Pre-Feasibility Study of Kaolin Beneficiation Plant

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Pre-feasibility Study of Kaolin Beneficiation Plant

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Trade Development Authority of Pakistan.

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List of Abbreviations

Alphabets	Abbreviation	Explanation
B	Bn	Billion
F	FY	Fiscal Year
	Ft	Feet
H	HS Codes	Harmonized System Codes
I	ITC	International Trade Center
K	KG	Kilogram
	Km	Kilometer
M	MT	Metric Tons
	Mn	Million
	MT	Metric Tons
P	PKR/Rs	Pakistani Rupee
U	UN	United Nations
	U. S	United States of America
	UK	United Kingdom
	USD	United States Dollar
T	TPD	Tons Per Day

Executive Summary

Pakistan is endowed with huge reserves of minerals spanning an impressive 600 000 km^2 owing to its geographical makeup. The mineral sector in Pakistan contributes around 2% to GDP. This endowment with sizeable natural resources offers an opportunity for Pakistan to tap this potential. It's important to delve into the potential of our mineral sector, exploring its possibilities both domestically and internationally, and predicting future trend.

Significant reserves of China clay are found in the areas of Nagarparkar, Thar, in Sindh and Swat in Khyber Pakhtunkhwa. As for the reserves found in the area of Salt Range these reserves are limited in extent and lower in quality as compared to swat clays.

The global kaolin market size is projected to reach approximately USD 5.87 billion by 2030, progressing at a CAGR of 3.47% in the forecast period.

Pakistan has exported China clay while importing refined grinded Kaolin for industrial use. Pakistan imported $11.7 million worth of kaolin (China clay) and kaolinic clays with US and China being our biggest suppliers.

Given its potential, mineral wealth of Pakistan can be a great source of income for Pakistan. To tap its mineral wealth and source raw material from the local market rather than relying on imported refined product Pakistan needs investment in the mineral sector. Increased and prudent investment will lead to development of the mineral sector and value addition to the minerals including China clay which will play a critical role in increasing our mineral exports.

Kaolin has a high potential for exports as it is widely used in various industries such as paper, ceramics, paint, rubber, and fiberglass. Due to its unique chemical and physical properties, the demand for kaolin is increasing globally, particularly in countries that lack natural resources for its production.

In addition, there’s a need to encourage research and development to improve the processing and refining techniques of kaolin, making it more competitive in the global market. By developing a strong kaolin industry, Pakistan can not only increase its exports but also contribute to the growth of its economy

For this purpose, TDAP and EFP decided to make a collaborative effort to explore the available avenues that will lead to exports of value-added minerals by Pakistan. This report explores the opportunities available in the value addition of kaolin, its global market, Pakistan trade pattern and international trade of kaolin, investment needed to set up a Kaolin beneficiation plant, impediments faced by the mineral sector and recommendations and the way forward.

Chapter 1

Introduction

Pakistan has a number of mineral resources in abundance. There is a dire need to analyze the mineral sector potential, its analysis in domestic and international perspective, future trends.

Kaolin and kaolinic clays (HS-250700) are soft, earthy mineral with a long history dating back millions of years, formed through the hydrothermal decomposition of granite rocks. They're mostly extracted through open pit mining, and then undergo a series of crushing, milling, refining, and purification processes, including thermal treatments like drying and calcining, to create different grades of the mineral.

Kaolin (commonly referred to as China Clay) is used in number of different applications, depending on its subsequent processing. Kaolin is used in a variety of different products, in a number of sectors. In paper filler it is used to alter the properties of wood fiber, adding opacity and brightness and reducing cost. In tableware and sanitaryware kaolin adds whiteness and contributes to mullite skeleton formation during firing. In specialty applications (namely, performance minerals for paints and coatings, adhesives, leather processing, insulation, plasterboard, tapes, sealants, biocides, rubber, explosives and textile coating) kaolin is used to add texture, or as a white pigment.

Usually, each application of kaolin identified above will require a different grade and quality of kaolin and thus kaolin for one application is not substitutable on the demand-side for kaolin for another application.

Due to its low cost and versatility, kaolin is a highly attractive option for many industries, making it a significant contributor to the economy and national development. Effective exploitation and management of this valuable resource can have a substantial impact on the economy. In the FY 2022, 16000 tons of kaolin/China clay was extracted in Pakistan.

