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Current Situation and Future Prospects of Raw Copper in Pakistan

Researcher Name: Maryam Younus

Research Head: Dr. Khalid Mustafa

Research Wing

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Abbreviations & Acronyms

GSP	Geological Survey of Pakistan
USGS	United States Geological Survey
EM	Electromagnetic
IP	Induced Polarization
ER	Electric Resistivity
REE	Rare Earth Elements
ICSG	International Copper Study Group
FEZ	Free Economic Zone
EPZA	Economic Processing Zone Authority
EVs	Electric vehicles
IEA	International Energy Agency
GDP	Gross Domestic Product
TDAP	Trade Development Authority of Pakistan
HS	Harmonized System
WeBoc	Web based One Customs
WTO	World Trade Organization
LME	London Metal Exchange
R & D	Research and Development

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Executive Summary

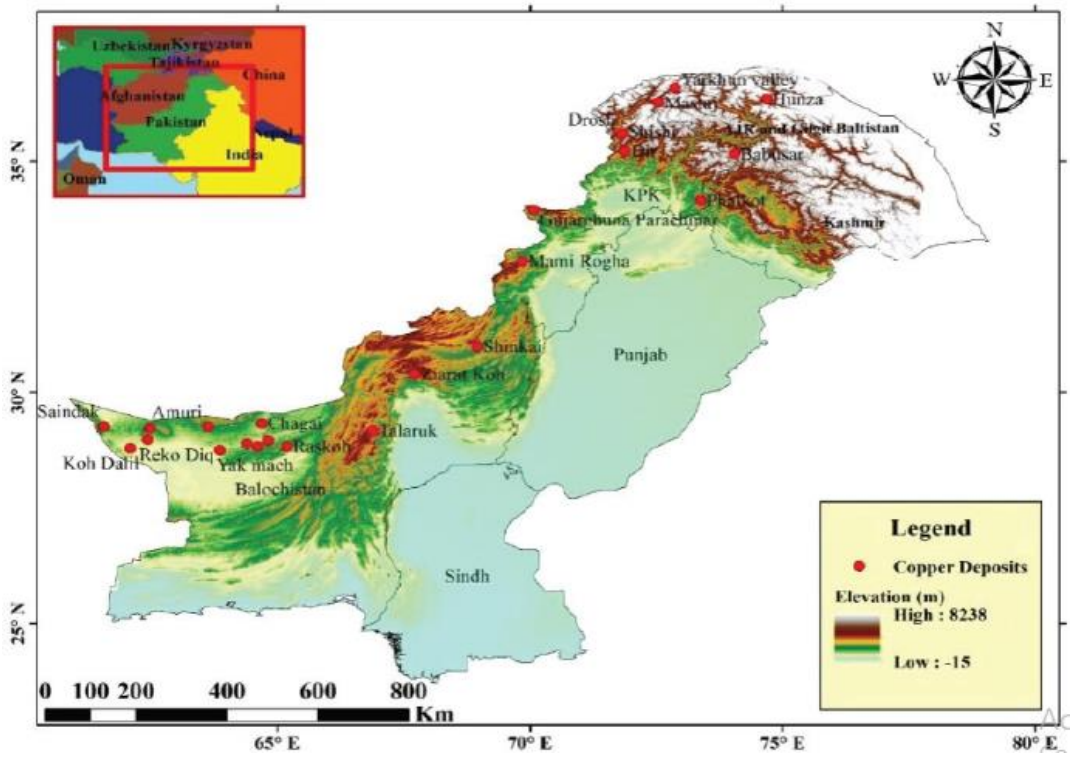
The mineral sector of Pakistan, despite having huge reserves of good quality minerals, is still lagging far behind as compared to the world's mineral market. Pakistan has the world's fifth-largest copper reserves. Copper production will play a significant part in the global shift to renewable energy over the next decade, as governments increase the production of solar and wind technology, as well as electric vehicles, to achieve climate goals. In 2020, Pakistan produced approximately 13 thousand tons of copper ores. Pakistan has the only importer of copper ores in China. Pakistan is exporting its copper ores and concentrates only to China at a very low cost. There are more opportunities for the private sector and direct foreign investment in the mining, processing, and trading/exports subsectors. Reko Diq is one of the largest undeveloped copper and gold deposits globally, capable of producing 200,000 tons of copper and 250,000 ounces of gold a year for more than half a century. The Reko Diq project will be one of the largest copper and gold mining projects in the world. Reko Diq, probably, has arrived at the right time and still continues to be in the right time frame due to the emergence of EVs and renewable energy like solar.

Currently, Pakistan's export per unit cost is incomparable with the world average cost. Pakistan is exporting its products at a very minimal cost. It is a matter of concern that Pakistan is managing its copper sector poorly. It can be a source of addition to the export volume if we manage the pricing of the product and also explore new markets such as Japan, Korea, Germany, Canada, Spain, USA, India, etc. Mis invoicing also came out as a major issue in the mineral sector. When it comes to copper articles, Pakistan currently exports the majority of refined copper, waste and scrape, copper bar and rods, copper wire, copper foil, copper tubes, and pipes. Pakistan needs to diversify its export destinations instead of solely depending on China for its exports. Pakistan should explore Europe, the Middle East, and CARs. Value addition can play a significant role in increasing export volume instead of exporting copper ore and concentrates if Pakistan starts working on producing other value-added products like unrefined and refined copper, master alloys, copper bars, and rods. It is expected that in the near future, Pakistan's copper production and exports value will increase by 10 times.

This study concluded that Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher value semi-finished or finished products. Similar to Indonesia, Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher-value semi-finished or finished products.

Chapter 1: Introduction

Nature has generously gifted Pakistan, especially Baluchistan province, with natural resources of metals such as gold, copper, mercury, antimony, and silver. Many attempts are being made for scientific investigations and the development of mineral resources in the Baluchistan province. Saindak town in the Chagai District of Baluchistan, Pakistan, is popular for its copper-gold mines. The Geological Survey of Pakistan and foreign investors have exposed vast depositions of copper in many places. Saindak and Rekodiq deposits have reserves of about 4.5 billion tons of copper. The total recoverable minerals of copper, gold, and silver from the Saindak deposits are roughly in the range of about 1.69 million tons, 2.24 million ounces, and 2.49 million ounces, respectively[1].



Map showing the main localities of reported copper mineralization in Pakistan

The Geological Survey of Pakistan reported a considerable amount of copper sulfides during their exploration of the Bela ophiolite zone in early 1970. Copper is commonly intercalated in the Bela ophiolitic basalt units. The copper ophiolite sequence belt crosses from Gilgit Baltistan, Kohistan, North Waziristan, and Quetta to Iran[2]. The mineral sector of Pakistan, despite having

[1] Pakistan GSo. [cited 2022]. Available from: https://gsp.gov.pk/national-internationalcollaborative-projects/. 2. Ahmad

[2] Shah STH, Khan NG, Abbasi MIH, Tabassum K, Shah SKW. The Mineralization and Structural Geology of the Porphyry Copper Deposits of Pakistan. Nepal Journal of Science and Technology. 2020;19(2):130-6.

huge reserves of good quality minerals, is still lagging far behind as compared to the world's mineral market. As compared to the world's minerals (HS code: 26; ores, slag, and ash) trade market of 376 billion USD, the export of Pakistan is negligibly small, with a value of only 152 million USD during the year 2021. Pakistan is endowed with significant mineral reserves. The country has the world's second-largest salt mines and coal reserves, the fifth largest copper and gold reserves, as well as an estimated 618 billion barrels of crude oil. Pakistan's most valuable and potential minerals include marble, granite, coal, chromite, gypsum, copper, gold, iron ore, lead, zinc, bauxite, crude oil, and natural gas. From the global perspective, there are billions of commercially extractable reserves of these minerals that give both comparative and competitive advantages to Pakistan. Pakistan has the world's fifth-largest copper and gold reserves. Despite the huge potential, the contribution of the mineral sector to Pakistan's GDP is around 2.38 percent, and the country's exports are only about 0.53 percent of the total exports.

By the early 21st century, Chile had become the world's leading producer of copper. Other major producers include Peru, China, and the United States. Global copper reserves are estimated at 880 million tons and annual copper demand is 28 million tons, while annual production, on average, is reported at 20 million tons. Current copper resources are estimated to exceed 5,000 million tons. (United States Geological Survey [USGS], 2020). e top countries with copper reserves are Chile, Peru, Australia, Russia, Mexico, the United States of America, Poland, and China. Chile is the leading country in copper production, with a production value of 5.7 million tons, more than 1/4th e global production. Other countries such as Peru, China, Congo, and the USA are the top producers of copper reported for the year 2020.

In 2020, Pakistan produced approximately 13 thousand tons of copper. Pakistan has the only importer of copper ores, which is China. Pakistan is exporting its copper ores and concentrates only to China at a very low cost and to the other exporter countries like Chile, Peru, Mexico, etc. Pakistan is exporting copper ores to China at half the cost in comparison to the global average per ton cost. Pakistan has got huge potential for investment in the mineral sector. There are more opportunities for the private sector and direct foreign investment in the mining, processing, and trading/exports subsectors. There are huge copper reserves in Pakistan and they are mainly concentrated in Baluchistan, Gilgit-Baltistan, and North Waziristan. In RekoDiq, Baluchistan, the main deposits of copper and gold are present. There are also copper deposits in Daht-e-Kuhn, Nokundi, located in the Chaghi district, and Lasbela.

Copper production will play a significant part in the global shift to renewable energy over the next decade, as governments increase the production of solar and wind technology, as well as electric vehicles, to achieve climate goals. Governments and policymakers, particularly in the US, Europe, and China, have made significant investments in renewable energy sources and technology as worldwide energy consumption is expected to increase in the coming years.

Copper is necessary for transforming and transmitting these sustainable energy sources to a useful final state. Copper's qualities make it the most cost-effective material for a variety of sustainable energy systems, including cables, batteries, transistors, and inverters.

Using data sources such as Trade Map, Wits, the Statistical Bureau of Pakistan (SBP), and the Geological Survey of Pakistan, this study investigates the overview of World mine resources production and reserves, global trade trends and local trade trends (Production, imports, exports, consumption, prices, quantity, consumers and suppliers, employment, mines), tariff analysis, events, trends, and issues, and identifies opportunities and issues in the raw copper.

Chapter 2: Background

Copper is a chemical element with very high thermal and electrical conductivity. According to the United States Geological Survey (USGS), copper is the third-most-consumed industrial metal in the world, trailing only iron and aluminum. Native copper is found in many locations as a primary mineral in basaltic lavas and also as reduced copper compounds, such as sulfides, arsenides, chlorides, and carbonates. Copper is commercially produced mainly by smelting or leaching, usually followed by electrodeposition from sulfate solutions. The major portion of copper produced in the world is used by the electrical industry; most of the remainder is combined with other metals to form alloys. It is also technologically important as an electroplated coating.

Brasses (copper and zinc), bronzes (copper and tin), and nickel silvers (copper, zinc, and nickel, no silver) are an important series of alloys in which copper is the main constituent. There are many useful alloys of copper and nickel, including Monel; the two metals are completely miscible. Copper also forms an important series of alloys with aluminum, called aluminum bronzes. Beryllium copper (2% Be) is a one-of-a-kind copper alloy that can be heat hardened. Copper is a part of many coinage metals. Long after the Bronze age passed into the Iron Age, copper remained the metal second in use and important to iron. By the 1960s, however, cheaper and much more plentiful aluminum had moved into second place in world production. Cuprous oxide is a red or reddish-brown crystal or powder that occurs in nature as the mineral cuprite. It is produced on a large scale by the reduction of mixed copper oxide ores with copper metal or by the electrolysis of an aqueous solution of sodium chloride using copper electrodes. The pure compound is insoluble in water but soluble in hydrochloric acid or ammonia. Cuprous oxide is used principally as a red pigment for antifouling paints, glasses, porcelain glazes, and ceramics and as a seed or crop fungicide. Cuprous sulfide is insoluble in water but soluble in ammonium hydroxide and nitric acid. Its applications include use in solar cells, luminous paints, electrodes, and certain varieties of solid lubricants. Cupric sulfate is a salt formed by treating cupric oxide with sulfuric acid. Cupric sulfate is utilized chiefly for agricultural purposes, as a pesticide, germicide, feed additive, and soil additive. Among its minor uses are as a raw material in the preparation of other copper compounds, as a reagent in analytic chemistry, as an electrolyte for batteries and electroplating baths, and in medicine as a locally applied fungicide, bactericide, and astringent.

