its role in sustainable gemstone resource development in Ethiopia. The study's scope is restricted to colored gemstone, the social and economic value of gemstone technology, the difficulties faced in the sector, and the supply chain of the gemstone industry.

## CHAPTER 2 -LITERATURE REVIEW

### 2.1 GEMSTONE

According to the UN Standard International Trade Classification System, gemstones are defined as all precious and semi-precious stones (regardless of whether they have been worked or graded), with the exception of all diamond categories, precious stones made of non-mineral, organic materials (such as pearls, ivory, corals, and fossilized tree resins), and precious stones made of synthetic or reconstructed materials (van der Wal and Haan 2010).

Gemstones are natural minerals that are utilized as valuable stones in jewelry and other accessories. Despite the fact that colorful gemstones and diamonds are both regarded to be gemstones, they are frequently treated differently because their supply chains differ noticeably. Gemstone minerals, which are widely used in jewelry due to their unique attractiveness, characteristics, and inherent behavior, are also abundant in Ethiopia. Nevertheless, these natural resources were traded in raw form without additional processing to other industrialized countries in order to generate foreign currency (Teshome and Kolhe).

Since prehistory, people have been mining and valuing gemstones (Ali 2009). The art of lapidary or gems cutting was relatively well-developed in the Indian subcontinent by the early 1st millennium CE. Lapidaries originated around 3000 BC (the Bronze Age), the period when the earliest techniques of sawing, drilling, faceting, and polishing were used for gem faceting. However, bruising (the art of striking one mineral to shape another) dates back a million years, making it one of the oldest techniques on earth. Cutting precious stones and lapidary certainly begins as an offshoot of day- to-day activity.

As it is understandable from those concepts, at different stages of civilization, mankind tried to use the natural resources, especially gems, by slightly reshaping them as the stages of technology and human needs required. The same holds true in the case of Ethiopia concerning the consumption of gemstone resources.

Gemstones can be found in different places in Ethiopia (**Figure 2**): in northern, southern, southwest, central, and almost every part of Ethiopia. Opal, Sapphire, Aquamarine, Emerald, Quartz, Obsidian, and more are found in Ethiopia, and even though this is true, the country as a nation is not consuming the resources properly and appropriately (Ministry of Mines, 2019).



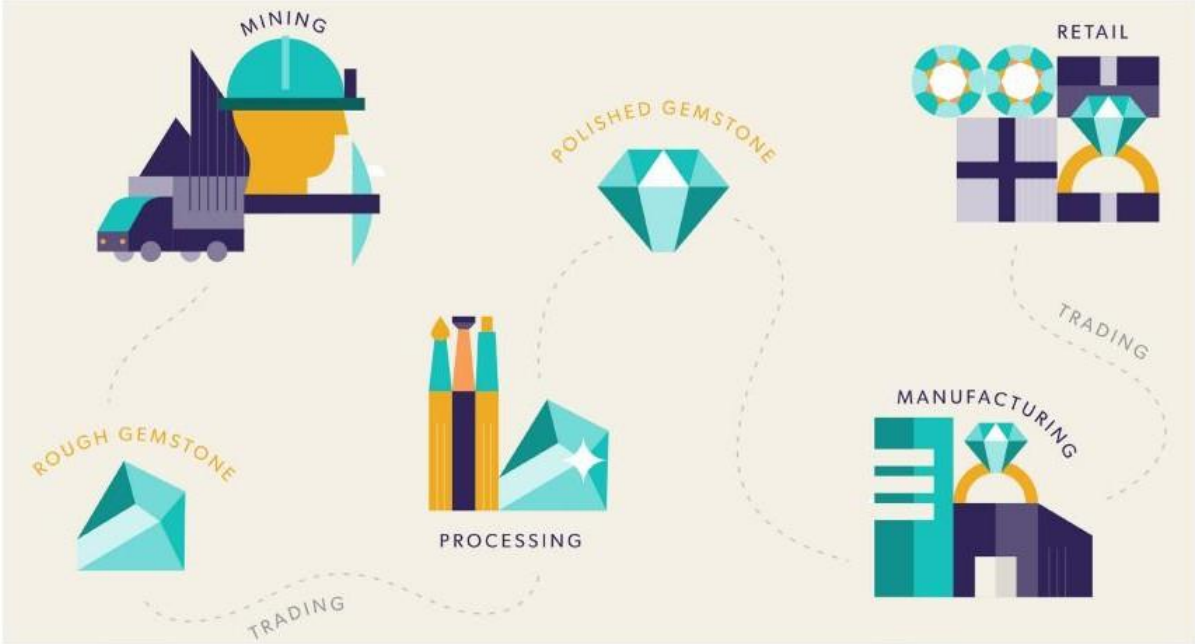
**Figure 2 Ethiopian map showing the location of the country's crucial gem sources: sapphire around Axum town, opal nearby Wegel Tena, and emerald near Shakiso (Gemological Institute of America, 2019).**

## **2.1 GEMSTONE VALUE CHAIN**

The colored gemstone industry's trade relations are quite different from the diamond industry. In contrast to the diamond sector, the colored gemstone business is extremely fragmented on every level, from exploration to mining, to processing and distribution, with many small businesses intertwined in complex investment connections. Increased industry consolidation has resulted in the creation of bigger firms which have integrated various segments of the supply chain from the source to retailer. However, there aren't any dominant trading firms, and research indicates that no single operating business dominates more than 2% of the market, as determined by the volume or the value of exports (van der Wal and Haan 2010). While the steps in the process of gemstone manufacturing are consistent, the knowledge and experience required for different materials, sizes and cuts varies. This variety means that for jewelers, there is no single go to gemstone manufacturer (Lee 2021).

Regardless of how complicated colored gemstone supply chains are, the phases that a gemstone goes

through on its route from the mine to being sold as jewelry to the end customer are the same, namely mining, cutting and polishing, manufacturing, and retail (Collet, Curtze and Reed).