Kaolin like other minerals is a limited and non-renewable resource, and must be exploited prudently in the larger interest of the country. Over the years, minerals and mineral based industries have made significant contributions to the economy and the national wellbeing. A properly planned, efficiently regulated and professionally managed mineral industry can make a significant contribution to national development and achievement of growth.

1.1 Reserves of Kaolin (China Clay) in Pakistan

The Thar region in Sindh, Mianwali in Punjab and Swat valley in KP contain vast reserves of kaolin. However, the kaolin mined in Sindh in of better quality as compared to that in Punjab. The quality of kaolin produced after processing heavily depends on the purity of ore mined hence, better the quality of ore the better the processed kaolin we get for end use applications.

Figure 1 Reserves Geo-Tagging

Source: Research Wing

1.2 Significance of the Study

This project will help to tap the potential provided by vast mineral reserves in Pakistan.

The study will be beneficial for the following stakeholders:

1. Potential Investors.

2 Government Agencies

Chapter 2

Market Overview

2.1. Major uses of Kaolin

Paper Industry

Kaolin, a naturally occurring soft mineral, is a game-changer in the paper industry. By blending with cellulose fiber in wood pulp, it transforms plain paper into a luxurious and smooth canvas. And when mixed with water and adhesive, it becomes a brilliant coating that amplifies the paper's opacity, brightness, and printability. Simply put, kaolin takes paper from dull to dazzling, making it an essential ingredient in the creation of premium quality paper products.

Table 1 Paper Grade Kaolin

Type	Brightness
Air floated kaolin	80–81
Whole clay filler	81–85
Water-washed filler	81–86
Delaminated filler	87–89
Calcined kaolin extender,	91–95

Paint Industry: Paint industry is also a significant market for kaolin.As a pigment extender, kaolin not only thickens and balances the paint, but also gives it a silky-smooth finish and radiant sheen. And when it's delaminated or calcined, it transforms into a powerhouse ingredient that enhances the paint's durability and washability. Whether it's for a subtle touch or a bold statement, kaolin is the secret ingredient that elevates paint to the next level.

Ceramics: In the ceramics industry, kaolin is a vital ingredient due to its unique chemical and physical characteristics. These properties, including plasticity, strong consistency during creation, strength after firing, color, heat resistance, ease of molding in sanitaryware, low to no water absorption, and controlled shrinkage, make kaolin a crucial component in producing a range of ceramics products, such as dinnerware, bathroom fixtures, tiles, electrical porcelain, pottery, and refractory materials.

Rubber

Kaolin is utilized in the rubber industry due to its cost-effective reinforcing and stiffening characteristics. While carbon black is the preferred pigment for black rubber products, kaolin is used in non-black rubber goods.

Fiberglass

In the production process of fiberglass, which is a key material in the manufacture of lightweight composites for various industries such as automotive, marine, aerospace, among others, kaolin is utilized.

2.2. Kaolin Production Trend Globally.

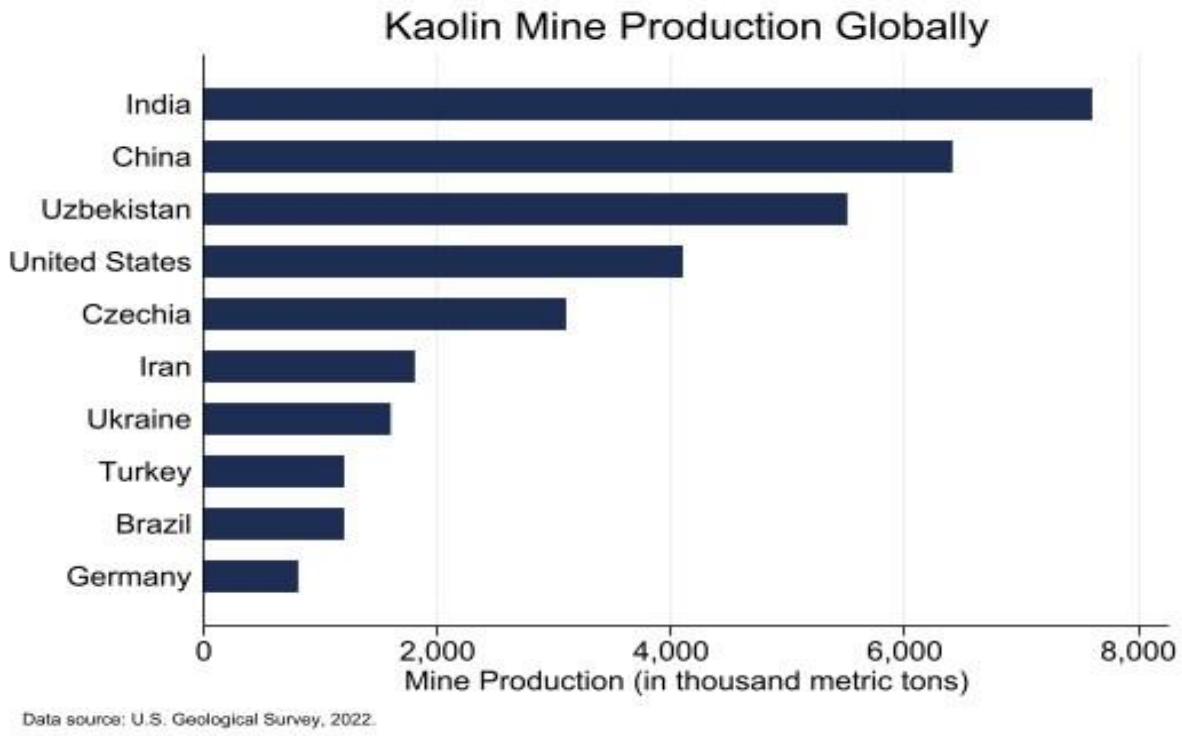
2.2.1. Mine Production of Kaolin "250700" by leading producers in the world in 2021