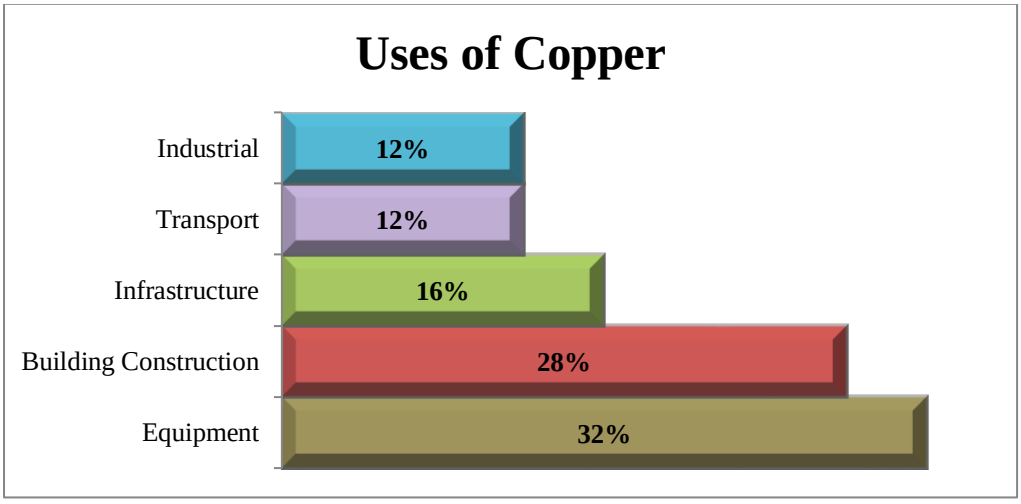
There is a presence of fifteen other precious metals with copper, including lithium, sodium, magnesium, aluminum, silicon, potassium, calcium, manganese, titanium, iron, copper, zinc, silver, strontium, and barium. Some techniques like CF-LIBS and LA-TOF-MS can successfully be used for copper ore analysis.

Most copper is used in electrical equipment such as wiring and motors. This is because it conducts both heat and electricity very well and can be drawn into wires. It also has uses in construction (for example, roofing and plumbing), and industrial machinery (such as heat exchangers). Copper sulfate is used widely as an agricultural poison and as an algicide in water purification. Copper compounds, such as Fehling's solution, are used in chemical tests for sugar detection.

The volcanic and igneous intrusions along the suture zones, the Karakoram block, the Magmatic arcs, and the ophiolitic thrust belts host the copper mineralization in Pakistan. Recent and previous works in Pakistan relied on traditional techniques, and advances in investigation and excavation have been underutilized. Whereas more sophisticated geophysical and geochemical techniques are now employed extensively for copper exploration. For copper excavation, more recent and sophisticated mechanisms should be adopted rather than relying solely on open-pit mining. It is, therefore, suggested that detailed and composite geophysical, geochemical, and geological work should be carried out in the districts known for copper mineralization.

Geophysical approaches such as electromagnetism (EM), induced polarization (IP), and electric resistivity (ER) surveys can provide better signatures for copper deposits in the subsurface. These exploration techniques can define the subsurface extension well due to the copper's high conductivity, good charge ability, and association with sulfide. The integration of gravity data with borehole data and earlier or recent remote sensing data can also lead to better exploration and tonnage[3].

2.1 Uses of Copper



Source: The World Copper Factbook 2021

[3] Ibid

2.2 Alloys of Copper

There are around 570 copper alloys, each with a unique combination of properties to suit many applications, manufacturing processes, and environments.

1- Brass is formed by the combination of copper and zinc.
2- Bronze is formed by combining copper and tin.
3- Cupronickel is formed by combining copper and nickel.
4- Aluminum Bronze is formed by combining copper and aluminum.
5- Arsenical Copper is formed by combining copper and arsenic.
6- Copper Tungsten is formed by combining copper and arsenic.
7- Gunmetal is composed of copper, tin, and zinc.

2.3 Copper Reuse and Recycling

Copper recycling plays an important role in copper availability since today's primary copper is tomorrow's recycled material. The recovery and recycling of copper also help to satisfy increasing demand and to build a sustainable future for future generations. Over the last decade, recycled copper supplied more than 30% of global copper demand. Future innovative policies and technologies should continue to contribute to resource efficiency in mining "primary" copper and recycling "secondary" copper.

1- Copper is 100 percent recyclable without loss of quality.
2- Copper is the most recycled metal after iron and aluminum.
3- Around 40 percent of the demand for copper within Europe is supplied from recycled copper.
4- Recycling a ton of copper uses 20% of the energy that would be used to mine and extract the same copper.
5- The copper recycling process has much in common with that used to extract it, but requires fewer steps. High-purity copper is melted in a furnace and then reduced; low-purity copper is refined through electroplating in sulfuric acid.

2.4 Copper Production Process

Stage 1: Crushing and Grinding: The purpose of crushing and grinding is to reduce the size of the potential ore particles to a size where there is sufficient REE (Rare Earth Elements) mineral liberation and the size distribution is suitable for the chosen downstream mineral recovery process.

Stage 2: Froth Flotation: Froth flotation is a process for selectively separating hydrophobic materials from hydrophilic ones.

Stage 3: Roasting: Roasting is selective sulfation of copper and cobalt, while ferrous minerals and components are oxidized to hematite. The sulfates are dissolved in the leaching stage.

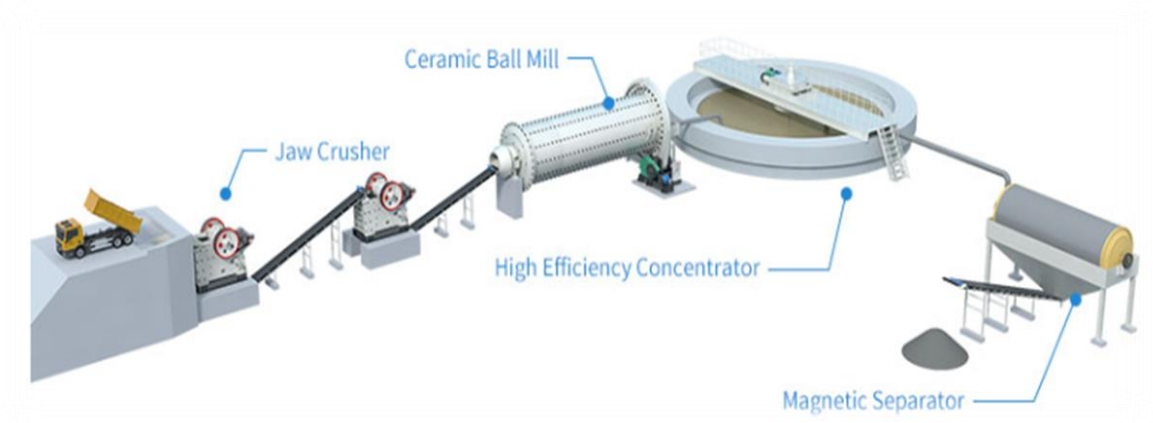
Stage 4: Smelting with Fluxes: Flux, in metallurgy, is any substance introduced in the smelting of ores to promote fluidity and remove objectionable impurities in the form of slag. In the

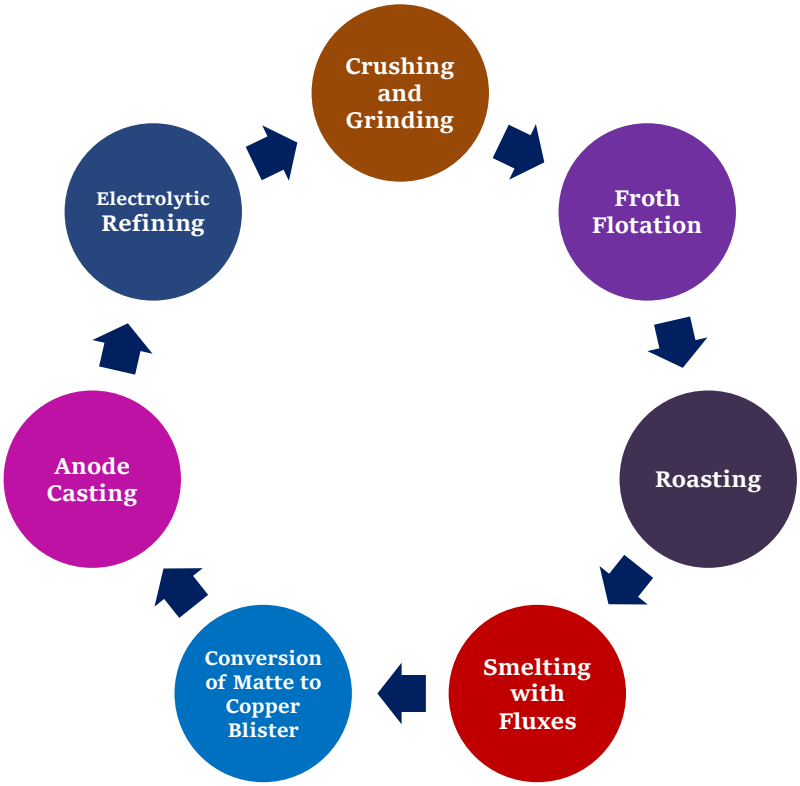
smelting process, either hot calcine from the roaster or raw unroasted concentrate is melted with siliceous flux in a smelting furnace to produce copper matte. The required heat comes from partial oxidation of the sulfide charge and from burning external fuel.

Stage 5: Conversion of Matte to Copper Blister: Partly purified copper with a blistered surface formed during smelting.

Stage 6: Anode Casting: The anode is made from impure copper.

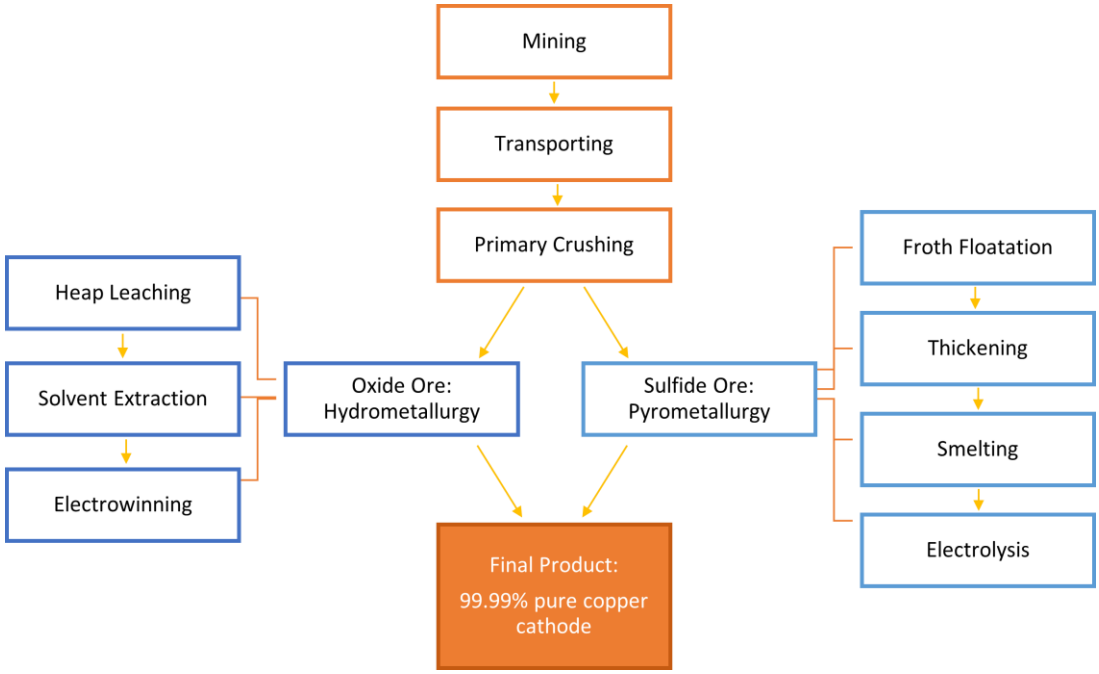
Stage 7: Electrolytic Refining: Electrolytic refining is a process of refining a metal (mainly copper) by the process of electrolysis.





Copper processing is a complicated process that begins with the mining of the ore (less than 1% copper) and ends with sheets of 99.99% pure copper called cathodes, which will ultimately be made into products for everyday use. The most common types of ore, copper oxide, and copper sulfide, undergo two different processes, hydrometallurgy and pyrometallurgy, respectively, due to the different chemistries of the ore. Copper oxides are more abundant near the surface, but are considered low-grade ore with a lower concentration of copper. Although this requires more ore to be extracted and processed, this process is less expensive, so oxides can still be mined at a profit.

Flow Chart: Copper Processing



Copper extraction techniques refer to the methods for obtaining copper from its ores. This conversion consists of a series of chemical, physical, and electrochemical processes. Methods have evolved and vary from country to country depending on the ore source, local environmental regulations, and other factors.

As in all mining operations, the ore must usually be beneficiated (concentrated). To do this, the ore is crushed, and then it must be roasted to convert sulfides to oxides, which are smelted to produce matte. Finally, it undergoes various refining processes, the final one being electrolysis. For economic and environmental reasons, many of the byproducts of extraction are reclaimed. Sulfur dioxide gas, for example, is captured and turned into sulfuric acid, which is then used in the extraction process.