**Figure 3 Colored gemstone supply chain (Lee 2021)**

Before it reaches the client, the raw gem discovered by a prospector or miner will be sold and resold multiple times between various layers of intermediaries and traders. According to value chain case studies, the retail price of the finished product is roughly 11 times that of the raw stone (van der Wal and Haan 2010).

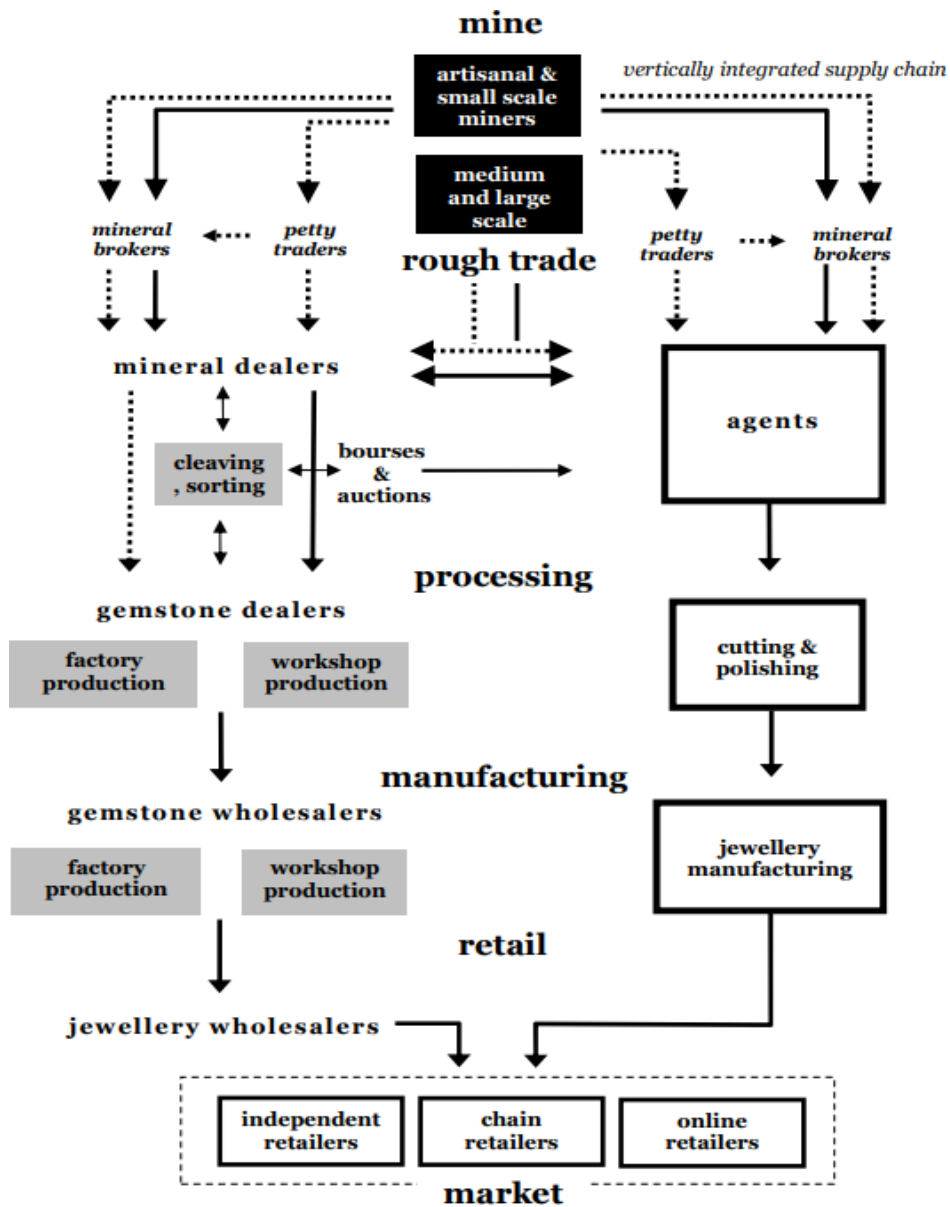


Figure 4 Gemstone Value Chain and Key actors (van der Wal and Haan 2010)

## **2.2 LAPIDARY TECHNOLOGY**

The true worth of precious stones is not revealed until they are cut and polished by lapidary skilled workers. The contemporary lapidary service is an outcome of old gem-cutting and polishing techniques that have been adopted to new technology, thereby assisting the diamond-cutting sector. Lapidary expertise is an industry success story, having been positioned as a gem-cutting center and market provider of cut and polished, free-size, and calibrated stones. (Shyamalie and Dhammika, 2010).

In Ethiopia, the lapidary technology industry has been described as highly challenging. The most reported challenge was finding sufficiently trained staff for cutting and polishing gemstones and then further training them to bring their skill levels up to an internationally competitive standard. Interviewees frequently complained that the cutters and polishers they employed were not producing to a high enough standard, despite the fact that the majority had received training. (Kyngdon-McKay, Jorns et al. 2016).

## **2.3 BENEFITS OF LAPIDARY WORK**

Lapidary work offer numerous prospects to explore the natural world while making striking and meaningful works of arts. It is an ancient and timeless art providing plentiful benefits to modern day artisans. Lapidary work allows for artistic expressions. It is a contemplative and comforting practice that helps reduce stress or anxiety. Exploring fossils through lapidary techniques can be a worthwhile experience, helping us tie with our past.

## **2.4 MODERN LAPIDARY**

Lapidary is a centuries-old art form, with evidence of stone carving and polishing tools found in numerous archeological sites around the world. Beautiful jewelry, decorative items, and religious artifacts have been made from it. Lapidary has been used throughout history to create a wide range of ornamental items out of precious and semiprecious stones (Admin April,2023).

As civilization developed, the way gems are cut and shaped did changed through time. During the 1900s, new tools developed making gemstone cutting all more interesting. The creating of laps plated with diamonds made cutting stone more manageable.