Table 2 Global kaolin mine production

Country	Mine Production (in thousand MT)	As a % of World Total Production
United States	4100	9.1
Brazil	1200	2.7
China	6400	14.2
Czechia	3100	6.9
Germany	800	1.8
India	7600	16.9
Iran	1800	4.0
Mexico	120	0.3
Spain	450	1.0
Turkey	1200	2.7
Ukraine	1600	3.6
Uzbekistan	5500	12.2
Other	11000	24.4
Total	45000	100

Data Source: U.S. Geological Survey, 2022.

Figure 2 Kaolin Mine Production Globally



In the year 2022, India was the largest mine producer of kaolin followed by China, Uzbekistan, US and others as depicted in figure 2 above. The production of kaolin in India constitutes 16.9 % of the overall global kaolin production followed by China (14.2%), Uzbekistan (12.2 %), US (9.1%) and other countries. Due to its application in various industries such as paper, ceramics, rubber, paints, fiberglass etc., kaolin is an essential raw material that contributes to the GDP and overall development of a country. The figure above also highlights the fact that there's a need and demand for kaolin in the emerging as well as developed economies given its significance and applications in various important industries.

2.3. Imports and Exports of Kaolin and kaolinic clays

2.3.1 Leading Exporters of Kaolin and Kaolinic Clays (HS-250700)

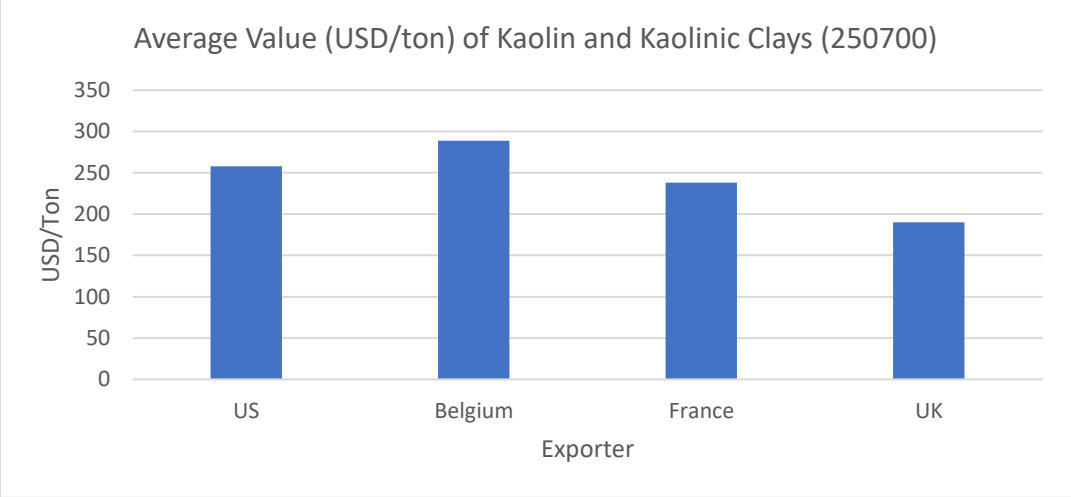
Table 3 Top 5 exporters of Kaolin and kaolinic clays