Most copper ores contain only a small percentage of copper metal bound up within valuable ore minerals, with the remainder of the ore being unwanted rock or gangue minerals, typically

silicate minerals or oxide minerals, for which there is often no value. The average grade of copper ores in the 21st century is below 0.6% copper, with a proportion of economic ore minerals (including copper) being less than 2% of the total volume of the ore rock. A key objective in the metallurgical treatment of any ore is the separation of ore minerals from gangue minerals within the rock.

The first stage of any process within a metallurgical treatment circuit is accurate grinding or comminution, where the rock is crushed to produce small particles (<100 μm) consisting of individual mineral phases. These particles are then separated to remove gangue, followed by a process of physical liberation of the ore minerals from the rock. The process of liberation of copper ores depends upon whether they are oxide or sulfide ores.

Subsequent steps depend on the nature of the ore containing the copper. For oxide ores, a hydrometallurgical liberation process is normally undertaken, which uses the soluble nature of the ore minerals to the advantage of the metallurgical treatment plant. For sulfide ores, both secondary (supergene) and primary (un-weathered), froth flotation is used to physically separate ore from gangue. For special native copper-bearing ore bodies or sections of ore bodies rich in supergene native copper, this mineral can be recovered by a simple gravity circuit.

2.5 Application

Copper concentrate is the first commercial product of the copper production line and is composed of approximately equal parts of copper, iron, and sulfide. Concentrates are the raw material for all copper smelters, which by processing obtain an impure form of metallic copper, anode, or blister copper, which is later used to produce high purity, refined copper. The production of concentrates implies the crushing and later milling of the ore down to a particle size, allowing the release of copper by flotation. The concentrates from different regions have approximately 24% up to 36% of copper. Copper concentrates are then submitted to a final filtration and drying process to decrease the humidity to 8–9 percent.

Copper, and to a lesser extent, byproducts such as molybdenum, sulfuric acid, and precious metals that come with copper in the ore, go through various stages and degrees of refinement.

1- Crushing and mining
2- Grinding
3- Concentrating
4- Leaching or smelting.
5- SX/EW or Electro Refining

Copper is processed in several stages, from extraction and crushing of the ore to electrolytic refining, which allows the obtaining of 99.99% pure copper cathodes. All copper is mined by digging or blasting sulfide and oxide ores, which are then crushed into walnut-sized pieces. Crushed ore is a ball or rod milled in large, rotating, cylindrical machines until it becomes a

powder with less than 1% copper content. Sulfide ores are moved to a concentrating stage, while oxide ores are routed to leaching tanks.

The copper concentrate, whose main components are copper, iron, and sulfide, is the first commercial copper product in an increasing chain of added value. During the same processing stage, molybdenum bi-sulfide is obtained, which is then processed to attain the commercial form of molybdenum trioxide. Minerals are concentrated into a slurry that is about 15% copper. Waste slag is removed. The water is recycled. Tailings (left-over earth) containing copper oxide are routed to leaching tanks or are returned to the surrounding terrain. Once the copper has been concentrated, it can be turned into pure copper cathode in two different ways:

1- Electro-Winning and Leaching
2- Electrolytic Refining and Smelting

Copper concentrate is smelted and converted to metallic copper, which allows it to attain forms that can be submitted for further refining, more than 99% pure, as in copper anode and copper blister. The main application of copper anode is to use it as raw material in the process of electrolytic refining to produce the electrolytic refined cathode, purity of 99.99 percent.

Leaching & Electro-Winning Methods

Leaching

Oxide ore and tailings are leached by a weak acid solution, producing a weak copper sulfate solution.

SX/EW (Electro-Winning)

The copper-laden solution is treated and transferred to an electrolytic process tank. When electrically charged, pure copper ions migrate directly from the solution to starter cathodes made from pure copper foil. Precious metals can be extracted from the solution.

The Smelting & Electrolytic Refining Method

Smelting

Several stages of melting and purifying the copper content result, successively, in matte, blister, and, finally, 99% pure copper. Recycled copper begins its journey to finding another use by being re-smelted.

Electrolytic Refining

Anodes cast from the nearly pure copper is immersed in an acid bath. Pure copper ions migrate electrolytically from the anodes to "starter sheets" made from pure copper foil or steel where they deposit and build up into a refined copper cathode. During this process, gold, silver, and platinum may be recovered from the used electrolytic bath.

After the smelting and conversion process, through a treatment of metallurgical gas generation that gives rise to other by-products are sulfuric acid and anodic slimes which are rich in silver and gold[4].

2.6 Top 20 global Copper Smelters by Capacity- 2021

(Thousand metric tons of copper)

Rank	Smelter	Country	Operator/Owner(s)	Process	Capacity
1	Guixi (smelter)	China	Jiangxi Copper Corp.	Outokumpu Flash	600
2	Birla Copper (Dahej)	India	Birla Group (Hidalco)	Outokumpu Flash, Ausmelt, Mitsubishi Continuous	500
3	Chuquicamata (smelter)	Chile	Codelco	Outokumpu/ Teniente Converter	450
3	Jinchuan (Fangchenggang smelter)	China	Jinchuan Non-Ferrous Metal Co.	Flash smelter	450
3	Hamburg	Germany	Aurubis	Outokumpu, Contimelt, Electric	450
3	Besshi/ Ehime (Toyo)	Japan	Sumitomo Metal Mining Co. Ltd.	Outokumpu Flash	450
3	Saganoseki/ Ooita (smelter)	Japan	JX Nippon Mining & Metals Co., Ltd.	Outokumpu Flash	450
8	El Teniente (Caletones)	Chile	Codelco	Reverberatory/ Teniente Conv.	400
8	Chifeng	China	Chifeng Jinfeng (Yunnan Copper 45%, Taisheng 45%, Jinfeng Copper 10%)	Side-Blown	400
8	Chinalco Southeast Copper (smelter)	China	Chinalco	Flash Smelter	400
8	Jinguan (smelter)	China	Tongling Non-Ferrous Metals Group	Flash Smelter	400
8	Xiangguang copper (smelter)	China	Yanggu Xiangguang Copper Co	Outokumpu Flash	400
8	Sterlite Smelter (Tuticorin)	India	Vedanta	Isasmelt Process	400
8	Norilsk (Nikelevy, Medny)	Russia	Norilsk Nickel	Reverb, Electric, Vanyukov	400
15	Pirdop (smelter)	Bulgaria	Aurubis (99.77%)	Outokumpu Flash	360
15	Ilo Smelter	Peru	Southern Copper Corp (Grupo Mexico 88.9%, international investment community 11.1%)	Isasmelt Process	360
17	Onahama/ Fukushima	Japan	Mitsubishi Materials Corp. (55.714%), Dowa Metals & Mining Co. Ltd.(31.621%), Furukawa Metals & Resources Co. Ltd. (12.665%)	Mitsubishi/ Reverb.	354
18	Heding Copper	China	Jiangxi Copper Corp. (Zhejiang Jiangtong Fuye Heding Copper Co., Ltd.)	Side-Blown	350
18	Jinlong (Tongdu)	China	Tongling Nonferrous Metals Corp. (57.4%), Sumitomo (35%), Pingguo Aluminium Co.	Flash Smelter	350
18	Sarchesmeh Copper Complex (smelter)	Iran	National Iranian Copper Industry Co.	Flash Smelter	350

Source: ICSG Directory of Copper Mines and Plants – March 2021 Edition

[4]Center SR. Available from: https://superfund.arizona.edu/resources/learning-modules-english/copper-mining-and-processing/processing-copper-ores.

2.7 Top 20 global Copper Refineries by Capacity- 2021

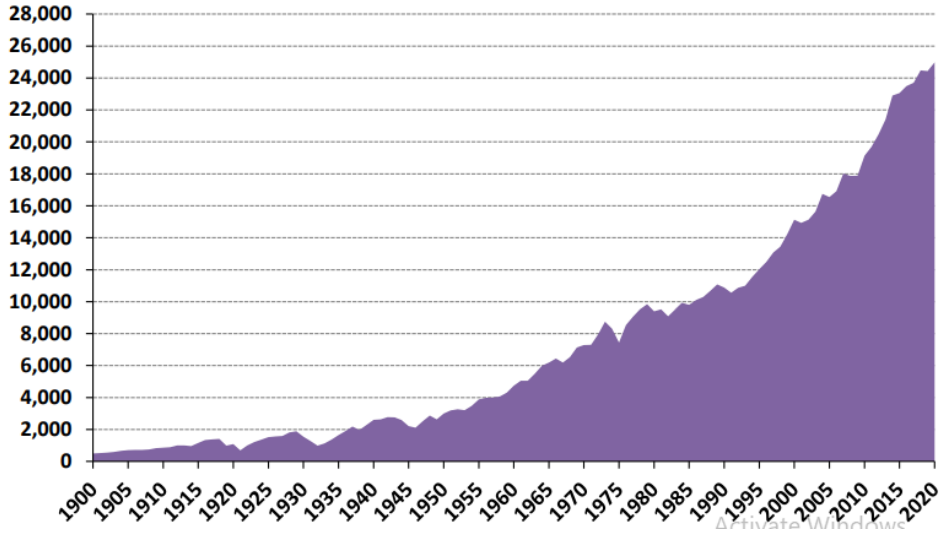
(Thousand metric tons of copper)

Rank	Refinery	Country	Owner(s)	Process	Capacity
1	Guixi	China	Jiangxi Copper Corporation	Electrolytic	1100
2	Shandong Fangyuan	China	Dongying, Shandong	Electrolytic	700
3	Daye/ Hubei (refinery)	China	Daye Non-Ferrous Metals Co.	Electrolytic	600
3	Jinchuan	China	Jinchuan Non Ferrous Co.	Electrolytic	600
5	Yunnan Copper	China	Yunnan Copper Industry Group (64.8%)	Electrolytic	500
5	Birla	India	Birla Group (Hidalco)	Electrolytic	500
7	Sterlite Refinery	India	Vedanta	Electrolytic	460
7	Pyshma Refinery	Russia	UMMC (Urals Mining & Metallurgical Co.)	Electrolytic	460
9	Jinchuan (Fangchenggang	China	Jinchuan Non-Ferrous Metal Co.	Electrolytic	450
9	Toyo/Niihama (Besshi)	Japan	Sumitomo Metal Mining Co. Ltd.	Electrolytic	450
9	Amarillo	United States	Grupo Mexico	Electrolytic	450
9	Chuquicamata Refinery	Chile	Codelco	Electrolytic	450
13	Onsan Refinery I	Korean Republic	LS-Nikko Co. (LS, Nippon Mining)	Electrolytic	440
14	Hamburg (refinery)	Germany	Aurubis	Electrolytic	416
15	El Paso (refinery)	United States	Freeport-McMoRan Copper & Gold Inc.	Electrolytic	415
16	Las Ventanas	Chile	Codelco	Electrolytic	410
17	Baiyin	China	Baiyin Nonferrous Metals	Electrolytic	400
17	Jinguan (refinery)	China	Tongling Non-Ferrous Metals Group	Electrolytic	400
17	Jinlong (Tongdu) (refinery)	China	Tongling NonFerrous Metal Corp. 52 %, Sharpline	Electrolytic	400
17	Zijin	China	Zijin Mining Company 50%, Minxi Xinghang 50%	Electrolytic	400

Source: ICSG Directory of Copper Mines and Plants – March 2021 Edition

2.8 World Refined Copper Usage, 1900-2020

(Thousand metric tons of copper)



2.9 Current Developments-Reko Diq

Reko Diq is a large copper and gold deposit containing 12.3 million tons of copper and 20.9 million ounces of gold in inferred and indicated resources. Reko Diq is one of the largest undeveloped copper and gold deposits globally, capable of producing 200,000 tons of copper and 250,000 ounces of gold a year for more than half a century.

In a significant development, the government of Pakistan awarded the development contract of the Reko Diq project to a Canadian company, "Barrick Gold", while its penalty of $11 billion, imposed on Pakistan by the World Bank tribunal, has been waived. The company is expected to invest several billion dollars in one of the world's largest gold and copper deposit holding mines in Baluchistan province. The project was suspended in 2011 because of a dispute over the legality of its licensing process. Barrick will be the operator of the project, which will be offered a mining lease, an exploration license, surface rights, and a mineral deal, stabilizing the fiscal regime applicable to the project for a specified period.

As per the terms of the new agreement, the Reko Diq project will be revived and developed by Barrick Gold in partnership with Pakistani entities. Barrick Gold will own 50% of the new project company. Pakistan will own the remaining 50%, which will be divided equally between the federal government and the provincial government of Baluchistan.

The federal government's 25 percent shareholding shall be divided equally among three state-owned entities (SOEs) of the federal government, namely Oil & Gas Development Corporation Limited (OGDCL), Pakistan Petroleum Limited (PPL), and Government Holdings Pakistan Limited (GHPL). Baluchistan's share shall be held by a company wholly-owned and controlled by the government of Baluchistan. In developing the project, nearly USD 10 billion shall be invested in Baluchistan, including USD 1 billion that shall be invested in social uplift projects such as roads, schools, hospitals, and the creation of technical training institutes for mining. The investment will create over 8,000 new jobs. The Reko Diq project will be one of the largest copper and gold mining projects in the world. To ensure optimal utilization of the nation's mineral wealth, the government is also considering setting up a smelter (smelting is a form of extractive metallurgy) to produce a metal from its ore. Smelting uses heat and a chemical reducing agent to decompose the ore, driving off other elements such as gases or slag and leaving just the metal behind. The reducing agent is commonly a source of carbon, such as coke, charcoal, or coal.