The current era of lapidary has brought forth tremendous progress, allowing the craft people of the trade to broaden their talents and explore new frontiers (Admin April,2023). We have the

fantastic gemstone cutting and polishing equipment we know today because to a long history of evolution (cuttingedgesupply)

The utilization of computer-aided design and 3D printing technology enables higher level of accuracy and precision than ever before, allowing unparalleled access to procedures that would have been impossible just a few decades ago. With improved accuracy, artisans are able to produce higher level of quality work while simultaneously reducing waste and cost associated with traditional process.

With increased accuracy, artisans are able to create higher-quality work while decreasing waste and costs associated with traditional processes.

In general, recent advances in lapidary technology have transformed the industry while making it more accessible to its artisans.

## **2.5 MODERN LAPIDARY EQUIPMENT**

### **2.5.1. TRIM SAWS OR SLAB SAWS**

Not all rocks and gemstones are sized equally, so when it comes to cutting the rock collection, there are two types of saws: a trim saw and a slab saw. A trim saw has a small, thin blade that is made for cutting small stones into smaller chunks or for creating a flat edge for a cabochon. It is a good starter option. A slab saw has a larger and thicker blade, making it suitable for trimming down rough rock slabs or large stones that won't fit into a trim saw. This has a vise to help you trim the rock safely.



**Figure 5 Trim saws or slab saws**

### **2.5.2. ROCK TUMBLERS**

A tumbler is one of the must-have pieces of equipment in a workshop. There are two types of tumblers: rotary and vibratory, but both serve the same purpose of polishing and rounding rough stones. Rotary tumblers are barrel-shaped and rotate slowly to polish the rocks inside with the help of other rocks and abrasives. Vibratory tumblers (or vibes for short) take much less time to polish up stones and maintain the original stones' shape. Vibes have a container that shakes the rocks rapidly; the shaking causes friction, which in turn polishes the rocks.



**Figure 6 Tumbler**

### **2.5.3. TUMBLING FILLER**

When working with a small number of rocks that don't fill up your tumbler's barrel, you'll need to use filler. You can use ceramic or plastic fillers; both provide cushioning and extra polish to your stones without damaging them.

### **2.6.4 CABLING OR CABOCHON CUTTERS**

Cabochon is a way of cutting gemstones to create a smooth and polished curved surface. In its simplest form, this cut consists of a domed, polished top with a flat, unpolished back. Use a template with a copper or aluminum pencil to draw lines in order to get the perfect shape.



**Figure 7 Cabochon cutter**

## 2.6.5 TEMPLATES



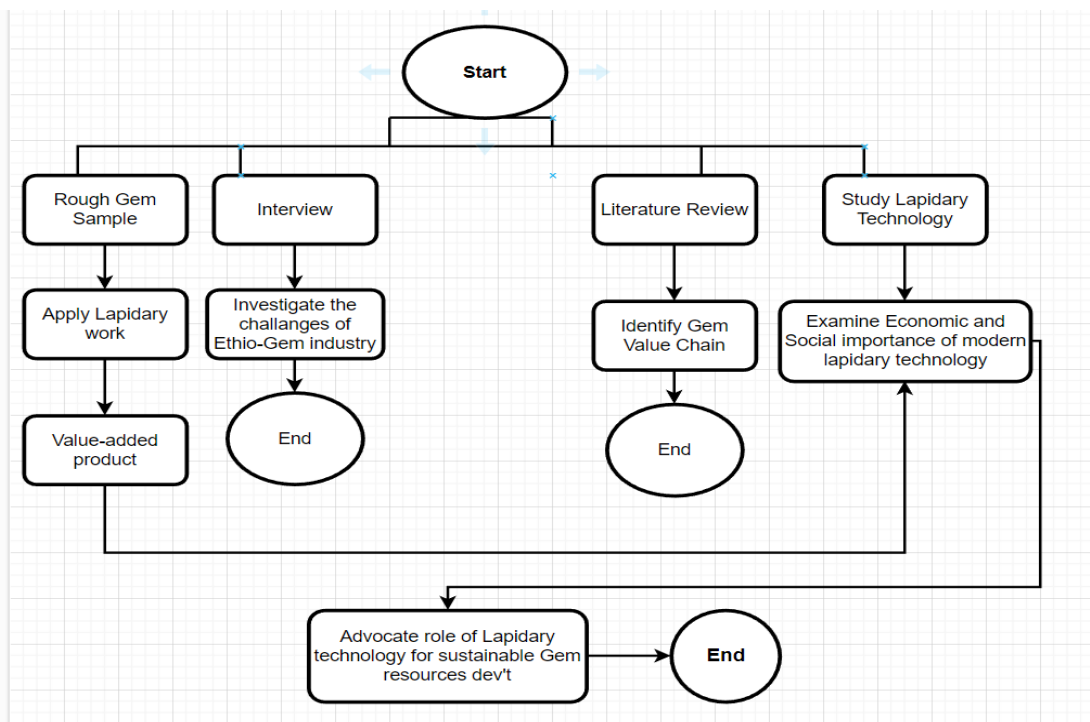
**Figure 8 Templates**

## CHAPTER 3- METHODOLOGY

### 3.1 METHODS AND MATERIALS

This study is conducted to comprehend the application of lapidary technology for sustainable gemstone sources and to draw out possible development options for the rough gemstone resources in Ethiopia. In order to achieve this objective, first, literature review is made to understand the gemstone value chain and identify the various stages of the lapidary process. Then semi- structured interview is made to understand the challenges faced to the gemstone industry in Ethiopia. A representative gemstone sample is collected from Wegel Tena, Amhara Regional State which is used for the lapidary work. The gemstone sample is then cut and polished using the lapidary equipment's at the Ethiopian Mineral Corporation to add value to the rough gemstone. A cost-benefit analysis is performed for the purpose of decision making on the lapidary technology for gemstone resource development and compare the value addition to the rough gemstone sales. Finally, the economic and social importance of the lapidary technology was examined to comprehend its effect on the earning from the sector and to advocate it.