Exporters	Exported value in 2017	Exported value in 2018	Exported value in 2019	Exported value in 2020	Exported value in 2021
United States of America	560353	581349	565677	506905	616761
United Kingdom	214851	230109	198436	179463	259334
China	114517	114865	117213	141486	183316
Brazil	181800	170381	153075	125149	122219
HK, China	11191	11363	56915	83057	100829
Source: ITC Trade Map					

2.3.2 Average Unit value of Kaolin and kaolinic clays

The data as depicted by the figure below shows that the value of kaolin and kaolinic clays exported by countries like US, Belgium, France and UK is as high as $289 on average which is per unit value of kaolin and kaolinic clays exported by Belgium in 2021 followed by US, France and United Kingdom.

Figure 3 Average Value of Kaolin and Kaolinic Clays Sold By Leading Exporters



Data Source: ITC Trade map

2.3.3 Leading Importers of Kaolin and kaolinic clays HS- 250700

Table 4 Top 5 importers of Kaolin and kaolinic clays

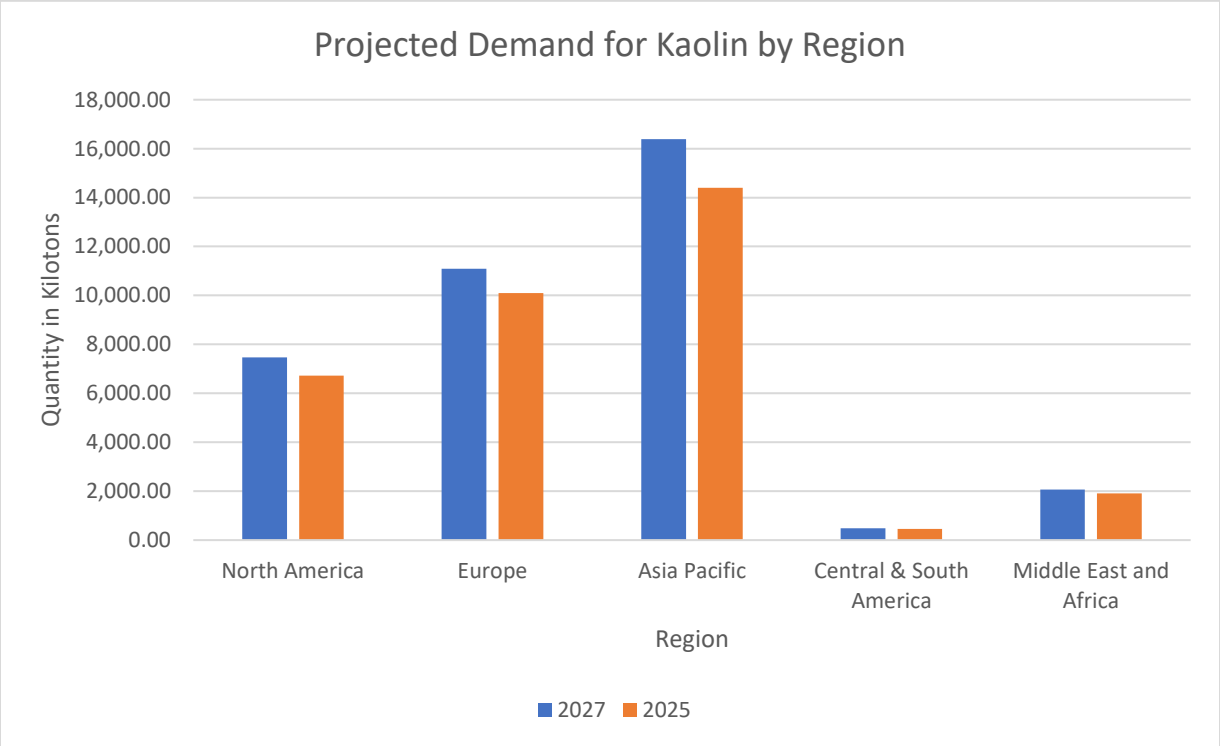
Importers	Imported value in 2017	Imported value in 2018	Imported value in 2019	Imported value in 2020	Imported value in 2021
Spain	148204	148290	128905	116869	172721
China	119682	154743	143819	125923	148293
Belgium	135428	128792	123092	111093	126788
Germany	123501	124675	106892	99696	105785
Japan	143286	129581	117050	91364	105757

Data: ITC Trade map (All the values in USD '000)

2.3.4 Projected Market Demand for Kaolin

The market demand for kaolin is expected to reach 37.50 million tons by volume in 2027. Fiberglass is one of the major materials used for manufacturing lightweight composites for the automotive, marine, aerospace and other industries. Due to anticipated rise in the demand of fiberglass the demand for kaolin is also expected to rise in the next few years as kaolin is often used in the production process for fiberglass. Alongside fiberglass the projections of increase in the demand for ceramics will lead to rise in the demand for kaolin since kaolin provides whiteness, durability and smoothness to the ceramic finished products.