2.10 Pakistan vs. Iran-Copper

Iran started developing its copper mine at Sarchashmeh (Kerman province) around the same time as RDC was formed in the 1970s. Iran managed to continue the project. Today, a completely integrated project runs with copper cathode production exceeding 200,000 tons per year. An investment has been recouped several times. Iran's Sarchashmeh deposit is richer than Reko Diq in terms of copper percentage, at 0.70% as compared to Reko Diq's 0.41%. Iran's good experience and our bad experience tell us that one should not be overzealous in terms of value-added and downstream industry, jeopardizing the project itself.

Finally, investment occurs when the politics and economics of the resource permit. There are three streams of revenue that accrue to the host government in mining projects, including copper. It is time for the parties in Reko Diq to develop a framework for restarting the project. There is a need for improving access to mineral areas and improving the internal climate at local and provincial levels.

2.11 Initial Requirement for Mining

1- Geological survey ---------- Surface evaluation
2- Geophysical survey ---------- In-depth evaluation
3- Exploratory survey ---------- Sample testing

2.12 Testing Labs

1- Geo-science Advanced Research Laboratory is situated in Islamabad
2- Mineral Testing laboratory is situated in Peshawar
3- Quality testing lab is situated in Karachi
4- SGS Pakistan (International) in Karachi (Head office), all major cities

2.13 Mining Licensing

Exploration License

An exploration license gives the license holder exclusive rights to explore for specific minerals within the specified license area. No mining activities can be undertaken on an exploration license.

- The following information is required for applying for an exploration license:
- A map showing the boundaries of the application area (scale 1:100 000).
- The principal mineral(s) of interest
- Details of the work program for each year of the license

Prospecting License

Prospecting licenses allow prospectors and small-scale miners to explore or mine in an area of fewer than five hectares.

- They can be issued to individuals or corporations.
- The license provides the holder with the right to apply for a mining or retention license if they identify a mineral resource.
- Prospecting licenses are granted for up to seven years and are not renewable.

Mining License

A mining license gives the license holder the sole right to mine for specified minerals. The applicant needs to show identification of a mineral resource before applying for a mining license.

There is a need to include the following information:

- A map showing the license area, including private land and Crown land (scale of 1:25,000 or larger).
- A mineralization report with exploration results for the described mineral resource, including:3-
- Pre-feasibility studies showing profit potential were completed by a suitably qualified person.
- If there are no pre-feasibility studies, the applicant can prove a commitment to mining.
- Details of the work program for each year of the license

2.14 National Agencies

1- Directorate General of Mineral Development (DMD), Baluchistan
2- Directorate General of Mineral Development (DMD), KPK.
3- Irrigation Department, Government of Baluchistan.
4- National Disaster Management Authority Pakistan (NDMA).
5- Saindak Metal Ltd. (SML).
6- Askari Cement Limited.
7- Pakistan Space & Upper Atmosphere Research Commission (Suparco).[1]

2.15 Estimated Costs

Copper Ore processing plant	91,000 ---- 98,00,000 US$
Copper Ore Crushing plant	10,000 ---- 200,000 US$
Copper Ore Flotation plant	10,000 ---- 215,000 US$
Copper Sulphide Flotation Machine	2400 ---- 63000 US$
Small Scale copper ore processing plant, Jaw crusher, grinding mill, flotation	1000 ---- 3500 US$
Beneficiation (Concentrates) plant	Rs 3.2 Billion
Smelter	1-2.7 Billion US$

Chapter 3: Analysis

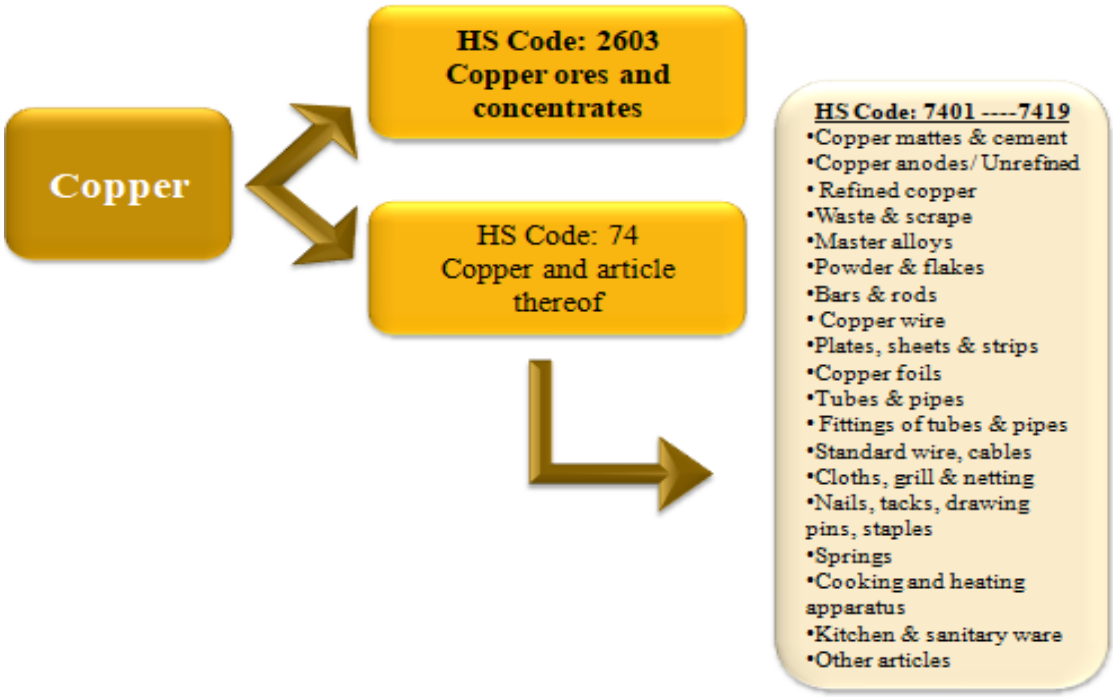
Copper sector is divided into two major sub categories.

(1) Copper ores and concentrates (raw copper as mineral) and,

(2) Copper articles including semi-finished, finished products, & waste and scrape.

In this analysis we focused on copper as mineral for this purpose, data of HS code 2603 from different data sources was used.

3.1 Flow Chart: Copper Sector



3.2 Global Overview

World Resources

A U.S. Geological Survey study of global copper deposits indicated that, as of 2015, identified resources contained 2.1 billion tons of copper, and undiscovered resources contained an estimated 3.5 billion tons.

World Mine and Refinery Production and Reserves

Reserves for multiple countries were revised based on company and (or) Government information.

Table 1: Global Reserves and Production

Countries	Mine Production		Refinery Production		Reserves
	2020	2021	2020	2021	
Chile	5,730	5,600	2,330	2,200	200,000
Australia	885	900	427	450	93,000
Peru	2,150	2,200	324	350	77,000
Russia	810	820	1,040	920	62,000
Mexico	733	720	492	470	53,000
United States	1,200	1,200	918	1,000	48,000
Congo	1,600	1,800	1,350	1,500	31,000
Poland	393	390	560	590	31,000
China	1,720	1,800	10,000	10,000	26,000
Indonesia	505	810	269	270	24,000
Zambia	853	830	378	350	21,000
Kazakhstan	552	520	515	470	20,000
Canada	585	590	290	300	9,800
Germany	---	---	643	630	---
Japan	---	---	1,580	1,500	---
Korea	---	---	671	650	---
Other Countries	2,840	2,800	3,450	4,300	180,000
World Total	20,600	21,000	25,300	26,000	880,000

In thousands tons.

Source: U.S. Geological Survey, Mineral Commodity Summaries, 2022

Global copper reserves are estimated at 880 million tons, and annual copper demand is 28 million tons, while annual production, on average, is reported at 20 million tons. Chile has 23 percent of total global reserves, followed by Australia with 10 percent, Peru with 9 percent, Russia with 7 percent, Mexico with 6 percent, the United States of America with 5 percent, Congo with 3.5 percent, Poland with 3.5 percent, China with 3 percent, and the remaining 30 percent is distributed among other countries. Worldwide mine production of copper was reported in 2021 at 21 million tons, and refinery production was 26 million tons. China is the top refinery producer, with a capacity of 10 million tons of copper. Chile is the leading country in copper production with a production value of 5.6 million tons, more than a quarter of the global production. Other countries such as Peru, China, Congo, and the USA are the top producers of copper reported for the years 2020 and 2021.

By volume, Chile was the leading copper-producing country in 2021, with a production volume of 5,600 thousand tons. Apart from the COVID-19 imposed lockdowns, the country's production output in the past has been impacted by adverse environmental conditions, labor strikes, etc. However, with over 20 projects expected to commence between 2020 and 2024, of which seven are under construction, the country's production is expected to grow in the coming years. Peru is the world's second-largest copper-producing country, with a production volume of 2,200 thousand tons. The Peruvian copper market witnessed a major slump in production in 2020 due to operational disruption caused by COVID-19. However, most of the copper mining activities in the country resumed at the end of 2020, but reduced workforces and other restrictions have continued to hamper production levels in the subsequent quarters. The other top three countries include China, the Democratic Republic of Congo, and the United States of America, which cumulatively produced 13 million tons of copper in 2021.

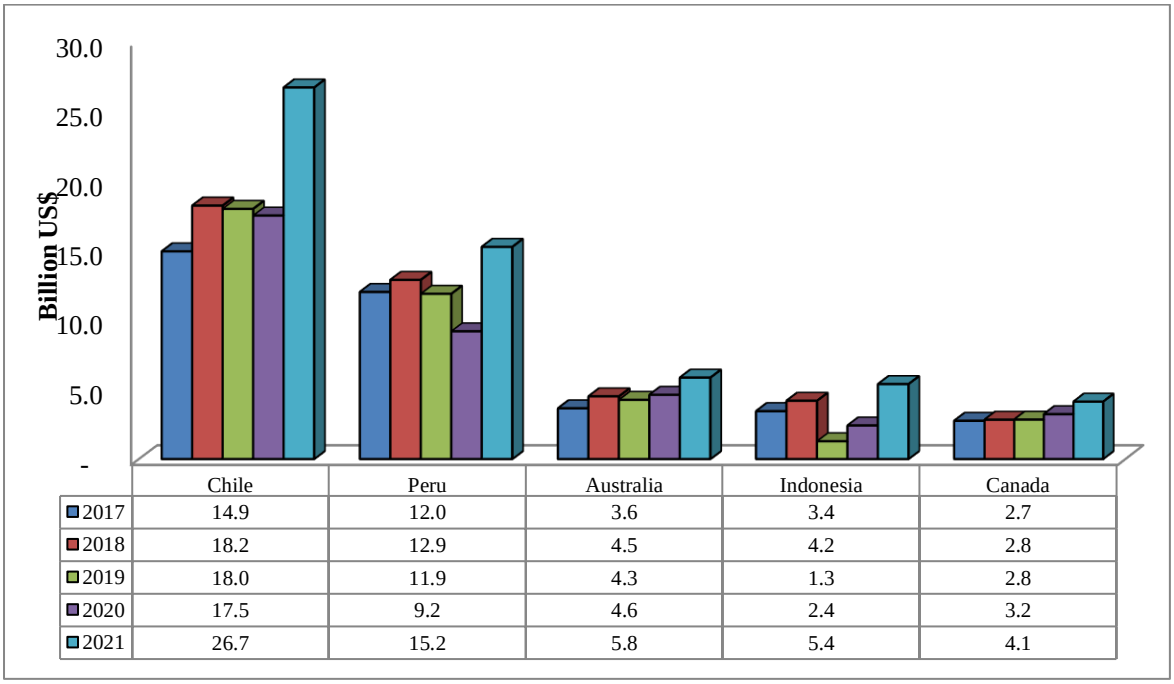
Table 2: Global Trade Scenario

HS Code	2603 (Copper Ores & Concentrates)				
Years	**2021**	**2020**	**2019**	**2018**	**2017**
Value (Billion US$)	88.6	58.2	58.8	63.2	55.4
Quantity (Million Tons)	37.4	35.4	37.7	37.3	34.8
Unit value (US$ Per Ton)	2,369	1,641	1,558	1,695	1,589
Top Global Exporters	Chile, Peru, Australia, Indonesia, & Canada				
CAGR(2017-21)	9.8%				
Top Global Importers	China, Japan, Korea, Germany, & Spain				

Source: ITC Trade Map.