The Methodology work flow for this project work is illustrated on the **Figure 9** below.



**Figure 9 Methodology work flow for a Gemstone Lapidary**

### **3.1 ORIGIN OF THE GEMSTONE SAMPLE**

The Ethiopian Mineral Corporation's workshop center is where the value-added processing is carried out on the gems samples that are from areas of the country with known gemstone resources. A rough gemstone samples collected from the Amhara Regional State around Wegel Tena is used to conduct the lapidary work for the purpose of this study.

### **3.2 PROCESSING METHODS**

#### **3.2.1 LAPIDARY MAKING**

For the lapidary making method the following materials are used:

- Raw obsidian ,agate and jasper samples
- Sawing Machine with Blade and Lubricants(water ),
- Templates,
- Trim Saw and Lubricants (water),
- Polishing and Grinding Machine with Polishing Wheels

### **3.3 PROCESSING STEPS**

#### **3.3.1 LAPIDARY MAKING**

The lapidary making method of gemstones processing passes through the following sequential steps:-

- Analyzing the Gemstone's character
- Cutting of row sample
- Pre-forming by using templates
- Pre-polishing and polishing

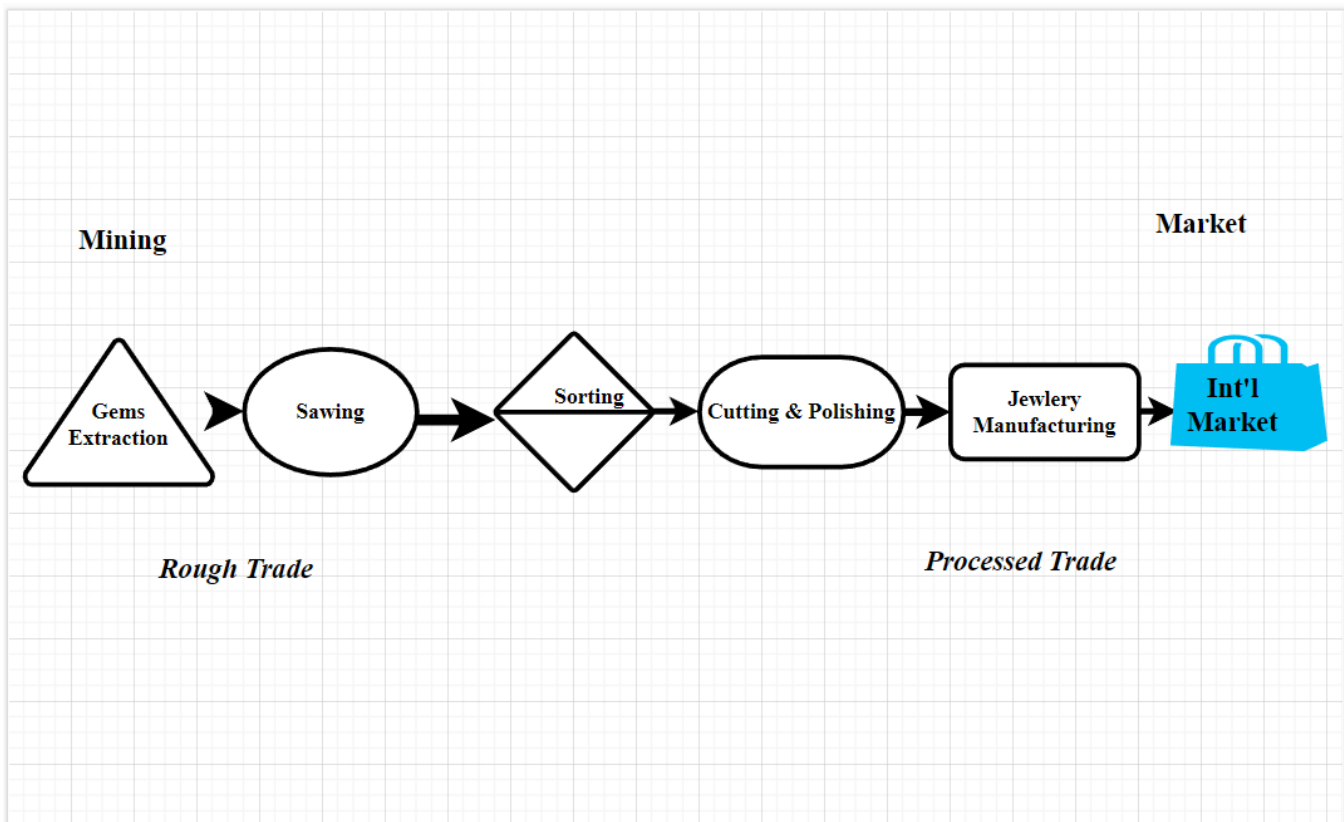
Finally, a simple economics and a cost benefit analysis of the rough gemstone trade versus the value added product is made to see the effect of applying lapidary work on the gemstone resource,

## CHAPTER 4- RESULTS AND DISCUSSIONS

Based on the methodology design, the followings are the results and discussions presented with reference to the aim of the study, which is to examine the role of lapidary technology to the gemstone resource development in Ethiopia.

### 4.1. GEMSTONE VALUE CHAIN AND LAPIDARY WORK PROCESSES

With small companies bound together in intricate trading relationship, the gemstone industry is highly fragmented at all levels from exploration, to mining, to processing and distribution.



**Figure 10 Gemstone Value Chain from mine to market**

The gemstone value chain has four major stages between the point of extraction at gemstone mining spots and the point of sale on the worldwide retail market. These are a) Sawing b) sorting c) cutting and polishing d) Jewelry manufacturing

## **4.2 LAPIDARY TECHNOLOGY AND TECHNIQUES**

In lapidary technology, there are so many processes and machinery that are used. The machine and the process are listed below.