Figure 4 Projected demand for kaolin by region



Data source: GVR Analysis

The Figure above depicts the projected demand for kaolin over the next few years. The largest demand for kaolin is expected to come from Asia pacific followed by Europe, North America, Central and South America and Middle east and Africa.

2.4 Exports and Imports of Kaolin and kaolinic clays (HS- 250700) by Pakistan

Kaolin is an important mineral that is used in the important industries. The exports of kaolin by Pakistan haven't been considerable given the potential and size of global market for Kaolin. Globally the exports of kaolin in 2021 stood at $1.9 billion. Pakistan's kaolin exports market was mainly India. Since 2020 there's been no kaolin exports to India and hence the value of exports reported in 2020 and 2021 stood at mere $2000.

Table 5 Exports of product by Pak: "HS-250700" Kaolin and other Kaolinic clays.

Importers	Exported value in 2017	Exported value in 2018	Exported value in 2019	Exported value in 2020	Exported value in 2021
World	42	78	89	2	2
China	0	0	0	0	2
South Sudan	1	2	0	0	0
Djibouti	2	1	0	1	0
Kuwait	0	12	0	0	0
India	40	62	62	0	0

Source: ITC Trade Map (Values in USD '000)

Table 6 Imports of Kaolin and kaolinic clays (HS- 250700) by Pakistan over the past years

Exporters	**Imported value in 2017**	**Imported value in 2018**	**Imported value in 2019**	**Imported value in 2020**	**Imported value in 2021**
U.S	5026	5476	5091	6238	6275
China	1775	2165	2312	2994	4031
UK	1133	1103	1192	985	918
Malaysia	207	132	86	115	240
Spain	133	286	131	54	185

Source: ITC Trade map (Values in 000' USD)

In 2021, Pakistan imported $11.7 Mn worth of kaolin from the world with the largest volume being imported from USA followed by China and other countries including UK, Malaysia and Spain who are the largest suppliers of kaolin to Pakistan as depicted by the table above.

2.5 **Mining of Kaolin (China Clay) in Sindh**

Figure 5 Mining site of Kaolin in Sindh

Chapter 3

Kaolin processing plant

First stage is crushing process; Hopper collects the ores and then the Vibrating feeder put material into jaw crushers. Then use cone crusher to make fine stone, screen machine help get qualified stone size smaller than 20 mm, bigger stone will come back to the cone- crusher. After crushing stage, Kaolin ore is grinding in the ball mill, most ore will be powder with water, other big size come back to ball mill by the Spiral Classifier. Third stage, in the flotation process, by rough selection and sweep selection, can get Kaolin concentrate. Fourth stage, the Kaolin concentrates are dried by Disc Vacuum filter and Dryer. For tailings, use tailings thickener and mixing tank output the tailings.