In this table, copper ores and concentrates (HS code: 2603) global trade data for the last five years is shown. The CAGR (2017–21) for the product has reached 9.8%. The interesting fact is that the 33.2 billion US dollar change is due to an increase in prices rather than an increase in quantity exported, as the quantity of exported product remained roughly the same throughout the period, but the per ton cost increased dramatically, reaching 2,369 US dollars from 1,589 US dollars. This could be the cause of an increase in the demand for copper. The top exporters of copper ore and concentrates are Chile, Peru, Australia, Indonesia, and Canada, while the top importers are China, Japan, Korea, Germany, and Spain.

Figure 1: Top Exporter Countries

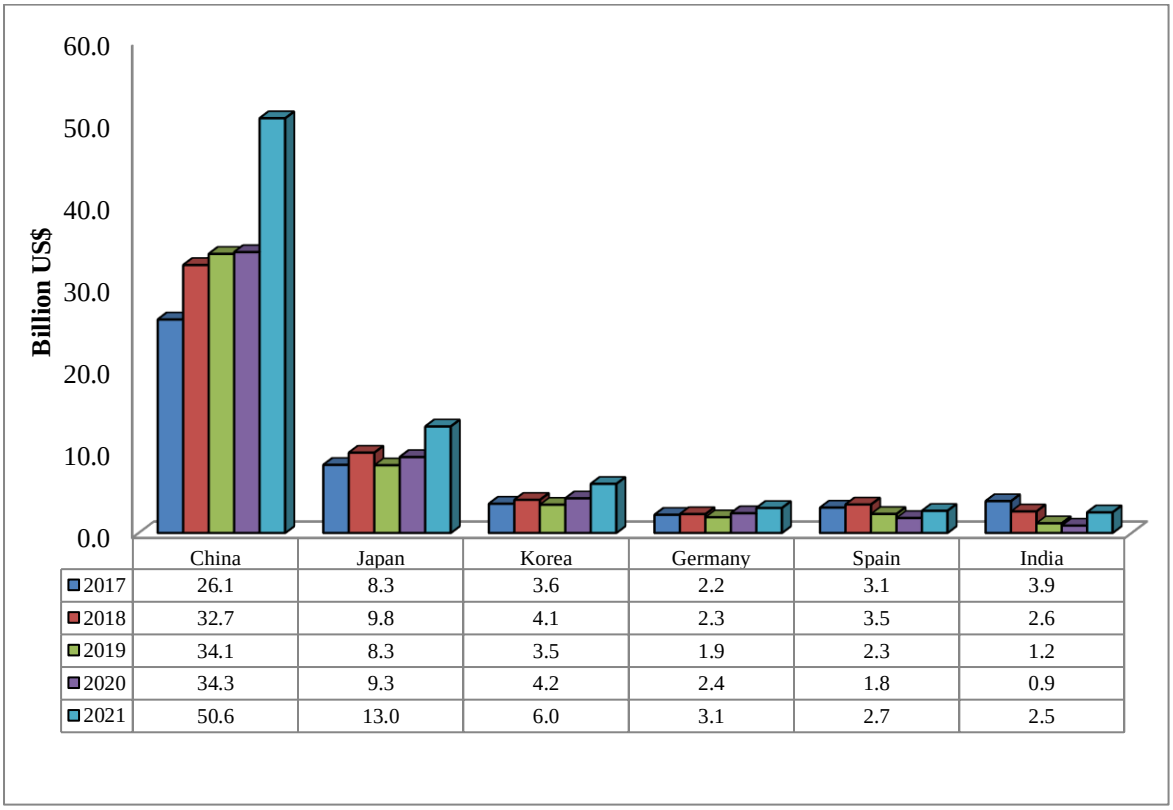


	Chile	Peru	Australia	Indonesia	Canada
2017	14.9	12.0	3.6	3.4	2.7
2018	18.2	12.9	4.5	4.2	2.8
2019	18.0	11.9	4.3	1.3	2.8
2020	17.5	9.2	4.6	2.4	3.2
2021	26.7	15.2	5.8	5.4	4.1

Source: ITC Trade Map.

Global exports of copper ores and concentrates (HS code: 2603) for the period of 2017–2021 are presented. The global trade volume of copper ores and concentrates for the year 2021 was 88 billion US dollars, with an annual growth rate of 9% and a quantity of 37 million metric tons of copper ores and concentrates exported at a cost of 2,369 US dollars per ton. Chile is the top exporter of copper ores and concentrates, with a value of 26.7 billion US dollars exported; Peru, with a value of 15.2 billion US dollars exported; and Australia, with a value of 5.8 billion US dollars exported. All exporter countries increased their trade volume throughout the period, particularly Chile, which increased its export value by more than $9 billion US dollars over the previous year.

Figure 2: Top Importer Countries



	China	Japan	Korea	Germany	Spain	India
2017	26.1	8.3	3.6	2.2	3.1	3.9
2018	32.7	9.8	4.1	2.3	3.5	2.6
2019	34.1	8.3	3.5	1.9	2.3	1.2
2020	34.3	9.3	4.2	2.4	1.8	0.9
2021	50.6	13.0	6.0	3.1	2.7	2.5

Source: ITC Trade Map.

Global imports of Copper ores and concentrates (HS code: 2603) for the period of 2017-2021 is presented. Top importers of Copper ores and concentrates ware China with imported value of 50.6 Billion US$, Japan 13 Billion US$ and Korea 6 Billion US$. All importers countries showed increase in the trade volume throughout the period specially China which has showed an increase of more than 16 billion US$ in its imported value when compared to the last year. China continues to import large quantities of concentrate to economically justify its high smelting capacity and supply its expansive industry and large population.

3.3 Local Overview

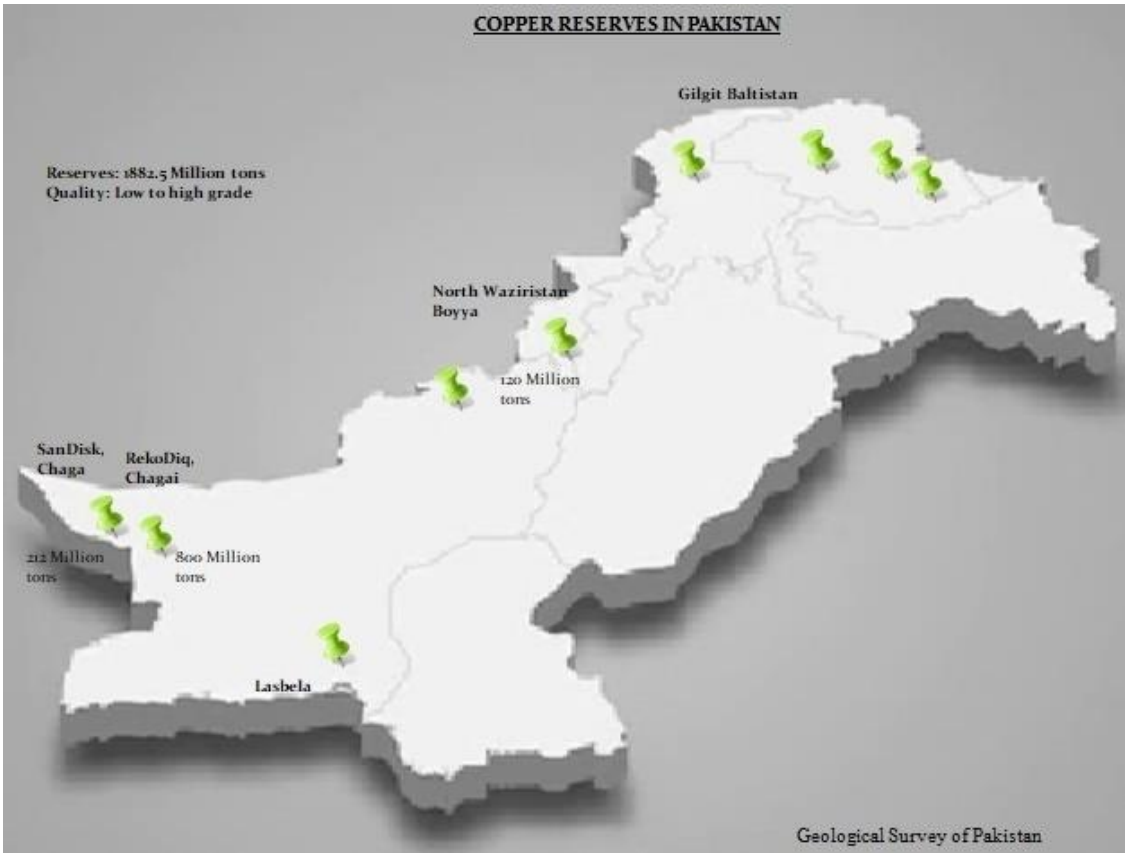


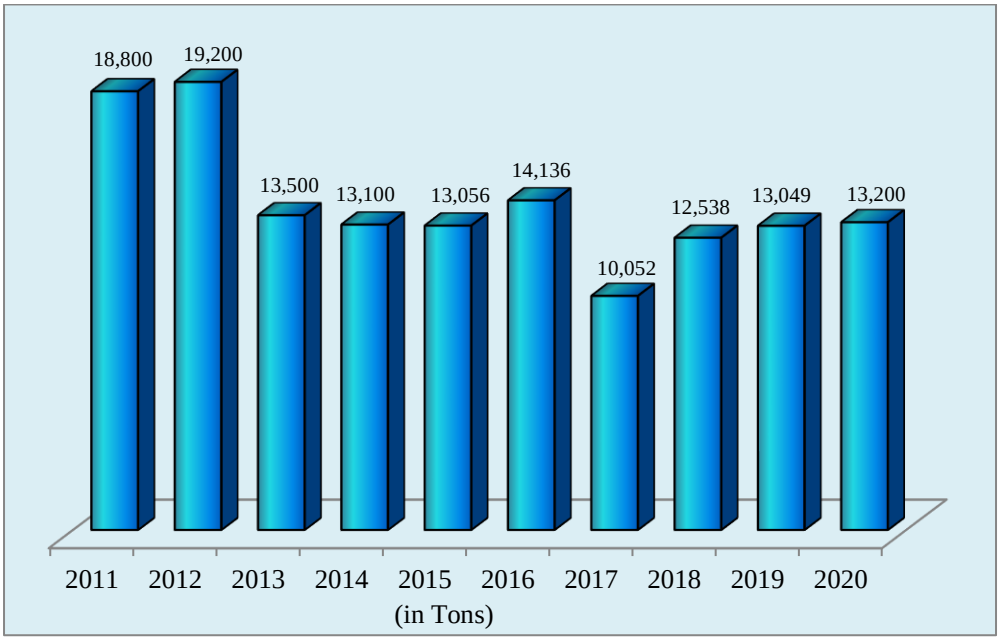
Table 3: Pakistan Trade Scenario

HS Code	2603 (Copper Ores & Concentrates)				
Trade:	**2021**	**2020**	**2019**	**2018**	**2017**
Export value	11.5 Million	6.18 Million	316,000	59,000	301,000
Quantity(Tons)	25,495	7,161	1,045	326	771
Unit value(US$/ Ton)	453	863	302	181	390
Pak Export to	China Cambodia:(2021Only): 17,000US$; 53 ton; 321 US$/Ton				
CAGR					
2017-2021	107%				
2020-2021	36%				
Pak Import from	None				

Source: ITC Trade Map.

In Table 3 Local trade overview has presented for Copper ores and concentrates (HS code: 2603) of last five years. CAGR (2017-21) for the product has reached to 107% and comparison on 2021 with 2020 showed CAGR 36%. In 2017 the exported value of the product was only 0.3 million US$ which now in year 2021 reached to 11.5 million US$. Reported quantity of the products increased from 771 tons to 25,495 tons while no major changes reported in the unit prices. Further compared with the international prices, Pakistan's exported cost is almost 500% time lower then international market price. China is remains the only importer country throughout the period. In 2021 Pakistan exported a small amount of copper ores and concentrates to Cambodia. Due to the unavailability of copper processing plants Pakistan not in the position of importing copper ores and concentrates.

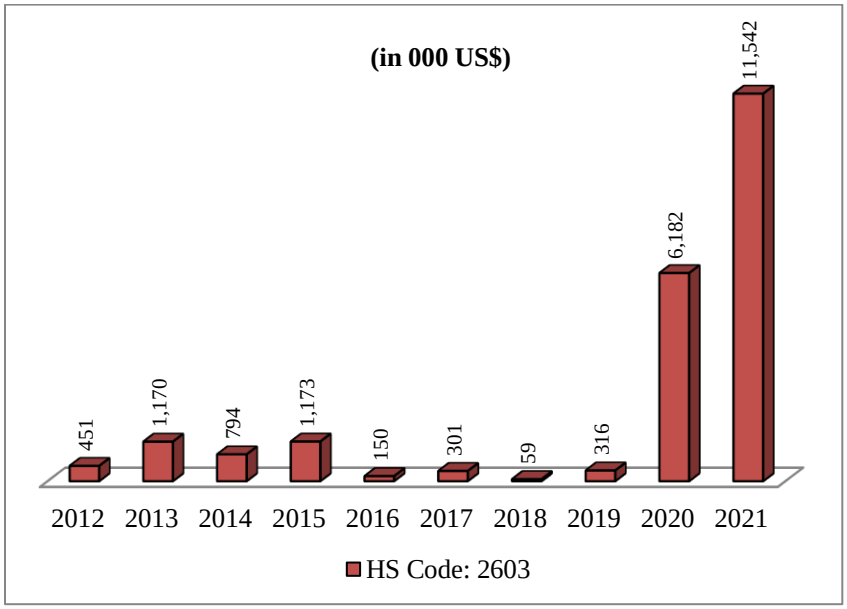
Figure 3: Raw Copper Production in Pakistan



Source: World Mining Data& World mineral Production 2016-20 (BGS)

Pakistan is not producing/extracting any promising amount of copper as last 10 years of data showed the trend of production which achieve the highest value of 19,200 tons in year 2012 after that year its declined and remain consistent throughout the duration the lowest value was reported in year 2017 where Pakistan extracted only 10,052 tons of copper ores. Currently Pakistan is extracting copper mainly from Saindak and North Waziristan (FATA). It is expected that in near future when Reko Diq copper mine will be operational Pakistan will produce 200,000 metric tons of Copper annually.