### **4.1.1. SAWING**

#### **Slabbing**

A slab saw is used to slice raw stone into slabs of the specified thickness. A standard slab saw is made for sawing big pieces of minerals (such as agate, jasper, lapis lazuli, sodalite, and jade, among others) into slabs or blocks for further processing, with the exception of diamonds. A turntable clamp is used to hold the stone to be worked so that the depth of cut can be doubled.



**Figure 11 Slab Saw**

#### **Trimming**

The trim saw is used to shape stones into cabochons, faceted stones, tiny plates, etc. for further processing. With petroleum oil as a coolant, diamond saw blades (150 or 250 mm in diameter) can cut any kind of stone. To saw the stone into the required shape and size, the stone is physically directed toward the blade. After cobbing and fine knocking, rough gemstones of the more precious variety are typically tiny enough to be sawed by a trim saw without being slabbed first.



**Figure 12 Trim saw**

#### **4.1.2. GRINDING AND POLISHING**

##### **Grinding**

The abrasive procedure of grinding is used to give rough forms to gemstones. The phrase describes the use of abrasive wheels in lapidary operations. The most popular wheels come in a variety of sizes and forms, are manufactured of silicon carborundum, and use abrasive grains of various sizes depending on the wheel's intended use. Many grinding wheels used in modern practice have diamond grains attached to a metal or plastic matrix.

A gem cutter uses grinding wheels to shape cabochons and to preform rough for faceted gems, as well as to grind bevels on flats, shape carvings, profile pieces for inlay work, and many other tasks.

While fine grits are utilized if the abrasive action needs to be slower and smoother, coarse grits are employed to manufacture wheels that remove material quickly. The numbering of grit sizes for loose grains and abrasive wheels in grinding equipment indicates the degree of fineness of the particles; for example, 100 grit is considered coarse and 1200 grit is considered very fine.

Table 4.1 lists the grits used in lapidary work, including coated and loose grain.

**Table 1 Grit Size from (Zion E. Simwanza (2001))**

<b>Grit Size</b>	<b>Micron Size</b>	<b>Purpose</b>
60	400	Rough grinding and Tumbling
100	150	Rough grinding and Tumbling
220	60	Fine grinding, lapping, and sanding
325	45	Very fine grinding, lapping, tumbling, and fine sanding
600	30	Very fine lapping and fine sanding
1200	15	Very fine lapping and pre-polishing.

### **Grinding Wheels**

Depending on the sort of machinery being used, carborandum wheels for gem cutting come in a number of diameters. The typical diameters range from 150 to 250 mm in diameter and 20 to 50 mm in thickness. Shaft holes are offered in sizes with diameters ranging from 20 to 30 mm to fit different equipment brands.

The most common grit for rough shaping is 120, which is a medium-soft grade. A 220-grit wheel in a medium-hard grade works best for fine grinding when the goal is to smooth surfaces rather than remove a lot of material.

**Table 2 Grit Size and Usage from (Zion E. Simwanza (2001))**

<b>Grit Size</b>	<b>Usage</b>
180	roughing (mostly done by vertical wheels)
400/600	quick cutting
1500	smoothing facets prior to polishing

### **Grinding Powder**

When employing diamond laps is not available, grinding powder is utilized in tumbling mills, vibrators, surface grinding machines, and for cutting faceted stones. For coarse and medium work, carborundum is used in grit sizes 80–320; for fine and very fine work, it is used in grit sizes 400–1200.

### **Sanding**

Strong fabric coated in a coating of silicon carbide grit is the most typical sanding material. Only two or three types of grit are typically required, ranging in size from very coarse to very fine. 220 grit is frequently used for coarse sanding, whereas 400 or 600 grit is frequently used for finer sanding.

The glue used to create standard sanding cloth is water-soluble. Another kind is resistant to the effects of water because it is saturated with plastic resin adhesive. Depending on the machine, sanding cloth comes in disk, strip, and belt forms. Water is used in almost all grinding, sanding, and polishing operations on gemstones.

## **Polishing**

The final step in the preparation of gemstones is polishing. The brilliant and radiant smooth surfaces typical of polished gems are produced by pressing the shaped stone with considerable force against yielding materials such as felt, leather, cloth, or wood that have been charged with polishing agents. With the exception of diamond, most polishing agents are oxides of metals. (Zion E. Simwanza (2001))

- aluminum oxide, 0–1 micron or finer
- eerie oxide
- chromic oxide
- ferric oxide
- chalk or the finest marble dust
- tin oxide
- tripoli = finest diatomite
- zirconium oxide diamond (powder or paste), 0–2 micron



**Figure 13 Polishing Machine**

There are two types of general polishers: those for polishing cabochons, flats, spheres, and other work demanding little accuracy; and those for polishing geometrically flat surfaces, such as on faceted gems. The first type embraces buffs constructed from yielding materials, such as fabric and leather, but also harder materials such as wood, which are less yielding.

#### **4.2.2 LAPIDARY TECHNIQUES**

It takes specialized equipment, lapidary arts skills, and a lot of practice to turn raw materials into jewels. Several of these procedures call for the use of tools or machines that, if handled without the right expertise, could harm you or your gemstone. Before attempting to use any machine or technique, you should get more training in it.

##### **Step 1: Analyzing the Gemstone's Character**

The project must be first determine the materials' worth for it. The shape that will yield the best value for the project should guide how can choose to prepare the ore. The cut must be chosen first for the majority of gemstones. Processed three samples—obsidian, agate, and jasper—in the best manner while also considering the caliber and characteristics of the raw materials.

Step 1.1: Observe the characteristics of the gemstone, determine whether it is transparent, translucent, or opaque, and look for flaws.



**Figure 14 Obsidian**



**Figure 15 Jasper**



**Figure 16 Agate**

Step 1.2: Examine the hue of the gemstone and evaluate the caliber of your raw materials using a channeled source of light.



**Figure 17 Assessed minerals by color and alignment.**

You can choose the best processing method by looking at the characteristics of the gemstone.