Figure 6 Processing stages of Kaolin

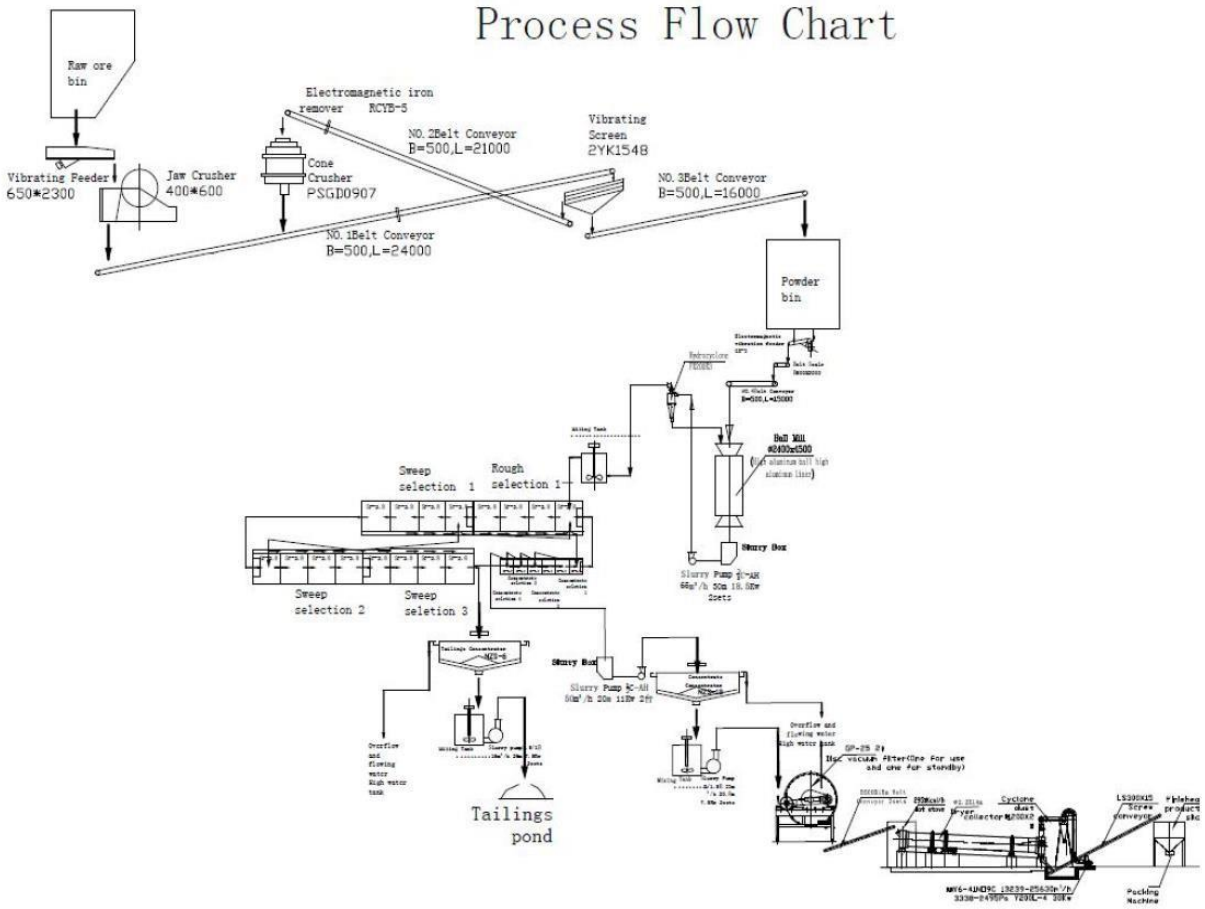


Table 7 Equipment List for Kaolin Processing Plant

S.No	Process	Item	Quantity	Power (KW)	Unit Price (USD)	Total Price (USD)	Remark
Crushing Process							
1	Raw Ore Bin	3X4m	1	/	-	-	Site fabrication
2	Vibrating Feeder	750*2500	1	2.2	3,850	3,850	
3	Jaw Crusher	PE400X600	1	30	12,925	12,925	
4	Fine Jaw Crusher	PE150*750	2	15	7,540	15,080	
5	Vibrating Screen	2YK1548	1	15	13,000	13,000	
6	1#Belt Conveyor	1#Belt Conveyor B500*19m	1	7.5	4,520	4,520	
7	2#Belt Conveyor	B500*23m	1	7.5	5,470	5,470	
8	3#Belt Conveyor	B500X21m	1	5.5	5,000	5,000	
Grinding Process							
9	Powder Bin	120m³	1				Site fabrication
10	Electromagnetic Feeder	GZ-3	1	0.2	1,153	1,153	
11	4#Belt Scale B500*2000	B500*2000	1	0.75	3,692	3,692	
12	5#Belt Conveyor B500X15m	B500X15m	1	5.5	3,810	3,810	
13	Ball Mill Φ1.83*3.6m	Φ1.83*3.6m	1	155	66,920	66,920	
14	Hydrocyclone FX200*3	FX200*3	1		15,000	15,000	
15	Slurry Box 1.5*1.5	1.5*1.5	1				Site fabrication
16	Slurry Pump	Q=50m3 H=20m	2	1	3,560	7,120	
Flotation Process							
17	Mixing Tank	Φ2000X2m	2	5.5KW*2	4,923	9,846	