Figure 4: Copper Ores & Concentrates Exports- Pakistan



Source: ITC Trade Map.

Copper ores and concentrates exported pattern showed a drastic increase in last 2 years current year 2021 showed exported values of 11 million US$ which showed growth of 87% . Due to the unavailability of copper processing plant and other related facilities Pakistan in not in the copper importing countries list. Currently, Pakistan is only exporting copper ores and its first commercial product which is concentrates. Copper concentrates requires minimal value addition.

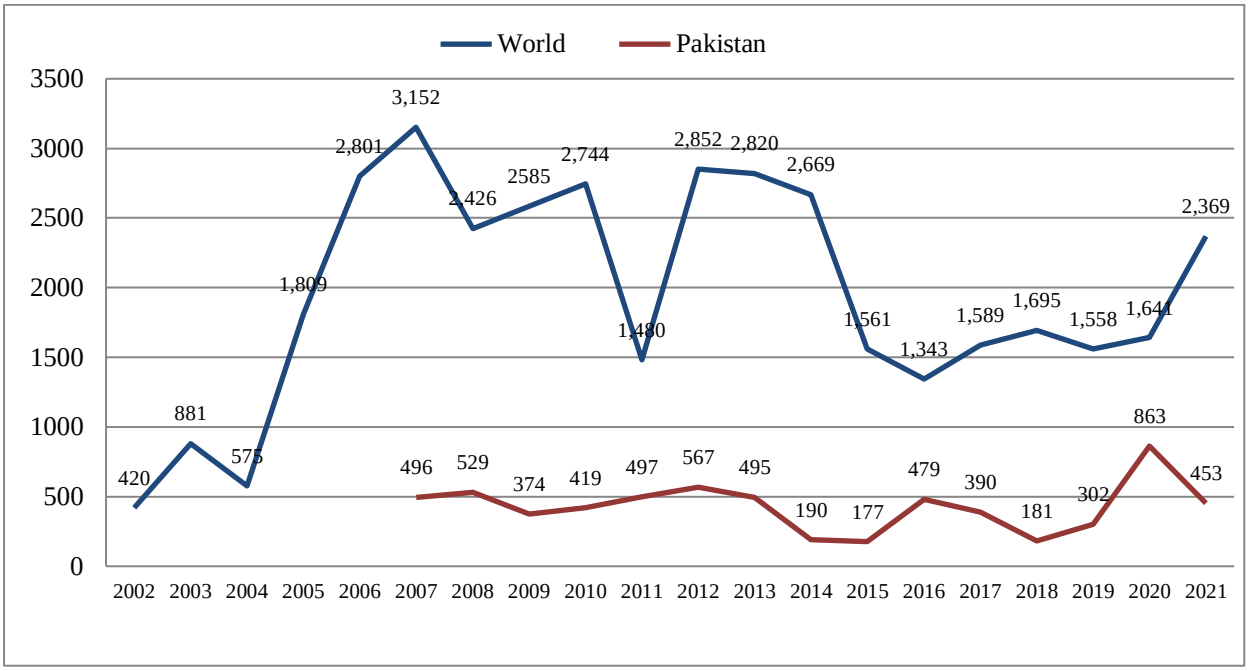
Table 4: Expoter List of year 2021

Exporters	Exported value (PKR)	Quantity (in Kg)
Degan Exploration Works (Pvt.) Limited	1,754,694,313	6,000,000
M/S BQ Impex	26,301,770	124,400
Universal Minerals Trading Company	21,838,673	300,010
Maraf International	19,890,123	88
Alliance Rendezvous	18,848,484	537,300
Four Season Exports	1,717,954	47,550
S.G Trading Corporation	1,112,085	48,620
Express Courier Link	1,729	5

Source: PRAL

3.4 Price Analysis

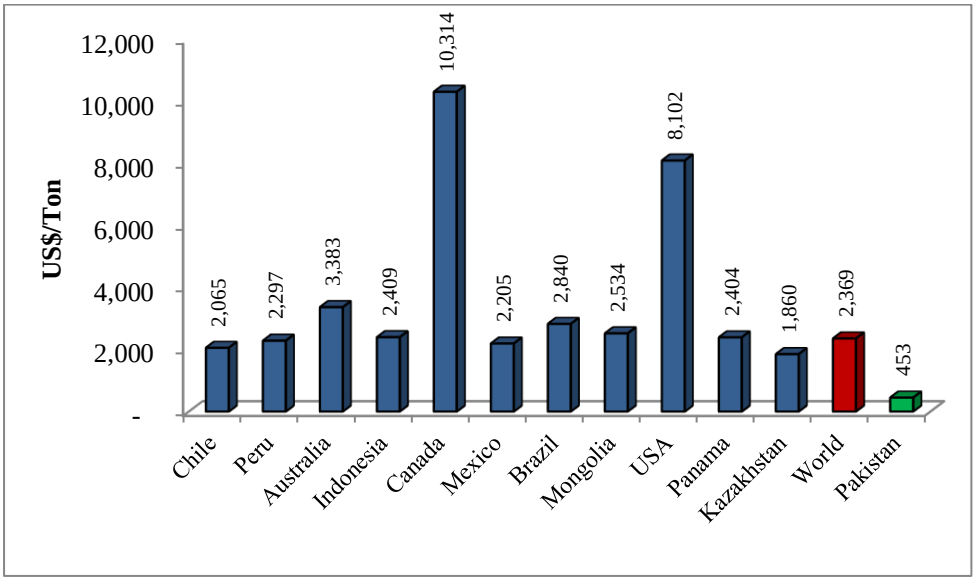
Figure 5: Price Comparison World versus Pakistan



Source: ITC Trade Map.

A price comparison showed that Pakistan's export per unit cost is incomparable with the world average cost. Pakistan is exporting its products at a very minimal cost. Furthermore, it was found that there had been no fluctuations reported during the past years. It is a matter of concern that Pakistan is managing its copper sector poorly. It can be a source of additional revenue to the export volume if we manage the pricing of the product and also explore new markets such as Japan, Korea, Germany, Canada, Spain, USA, India, etc.

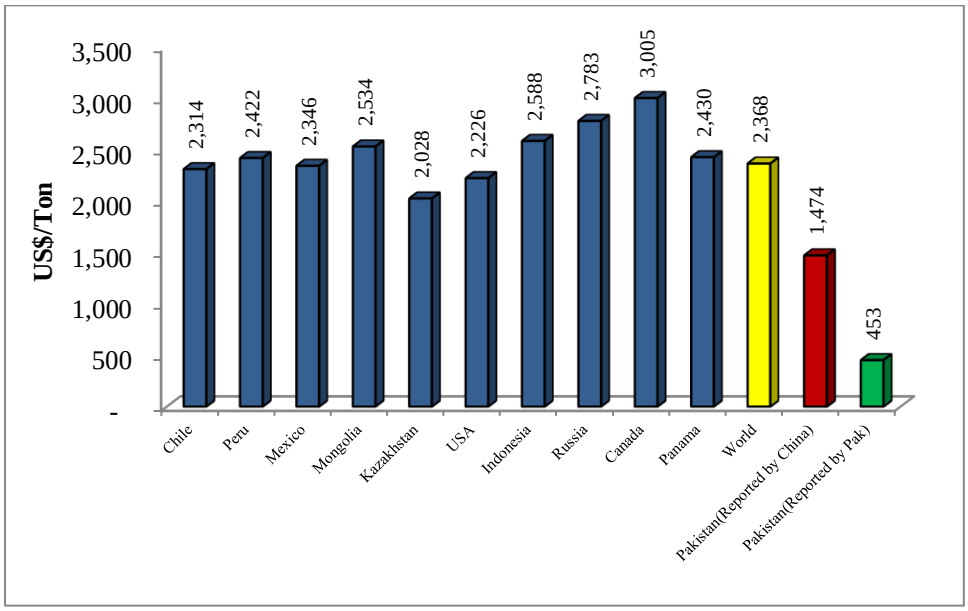
Figure 6: Unit Cost Analysis - 2021



Source: ITC Trade Map.

A comparison of Pakistan's exported unit costs with the top exporter countries unit values was made. Canada and the USA are exporting copper ores and concentrate at the highest cost, while other countries' export values were reported at between 1,860-3,383 US/Ton. Among the countries, Pakistan is exporting its products at the lowest cost at 453 US $/ton, which was reported at 863 US $/ton in the previous year.

Figure 7: Unit Cost analysis with respect to China



Source: ITC Trade Map.

Pakistan has the only importer of copper ores and concentrates, which is China. China pays only 453 US dollars per ton to Pakistan, whereas China pays between 2,028 and 3,005 US dollars per ton to other exporter countries such as Chile, Peru, and Mexico. India is exporting copper ores to China at 1,450 US dollar/Ton.

3.5 Misinvoicing

Table 4: Reporting Error China versus Pakistan

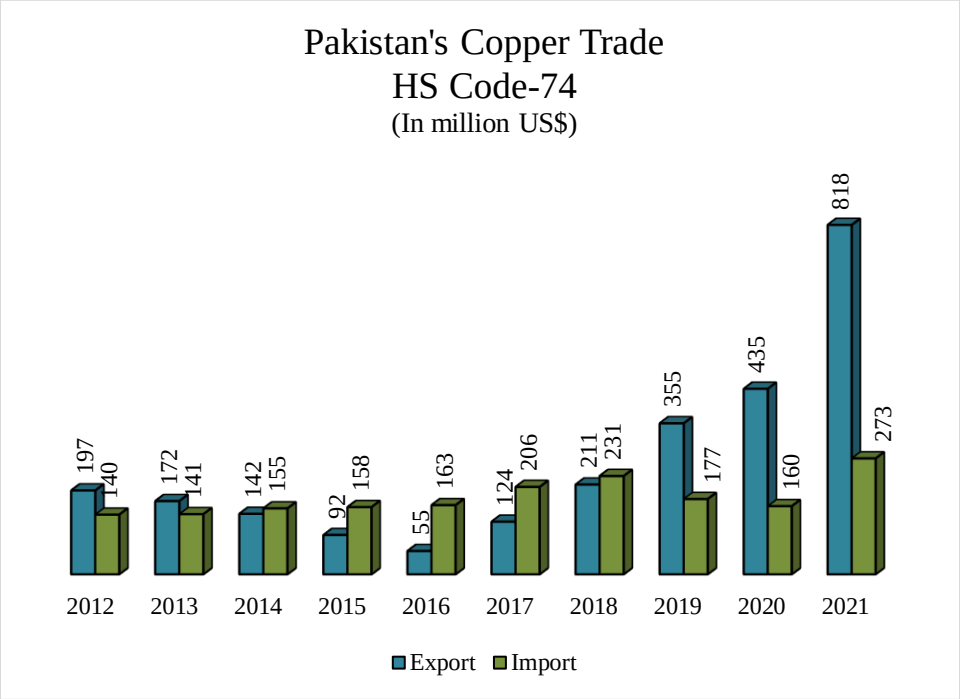
Years	Value(000US$)		Difference in reporting	Quantity		Difference in reporting	Per unit value		Difference in reporting
	Pakistan	China		Pakistan	China		Pakistan	China	
2017	259	305	-46	533	337	196	486	905	-419
2018	59	137	-78	326	420	-94	181	326	-145
2019	316	193	123	1,045	386	659	302	500	-198
2020	6,182	1,458	4724	7,161	1,677	5484	863	869	-6
2021	11,525	13,400	-1875	25,443	9,091	16352	453	1,474	-1021

Source: ITC Trade Map.

During the research it was explored that, there were major differences in data reporting from exporter and importer sides. As discussed earlier China is the major and only trading partner of Pakistan. Under reporting of trade values identified, while over reporting find out in trade quantities also unit cost showed vast differences especially in the recent year.