- Faceting techniques are frequently used to treat transparent gemstones without defaults.
- Cabochon procedures are suitable for transparent gemstones with inclusions that are translucent, opaque, or have an optical impact.

## Step 2: Assessing the Gemstone's Color

Positioning the gemstone dome in order to create an appealing cabochon is the first stage in determining the grinding and shaping of the cabochon. When choosing how to grind and shape a gemstone, we can use a source of light to identify the best and most vivid color play, or color band. Typically, this is accomplished in three easy steps:

Step 2.1: Using a bright source of light, find the optimal orientation of the color band (or the best color for stones without play of color) to identify the best and most obvious play of color



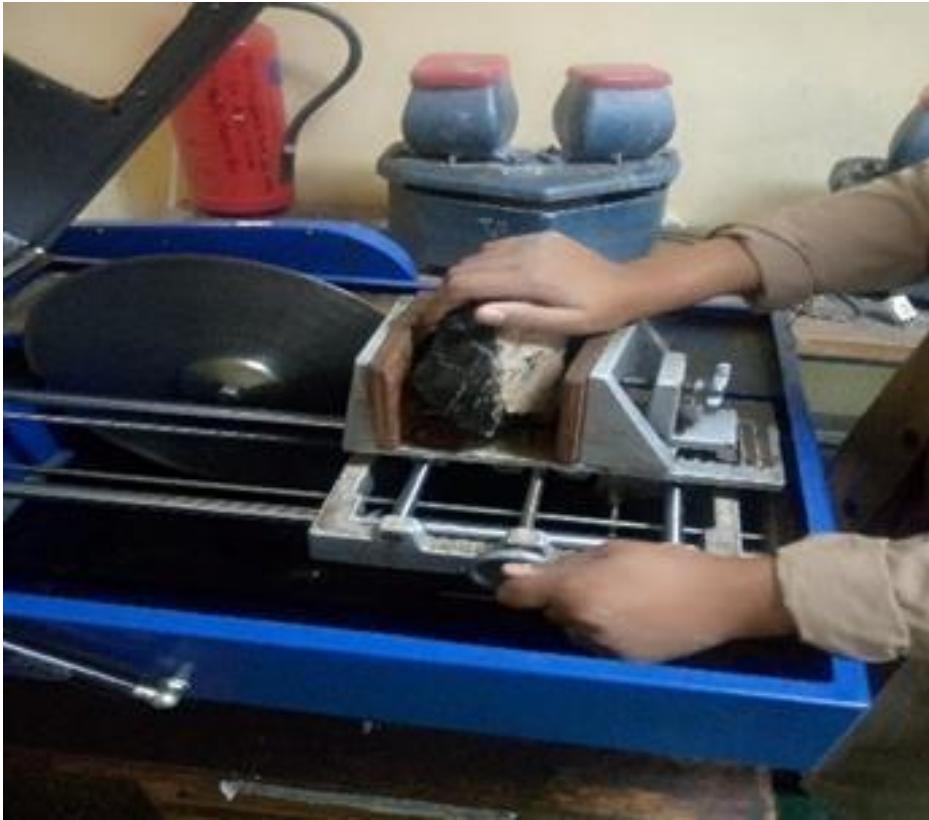
**Figure 18 determining alignments of the ore**

Step 2.2: The optical effect should be centered at the top of the face-up dome.

Step 2.3, which also involve positioning it so that the best color formation is aligned with it.

## **Step 3: Cutting**

Sawing is the action of separating or cutting large stones into smaller ones or eliminating extra material from large, rough stones. Lapidarists must put on safety gear, including masks and goggles, when performing this procedure, which involves using sawing machine.



**Figure 19 Sawing**

Step 3.1: Detect the part of the stone to be removed or sliced. Step 3.2: Draw a sawing line.

Step 3.3: Double-check the water or gasoil level of the sawing machine. Step 3.4: Saw carefully along the line that you have marked out.

Step 4: Pre-forming

The back and dome of the gemstone will be shaped by the lapidarist during the pre-forming phase. During this phase, lapidarists must put on safety gear, including masks and goggles. Usually, there are three steps in the procedure:

Step 4.1: Use 80 mesh and 220 mesh wheels to flatten the rear of the gemstone, bend the dome, and produce a chamfer.

Step 4.2: Use a template and a copper or aluminum pencil to draw lines to make the ideal shape; and finally,



**Figure 20** Templates are used to get the perfect shape.

Step 4.3: Focus on ensuring a symmetric and proportionate curved dome.



**Figure 21** Trimming

### Step 5: Pre-polishing and polishing

A lapidarist will polish the gemstone to perfection at this step. Lapidarist are required to put on safety gear during this phase, like masks, goggles, and earplugs. The processing process ends with this stage. The goal is to get a sparkling surface because a smooth, well-finished gemstone will only sell well. Two steps are normally involved in this:

Step 5.1: Using the 280, 600, 1200, and 3000 wheels, create a chamfer on the dome and the back of the gemstone. To reach the optimum outcome, process the data step-by-step, refining the pre-publish using progressively finer tools.



**Figure 22 Cabbing**

Step 2: Use a polishing pad to buff or a piece of felt with cerium oxide to polish jasper,agate or obsidian

Last step will be getting beauty full, polished and gilt samples of the ore

A



B



C



Figure 23 output (a laboratory result of work b from Yezna Jewelry and c from Ethiopian mine lab)

### **4.3 CHALLENGES OF ETHIOPIA’S GEMSTONE INDUSTRY**

A shortage of raw stone supply and a market for cut stones were the two main issues raised by the respondents in this study as reasons for the demise of numerous lapidaries. Contrary to popular belief, Ethiopia has never experienced a shortage of stones; rather, the lapidary operators have been offering extremely low prices for purchases, which has caused the miners to avoid them in favor of middlemen and the international market.