18	Rough Selection 1	SF2.8	4grooves	11KW*4+1.1KW	19,000	19,000	
19	Sweep Selection 1	SF2.8	4grooves	11KW*4+1.1KW	19,000	19,000	
20	Sweep Selection 2	SF2.8	4grooves	11KW*4+1.1KW	19,000	19,000	
21	Concentrate Selection	SF1.2	6 grooves	5.5KW*6+1.1KW	18,460	18,460	
Drying System							
22	Slurry Box	1.5*1.5*1m	1				Site fabrication
23	Slurry Pump	Q=35m3/h,H=20m	2	7.5KW*2	2,307	4,614	One for use and one for stand by
24	concentrate concentrator	NZS-12	1	3KW	27,650	27,650	
25	Mixing Tank	Φ1000X1	1	5.5KW	1,538	1,538	
26	slurry pump	Q=22m³,H=20m	2	5.5KW*2	2,000	4,000	One for use and one for stand by
27	disc vacuum filter	GPG30-6	1	3KW	34,874	34,874	
28	belt conveyor	B500*15m	2	5.5KW*2	3,810	7,620	
29	drying machine	ϕ1.5*15m	1	15	30,760	30,760	
30	Screw conveyor	LS250*15	1	5.5	3,460	3,460	
31	finished product silo		1				Site fabrication
Tailings Process							
32	Slurry Box	1.5*1.5*1m	1				Site fabrication
33	slurry pump	Q=50m³,H=30m	2	15KW	3,650	3,650	
34	control cabinet	Control whole plant	1	511.55KW	9,740	9,740	
TOTAL FACTORY PRICE						**370,752**	
EXW Factory Price After 5% Discount						**352,214**	

Chapter 4

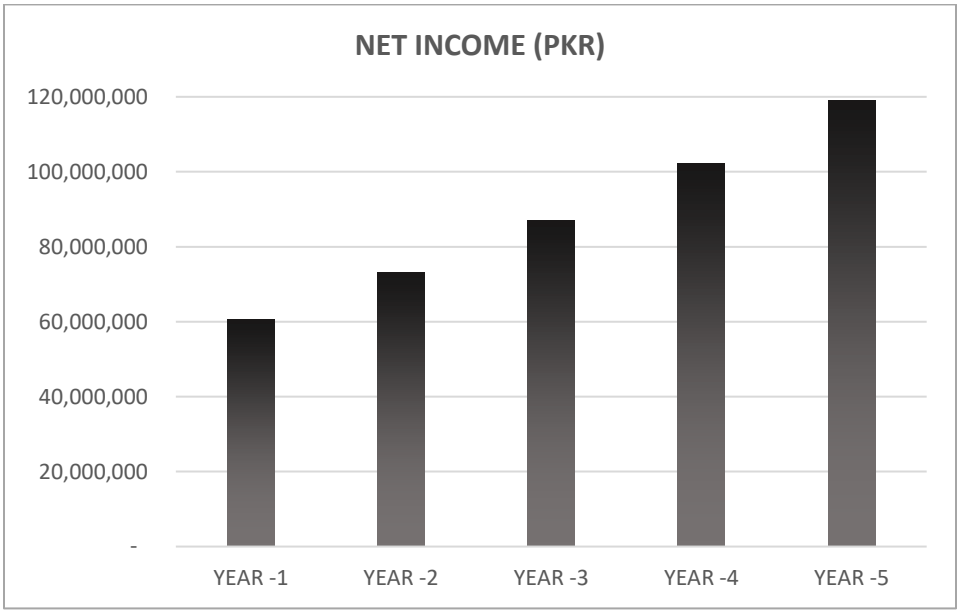
Feasibility

4.1 Estimated Profit

The Kaolin ore price is around 30 USD per ton with the purity of 60%. By converting this to its value-added product, we can generate huge revenue as the final product, i.e. white purified kaolin can be sold for up to 350 USD per ton.

From the feasibility analysis of 100 TPD Kaolin beneficiation plant, the estimated net income per year is shown below. The payback period is estimated as three years, eight months and the Internal rate of return is 14% for the period of five years.