3.6 Copper Articles (HS code: 74)

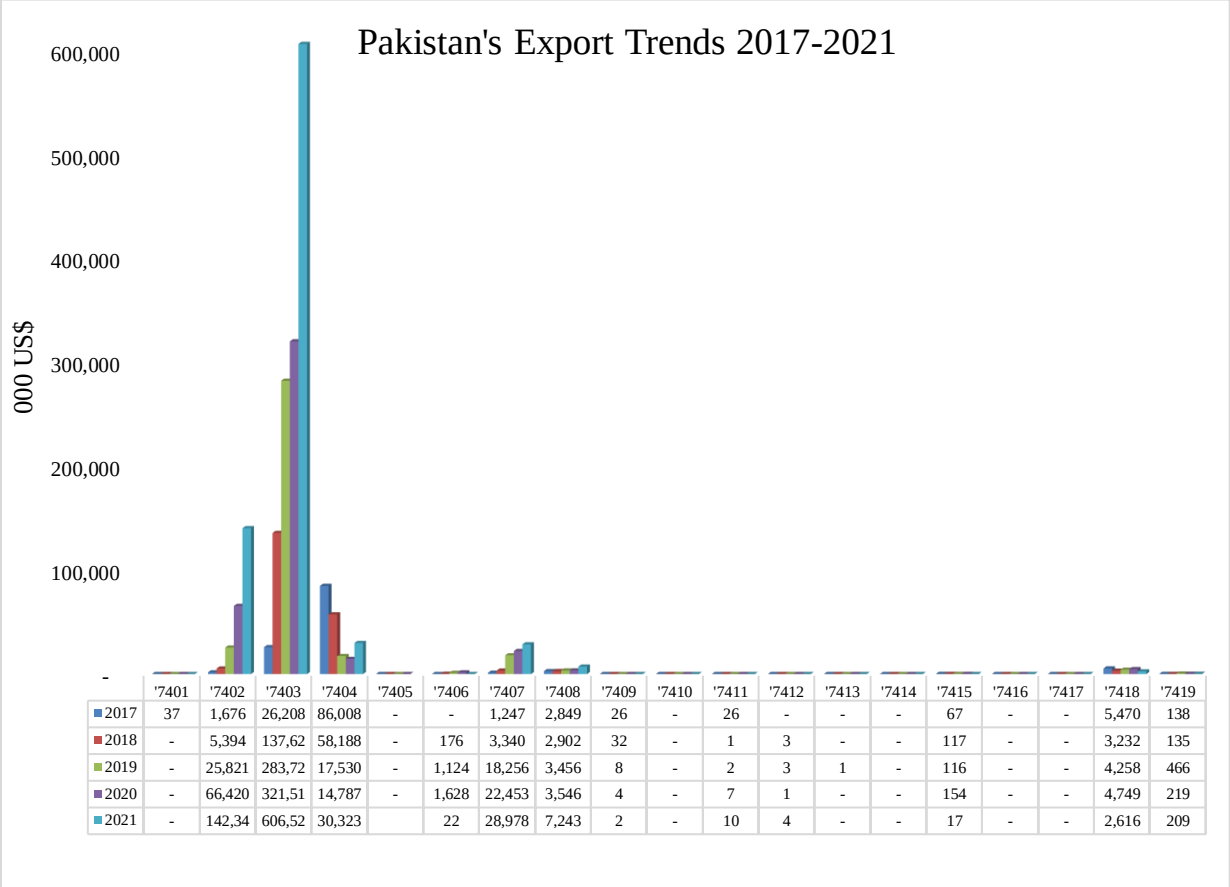
Figure 8: Pakistan's Copper Articles Trade Trends



Source: ITC Trade Map.

HS code 74 consists of copper products/articles. Pakistan's exports increasing drastically during past few years. Especially in last 5 year there is a high rise reported in the export value of copper articles. In year 2021 the exported value jumped to double from 435 Million US$ to 818 million US$, which is highly notable, while imports seems quite similar throughout the period but we can clearly see an increase of more than 100 million US$ in year 2021. China remains the top import destination for copper article in past years, other than china; UAE, Belgium, USA, Saudi Arabia, Hong Kong, Korea, Japan, Netherland and India are found in the list of top importer in recent years.

Figure 9: Overview of Copper Articles Exports in Pakistan



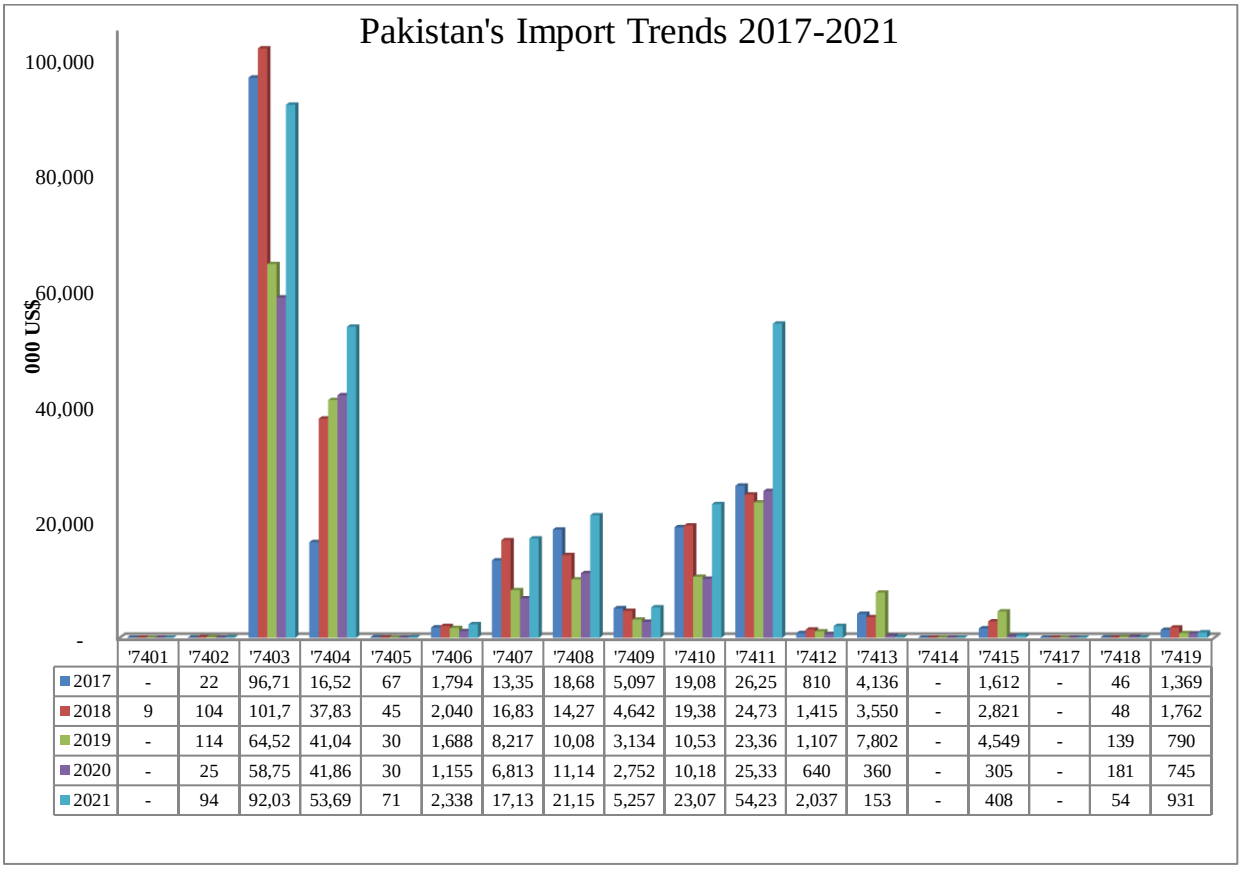
	'7401	'7402	'7403	'7404	'7405	'7406	'7407	'7408	'7409	'7410	'7411	'7412	'7413	'7414	'7415	'7416	'7417	'7418	'7419
2017	37	1,676	26,208	86,008	-	-	1,247	2,849	26	-	26	-	-	-	67	-	-	5,470	138
2018	-	5,394	137,62	58,188	-	176	3,340	2,902	32	-	1	3	-	-	117	-	-	3,232	135
2019	-	25,821	283,72	17,530	-	1,124	18,256	3,456	8	-	2	3	1	-	116	-	-	4,258	466
2020	-	66,420	321,51	14,787	-	1,628	22,453	3,546	4	-	7	1	-	-	154	-	-	4,749	219
2021	-	142,34	606,52	30,323		22	28,978	7,243	2	-	10	4	-	-	17	-	-	2,616	209

Data Source: ITC Trade map

Pakistan is mainly exporting the following copper products; refined, unrefined copper, waste and scrape, copper bar and rods, copper wire, copper household articles (table/kitchen/Sanitary/Part thereof). China remains the top exporter country for the maximum products including refined and unrefined copper, waste and scrape, bar and rods. For copper wires USA, UK and Chile are the top export destinations and household article were mainly exported to Saudi Arabia, Afghanistan, Kuwait, Bahrain and UAE.

Pakistan needs to diversify its export destination instead of solely depending on China for its exports. Pakistan should explore Europe, Middle East and CARs. Except that the other main problem is that Pakistan is exporting its product at very low cost which is not comparable with the international markets.

Figure 10: Overview of Copper Articles Imports in Pakistan



	'7401	'7402	'7403	'7404	'7405	'7406	'7407	'7408	'7409	'7410	'7411	'7412	'7413	'7414	'7415	'7417	'7418	'7419
2017	-	22	96,71	16,52	67	1,794	13,35	18,68	5,097	19,08	26,25	810	4,136	-	1,612	-	46	1,369
2018	9	104	101,7	37,83	45	2,040	16,83	14,27	4,642	19,38	24,73	1,415	3,550	-	2,821	-	48	1,762
2019	-	114	64,52	41,04	30	1,688	8,217	10,08	3,134	10,53	23,36	1,107	7,802	-	4,549	-	139	790
2020	-	25	58,75	41,86	30	1,155	6,813	11,14	2,752	10,18	25,33	640	360	-	305	-	181	745
2021	-	94	92,03	53,69	71	2,338	17,13	21,15	5,257	23,07	54,23	2,037	153	-	408	-	54	931

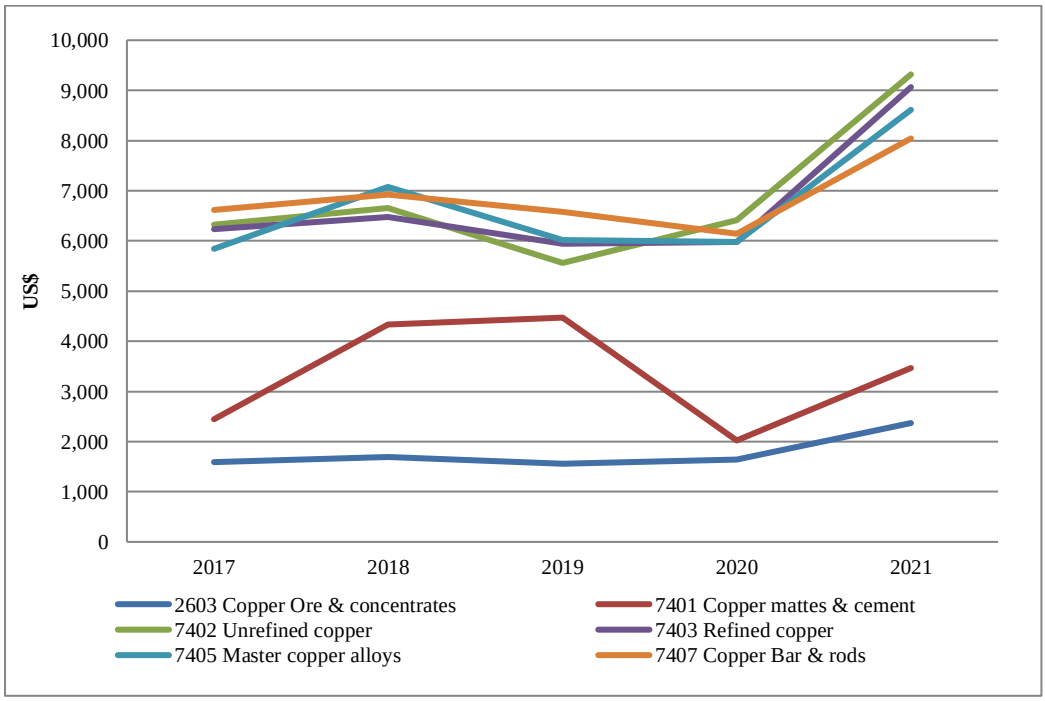
Data Source: ITC Trade map

Currently Pakistan is importing the following copper products; refined copper, waste and scrape, copper bar and rods, copper wire, copper foil, copper tubes and pipes. Pakistan is importing refined copper mainly from Zambia and China. Waste and scrape's imports reported from developed countries like USA, Belgium, Netherlands, and UK. Copper bars and rods mainly imported from Malaysia and Japan. UAE is the top exporter of copper wire followed by China. Copper foil usually imported from China, Turkey and Netherlands and copper tubes, pipes imported from China.