The reasons cited above for the downfall of the lapidary industry in Ethiopia may be the immediate causes, but the failure of government policies to safeguard the sector has had a long-term, pernicious effect. Only broad, indiscriminate laws covering the entire gemstone sector were implemented when the market for gemstones was liberalized; the demands of the local lapidaries were not considered. The fate of the industry was left up to the whims and ravages of ruthless market forces.

A more comprehensive view of the situation in Ethiopia's gemstone sector reveals that the issues now plaguing the lapidary sector can be pinpointed as described below.

#### **A. Lack of a Local Market for Gemstones**

Most industries only start to grow into international trade once their product line has completely saturated the local market. The lapidary sector in Ethiopia has never experienced this. Since the expatriate population began to decline, the sector has always focused on international markets. Insiders in the business have expressed dissatisfaction over the weak local market for gemstone products. In terms of economics, gemstone products are categorized as luxury commodities, and demand for them is correlated with the presence of discretionary income, which is essentially nonexistent for the great majority of Ethiopians. As was previously mentioned, poverty is to blame for this. This explains why the few remaining lapidaries are held by foreigners who have links to markets abroad and can afford to travel there.

#### **B. Over-liberalization of the licensing system**

There is no qualification process for applicants seeking a license as a gemstone dealer under the new liberalized economy. In the previous centralist economy, to be authorized to trade in gemstones, one had to be the owner of a mine, lapidary, or jewelry store. Unrestricted access to the gemstone trade has led to the emergence of "authorized" intermediaries. These intermediaries

roam the mine sites, purchasing carefully chosen stones of high quality while excluding low-grade stones that even lapidaries cannot afford. This is one of the reasons why some lapidaries complain about the lack of stones. The stones are typically bought in this way and then illegally exported from the nation.

### **C. Lack of Capital in the lapidary industry**

Typically, the lapidary business doesn't have the financial resources to give miners fair prices for rough gemstone acquisitions. This helps to explain why large mines have developed export markets whereas small-scale miners sell to middlemen, who typically provide slightly higher pricing.

### **D. Lack of an Established Gemstone Exchange**

The development of the gemstone business in general and the lapidary industry has been impeded by the lack of a Gemstone Exchange. International buyers prefer a single location to conduct all of their transactions, which Ethiopia now lacks. In order to negotiate their own market conditions, individual miners and lapidary business owners travel abroad. The small-scale miners sell their produce to middlemen since they cannot afford to travel. If there were a Gemstone Exchange facility, miners who are unaware of the value added when a rough gemstone is cut would be drawn to cut and polish their produce since they would be aware of the price differences between the two. As a result, a gemstone exchange would aid in the successful development of the lapidary business since producers would be encouraged to cut stones in order to boost profitability and cash flow.

### **E. Inadequate Government Policy on Downstream Processing**

Although processing minerals is mentioned in the existing mining strategy, exporting raw materials benefits their significant offshore commercial interests. It is obvious that in order to Change this scenario, suitable legislative action would be needed.

### **F. Lack of Financial Resources**

Many lapidary business owners lack the working cash needed to purchase the rough stones in the quantity and quality necessary for profitable operations.

### **G. Adequate Valuation Skills**

Many gemstone miners are not skilled in appraisal. They typically rely on middlemen who determine the prices and clearly take advantage of their ignorance. This is due to a number of causes, including:

- Lack of gemological skills and
- Inadequate access to marketing information on trends in pricing on international markets.

### **H. Inadequate Lapidary Skills**

Highly specialized training is necessary for the Ethiopian lapidary industry to assert itself, reach international gemstone markets, and favorably compete with the more than century-old skilled gem cutters of India, China, Thailand, and Israel. High-quality stones are painstakingly cut by experts, many of whom spend many years honing their craft.

Regarding the need for national manpower development, the government has applied a double standard. Similar organizations were created to support agriculture. Despite Ethiopia being a large producer of gemstones, no parallel training was offered for the sector of gemstone processing.

#### 4.4 ECONOMIC AND SOCIAL IMPACT OF LAPIDARY TECHNOLOGY

Table 3 Effects Lapidary Technology on Colored Gemstone in Ethiopia

No.	Type of Gemstones	Rough Gems Price (ETB/KG)	Price of value - added Gems (ETB/KG)	Estimated Difference (in ETB)	Difference in (%)
1	Jasper	275	85,000	84,725	30809.09
2	Agate	110	80,000	79,890	72627.27
3	Obsidian	165	80,000	79,835	48384.85
4	Opal	400,000	2,046,750	1,646,750	60547.27
5	Crystal Quartz	550	333,560	333,010	411.69