Table 5: Chapter 74 Product codes and labels

Code	Product label	Code	Product label
'7401	Copper mattes/cement	'7411	Tubes and pipes
'7402	Unrefined copper	'7412	Tube or pipe fittings
'7403	Refined copper	'7413	Stranded wire, cable
'7404	Waste and scrap	'7414	Cloth
'7405	"Master alloys	'7415	"Nails, tacks, drawing pins, staples etc
'7406	Powders and flakes	7416	Springs
'7407	Bars, rods	'7417	Cooking or heating apparatus
'7408	Copper wire	'7418	Table, kitchen or other household articles, sanitary ware
'7409	Plates, sheets and strip	'7419	Other articles of copper, n.e.s.
'7410	Copper foil		

Figure 11: Cost comparisons of value added products with raw copper



A cost comparison showed that value addition can play a significant role in increasing export volume instead of exporting copper ore and concentrates if Pakistan starts working on producing other value-added products like unrefined and refined copper, master alloys, copper bars, and rods. It is expected that in the near future, Pakistan's copper exports will increase by 10 times.

3.7 Tariff Phased by Pakistan

There are zero percent tariffs from all other countries except the following countries

Countries	Percentage of Tariff
Morocco	2.5
Ukraine	2
India	2.5
Brazil	2
Russia	2.3
Chile	6
Congo	5
Kazakhstan	2.3
Philippines	3
Uzbekistan	5

Chapter 4: Opportunities, Issues & Recommendations

4.1 Opportunities

1- The copper market is emerging once again towards green energy and electric vehicles (EVs).
2- Renewable energy requires four to six times more copper than fossil energy. The International Energy Agency (IEA) has projected that copper demand in the world would double in the coming two decades, i.e., by 2040.
3- Copper is the new oil as the exuberant voices reverberate. Its price and demand will double.
4- Current demand for copper lies around 28 million tons and supply is already short by 8 million tons, giving rise to higher prices.
5- The investor should also install the intermediate facilities of smelter and refinery to enable local processing by the downstream industry. Value addition and job creation are the cherished objectives of the government authorities.
6- Reko Diq, probably, has arrived at the right time and still continues to be in the right time frame due to the emergence of EVs and renewable energy like solar.

Already in 2021, copper prices reached their highest level in history at $10,030 per ton. Copper prices had kept going down from 1965 to 2005 and then started increasing to the current level. There is usually cyclical variation in metal prices including copper over a period of 5-10 years.

4.2 Issues

1- Ores or concentrates can only be exported out and cannot be used by the local industry.
2- Another doubt among local stakeholders, which has been recently spelled out, is that local refining would enable closer monitoring and regulation of copper and gold percentages, which at the concentrate stage remains doubtful.
3- Investor companies have their own objectives, interests, commitments, and linkages for concentrate processing.
4- Smelting and refining have traditionally been concentrated in larger and more advanced economies like Japan, South Korea, China, India, European states, and the US.
5- The smelter’s economic size is often larger (350,000–500,000 tons per year), which is bigger than the smaller mine size like RekoDiq's of 200,000 tons.
6- Often, investment requirements in the downstream industry are much more than mining investments, which may not be on the mine site and may be done by other parties.

Other Issues

1- Unskilled labor
2- Unavailability of quality assessment mechanisms
3- Mismanagement
4- Political instability

5- Land grabbing
6- Transportation issues
7- Lack of investment opportunities & security of investment
8- Infrastructure hurdles
9- Non-scientific mining methods
10- High wastage rate (up to 70-75%)
11- Processing plant-related issues (security issues, inconsistent availability of raw materials)

4.3 Recommendations

1- Skill development
2- Value addition
3- Quality assurance
4- Marketing & development
5- Mine development educational program (Katas School of Mines-Panjab)
6- Financial assistance (e.g., loans for mineral development)
7- Convert cheap labor advantages into a skilled workforce.
8- Trains can be a more efficient alternative mode of transport than trucks.

The following are key investment opportunities in the copper sector:

1- Modern copper mining projects
2- Copper smelting and refining plant

Integrated versus custom smelters

Unlike integrated smelters, which are tied to individual mines, custom smelters receive concentrate from several mining projects rather than being dependent on a single source for feedstock. As a result, custom smelters generally have greater flexibility in terms of processing options and related configuration parameters.

Similar to Indonesia, Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher-value semi-finished or finished products. Copper concentrates are widely used in the production of precious metals such as gold and silver. The country mainly exports to China. Similar to Indonesia, Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher-value semi-finished or finished products.

Chapter 5: GAP Analysis

5.1 Obstacles

Pakistan's mineral sector is still lagging far behind the world's mineral market despite having huge reserves and comparative advantages. This is due to some interconnected and cross-cutting issues across the sector. Some of the major and key gaps in the mineral sector are detailed below.

1- **Regulatory Framework** The lack of a uniform and investment-friendly national mineral policy or law with an appropriate regulatory framework endorsed by parliament is not there. The National Mineral Policy 2013 is not updated and various sub-clauses are in contradiction with provincial mineral policies as after the 18th amendment, the mineral chapter is given to provincial governments. The lack of uniformity between the national mineral policy and provincial mining policies/laws results in procedural delays and also creates hurdles for investors, particularly foreign investors. Problems arise due to the scattered nature of such procedures, while most of the mining regulations currently exist in the form of promulgated notifications.

2- **Infrastructure** The lack of appropriate business-enabling infrastructures, such as mine access roads, connecting road networks, utilities, and industrial zones, is a key factor in the minerals sector's low investment and slow growth. Besides the existing poor infrastructure, there are areas where valuable mineral deposits can be exploited, but there is no access to these areas. Due to the huge amount of investment in developing access roads and the availability of electricity and water resources, investors are reluctant to invest in these potential areas. The absence of constant supply, particularly for the export market, arises due to the nonexistence of stocking yards/warehouses.

3- **Technology** Current technology, both in the quarrying and processing subsectors, is obsolete and incapable of producing standardized and uniformly high-quality products for the domestic market in general and the export market in particular. The quarry wastage in Pakistan reaches 75%, as compared to the international standard of up to 45%. This is because of nonmechanized and outdated approaches such as blasting. The modern approaches of standardized production and the use of nontoxic materials for product finishing are nonexistent at the 17 processing facilities in Pakistan. There is no technology for the management and disposal of the quarry and processing wastage.

4- **Human Resource** There is a lack of a qualified and trained workforce at the mining and processing levels. The level of workforce in this sector can be gauged from the fact that there is no dedicated training institute providing quality training in mineral mining and processing. Similarly, there is no qualified and trained quarry master in the mineral sector where it is required. The lack of a qualified and trained workforce also leads to increased waste in the quarrying and processing industries.

5- **Access to Finance** Dedicated and friendly banking products for both the mining and processing sub-sectors are not available. The existing banking products focus on financing in urbanized commercial areas. The case is worst in the case of mining, where

there is no mechanism for mining collateralization. Banks require commercial property in urban areas as collateral for availing bank finance, whereas mining activities are concentrated in rural areas. On the processing side, financial institutions are reluctant to finance due to the high capital costs associated with modern technology. The existing banking products for export facilitation are also subjected to complicated documentation that leads to procedural delays, whereas export is a time-bound activity with a pre-agreed timeline.

5.2 Proposed Interventions

Some of the interventions that can help in the real transformation of the copper mineral sector to bring it at par with the global best players in the mineral sector are given as follows:

Regulatory Framework: A well-focused and friendly regulatory framework plays an important role in the overall minerals sector's development and expansion across the globe. In similarity, an investment-friendly regulatory framework is required for Pakistan. Some of the key points in this regard are as follows;

Valuable mineral reserves, such as copper, that are concentrated across the country should be brought to the attention of existing and potential investors. Mineral reserves in general and deposits, in particular, should be estimated and mapped through modern scientific techniques such as geo-modeling and 3D modeling. The existing mineral policies and allied rules should be revisited and reformulated in close consultation with all relevant public and private sector stakeholders. A dedicated and well-equipped "One Window Facility" should be developed, tasked with facilitating local and particularly foreign investorsin investment opportunities in the mineral sector from project conceptualization to the start of production. The charging of levies, duties, and royalties on minerals without technical or scientific classification creates hurdles for investors. All the levies, duties, and royalties should be fixed and should be categorized according to the nature of minerals.

Infrastructure: Business-enabling infrastructure is key to the sustainable development of the mineral sector and enhancing exports. Some of the key actions required in this regard are the development of mine access roads in existing and potential mineral-bearing areas across the country. According to industry experts, DGMMs data, and private sector stakeholders, each mining cluster in Pakistan requires 20–50 km of road infrastructure. Special electricity lines should be made available for each mineral mining and processing cluster across the country. Establishment of Common Facility Centers (Stocking Yards/Warehouses- with block squaring facilities). Development of Export Processing/Industrial Zones for Minerals,

Technology Up-gradation: Technology is as vital as the sector itself for increasing competitiveness and tapping international markets. Some of the key action points in this regard include the establishment of machinery pools (at least one in each cluster) in the country's major mining areas. Establishment of common facility and training centers in major mineral processing hubs (at least one in each cluster) modern stock yards/warehouses (export facilitation). A technology endowment fund for the up-gradation of the existing processing units and mines.

Marketing: Market development and marketing is one of the core elements of promoting dimension stone exports. For market development and focused marketing, there is a need for a long-term marketing strategy. It is proposed that Pakistan as a whole should adopt the marketing strategy of target marketing; identify and concentrate on the market segments that have greater demand, and select products in which we have competitive strengths like resource availability and or processing capability/know-how, etc. development of an export-oriented, focused marketing strategy for the mineral sector. domestic promotion, facilitation of investors to participate in international exhibitions, display centers, and export facilitation centers.

The lack of financial support for existing and potential investors is directly related to Pakistan's low investment in mineral mining and processing. Some key points in this regard include the State Bank of Pakistan's introduction of new financial products with proper mine collateralization mechanisms to meet the sector's financial needs. Financing against products, equity participation funds, credit guarantee schemes, cash flow-based financing, and so on are examples.

Human Resource Development: At present, most quarrying is done in a non-systematic manner involving indiscriminate blasting and improper drilling that produces up to 85% wastage across the value chain. This subsequently results in the depletion of natural resources. To save the industry from further destruction and make this industry competitive in the international market and to realize the true worth of this invaluable natural resource, it is imperative to resolve these issues. This can be achieved by introducing modern training facilities at all stages of the dimension stone value chain across Pakistan.

Establishment of improved and dedicated training facilities in major mineral-bearing areas with state-of-the-art machinery and training facilities. Besides this, training courses in modern quarrying and processing should be introduced in existing TVET institutes through proper regulation to cater to the skill requirements of the sector. Organizations such as PASDEC, PJGDC, TEVTA, TUSDEC, and NAVTTC should be tasked with this.

Under the chairmanship of Deputy Commissioners, committees may be constituted under the chairmanship of representatives of respective departments. The committee will monitor the accomplishment of targets allocated by the government in respective areas. The committee will also be able to accelerate the implementation of development activities, remove bottlenecks, and facilitate facilitation.

A District Economy Model: may be developed at the district level. Potential areas of mineral economic activities, investment opportunities, endowments, available human resources, technology entrepreneurship, etc. can be assessed and mapped for future planning and development as an integrated development within the national economy. This may be helpful in the acceleration of economic activity.

Chapter 6: Conclusion and Recommendations

Pakistan's export per unit cost is incomparable with the world average cost. Pakistan is exporting its products at a very minimal cost. It is a matter of concern that Pakistan is managing its copper sector poorly. It can be a source of addition to the export volume if we manage the pricing of the product and also explore new markets such as Japan, Korea, Germany, Canada, Spain, USA, and India, etc. Misinvoicing also came out as a major issue in the mineral sector. When it comes to copper articles, Pakistan currently exports the majority of refined copper, waste and scrape, copper bar and rods, copper wire, copper foil, copper tubes, and pipes. Pakistan needs to diversify its export destinations instead of solely depending on China for its exports. Pakistan should explore Europe, the Middle East, and CARs. Value addition can play a significant role in increasing export volume instead of exporting copper ore and concentrates if Pakistan starts working on producing other value-added products like unrefined and refined copper, master alloys, copper bars and rods. It is expected that in the near future, Pakistan's copper exports will increase by 10 times.

Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher value semi-finished or finished products. Similar to Indonesia, Pakistan should plan to stop the exports of copper ores (all metal ores) as an attempt to boost investments in the downstream sector and exports of higher-value semi-finished or finished products. The government must have a fundamental role in incentivizing the creation of new smelting plants in the country and negotiating with private companies to increase the overall smelting capacity in Pakistan. This is especially true considering that privately-owned mines represent a large portion of the copper concentrate exports that are sent largely to China. Policies should also focus on the creation of regionalized, non-integrated custom smelters, which have the best cost-effectiveness.

There are many examples worldwide (in Europe and Japan) of old smelters that were modernized and reached high and globally recognized quality standards. Justifiably large investments are needed to support projects focused on reducing costs and improving the capture of harmful gases.