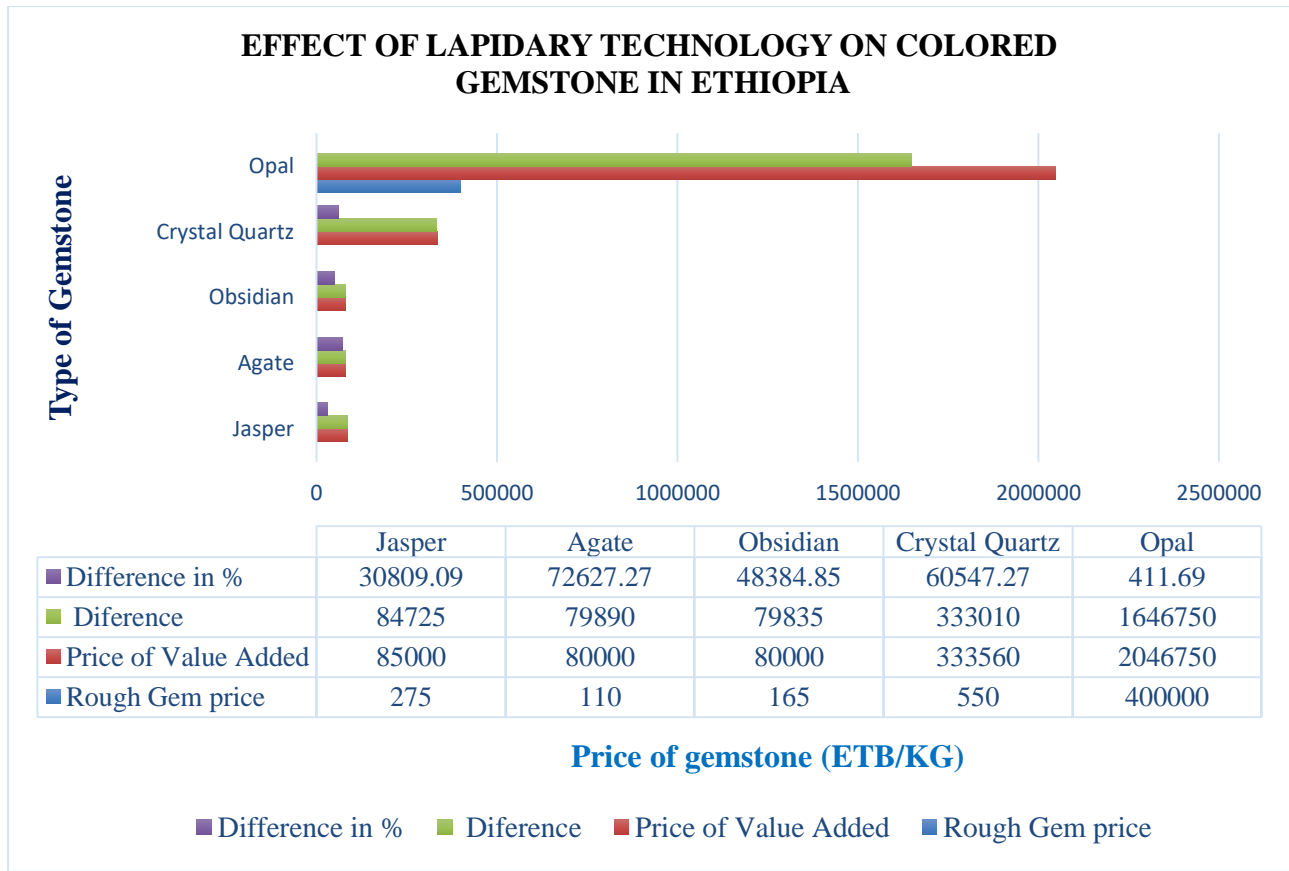


Figure 24 Effect of lapidary technology on colored gemstone in Ethiopia

As demonstrated on the **Table 3**, the price of rough jasper is about 275 Birr per kilogram, and the price of value-added jasper is 85,000 Birr per kilogram, with a significant price difference of 84,725 Birr. The price of rough agate is 110 Birr per kilogram, and the price of value-added agate is 80000 Birr per kilogram, with a substantial difference of 79,890 Birr (around 72627.27% increase). Similarly, the difference between rough obsidian, crystal quartz, and opal is 79835 ETB, 333010 ETB, and 1646750 ETB, respectively.

#### **4.4.1. ECONOMIC IMPACT OF LAPIDARY TECHNOLOGY**

- Ensuring optimal utilization of scarce resources; preventing waste of the nation's resources; and getting the most out of available resources.
- A multimillion-dollar industry will be established, creating huge job opportunities
- Stimulate other economic sectors, such as tourism, and foreign tourists and local buyers will be attracted.
- Generate foreign currency due to the exporting of goods.
- Art and craft shops will be opened in the country.
- There will be more investors in this lucrative business.
- The contribution of the sector to the GDP growth of the country would be tremendous.
- Increase in the productive capacity of the economy.
- protection against economic risks (e.g., unemployment, destitution in old age)

#### **4.4.2. SOCIAL IMPACT OF LAPIDARY TECHNOLOGY**

- It creates and develops knowledge, local skills, innovations, and opportunities for those who are engaged in these activities.
- There will be a transformation from manual work by smiths to industrial technology.
- A safe and conducive investment environment will be created to attract foreign investors.
- A big market link or chain will be created between the raw material supplier and industries. The present notation of undermining the resources, especially gemstones, will be corrected. A legal and readily accessible supply chain for raw gemstones must be established.

## **CHAPTER 5- CONCLUSION AND RECOMMENDATION**

### **5.1. CONCLUSION**

Ethiopia's gemstone sector is brimming with prospects; the presence of high-quality colored gemstones and understanding the value chain's problems, as well as adapting to modern lapidary technology, can lead to excellent results.

The stages of the gemstone journey in Ethiopia brusquely ended with the rough sellers and a few gem cutters. Moving forward, the remaining stages of the supply chain are critical for the nation's economic development if they are supported. Furthermore, the gemstone industry's value chain has fragmented nature, causing the sector to lag behind gold and other commodities. Its comprehensive monitoring system is substantially impacted by the gemstone's source, the dominance of formal and illegal small-scale mining, and the entire resource's journey from the mine to the cutting center and the market.

Ethiopia's gemstone business is lacking in terms of technology, financing, lapidary expertise, and regulated market systems. Lapidary's impact on the rough gemstone is significant. An economic analysis made of agate, crystal quartz, obsidian, jasper, and opal found that there is an increase between 400 and 70,000 folds due to the effect of lapidary technology and value added on the rough gemstone.

### **5.2. RECOMMENDATIONS**

In order to protect the business and enable a thriving gemstone cutting and polishing industry, enabling laws should be put in place to ensure that the appropriate economic return from the gemstone resources is achieved. Furthermore, the government must support the lapidary sector with the same commitment and intensity it used to grant Ethiopia mining rights for gemstones. This could be accomplished by taking steps to ensure a consistent supply of rough gemstone material from mines. Facilitating financial conveniences for licensed gemstone miners and dealers, as well as connecting Ethiopian gemstone producers to international markets for cut and polished stones, will increase the socio-economic role of artisanal and small scale mining (ASM) in sourcing and empower the sector. This can be accomplished through collaboration with financial institutions at the national, regional, and worldwide levels.

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