Figure 7 Net Income from the Project



4.2 Five-year projections

Below are the five-year financial projections of kaolin beneficiation plant:

Table 8 Financial Projections of kaolin beneficiation plant

	MONTHLY	YEAR -1	YEAR -2	YEAR -3	YEAR -4	YEAR -5
	AMOUNT (PKR)	AMOUNT (PKR)	AMOUNT (PKR)	AMOUNT (PKR)	AMOUNT (PKR)	AMOUNT (PKR)
REVENUES						
KAOLIN	**83,132,175**	**997,586,100**	**1,097,344,710**	**1,207,079,181**	**1,327,787,099**	**1,460,565,809**
DIRECT COSTS						
Electricity	25,248,000	302,976,000	333,273,600	366,600,960	403,261,056	443,587,162
Gas	4,593,186	55,118,232	60,630,055	66,693,061	73,362,367	80,698,603
Water	1,320,850	15,850,200	17,435,220	19,178,742	21,096,616	23,206,278
Raw Material	17,500,000	210,000,000	231,000,000	254,100,000	279,510,000	307,461,000
Freight	7,500,000	90,000,000	99,000,000	108,900,000	119,790,000	131,769,000
Reagents	1,200,000	14,400,000	15,840,000	17,424,000	19,166,400	21,083,040
Salary	1,755,000	21,060,000	23,166,000	25,482,600	28,030,860	30,833,946
Packaging Cost	1,842,750	22,113,000	24,324,300	26,756,730	29,432,403	32,375,643
Repair & Maint.	3,378,937	40,547,241	44,601,966	49,062,162	53,968,378	59,365,216
Miscellaneous	300,000	3,600,000	3,960,000	4,356,000	4,791,600	5,270,760
INDIRECT COSTS						
Depreciation	2,670,603	32,047,241	32,047,241	32,047,241	32,047,241	32,047,241
Shipping Cost	4,987,500	59,850,000	65,835,000	72,418,500	79,660,350	87,626,385
Interest Expense	5,744,193	28,950,730	24,227,515	19,022,532	13,286,641	6,965,689
TOTAL COST	**78,041,019**	**896,512,645**	**975,340,898**	**1,062,042,529**	**1,157,403,913**	**1,262,289,964**
PBT	5,091,156	101,073,455	122,003,812	145,036,652	170,383,186	198,275,845
Tax Income	2,036,462	40,429,382	48,801,525	58,014,661	68,153,274	79,310,338
PAT	**3,054,694**	**60,644,073**	**73,202,287**	**87,021,991**	**102,229,912**	**118,965,507**
CASHFLOWS						
Depreciation	**2,670,603**	**32,047,241**	**32,047,241**	**32,047,241**	**32,047,241**	**32,047,241**
OPERATING CASHFLOW	**5,725,297**	**92,691,314**	**105,249,529**	**119,069,233**	**134,277,153**	**151,012,748**

Source: Employers Federation of Pakistan research wing

Chapter 5

Opportunities, Impediments and Recommendations

Opportunities

1. Given the projected growth rates of demand for kaolin, Pakistan can capitalize on the opportunity since it is endowed with significant kaolin reserves.
2. With Pakistan importing significant volume of kaolin worth around $11.7 million in 2021 the value addition and production of refined and desired kaolin grade will help to meet the local industry demand.
3. Increase in exports of kaolin alongside reduction in its import if we meet the local industrial demand will have a positive impact on our trade account and foreign exchange earnings.
4. Investment in the development and value addition of kaolin will generate employment opportunities especially in the areas of Thar, Sindh and Swat, KPK.

Impediments

1. Nonscientific mining methods.
2. Connectivity and infrastructure hurdles.
3. Issues with access to finance.
4. Lack of coordinated effort and approach.
5. Inconsistencies in the availability of raw material or feed.
6. Lack of geological databases for global investors

Recommendations

1. Development of Infrastructure: Building the required infrastructure, including roads, bridges, ports, and other facilities is crucial to attract investment in the mineral sector.
2. Exploration and Surveys: It is important to encourage mineral exploration and geological surveys to identify new mineral resources and increase the reserves of known minerals.
3. Streamlining Regulations: The government should simplify and streamline the legal and regulatory framework so that investment gets promoted and there's an increase in competitiveness in the mineral sector.
4. Promoting Investment: The government should create investment-friendly environment and provide incentives to attract local and foreign investment in the mineral sector.
5. Provision of geological databases for global investors.
6. Skill Development: There's a need to invest in development of human capital to increase the skilled labor force in the mineral sector. This includes providing training and education programs to workers and promoting research and development.
7. Promoting and Encouraging Public-Private Partnership: Public-private partnership should be promoted in the mineral sector to share the risks and benefits of mineral development.

References

Siddiqui, M. A., Ahmed, Z., & Saleemi, A. A. (2005). Evaluation of Swat kaolin deposits of Pakistan for industrial uses. Applied Clay Science, 29(1), 55-72.

Ismail, S., Husain, V., & Anjum, S. (2019). Mineralogy and Genesis of Nagar Parker Kaolin Deposits, Tharparkar District, Sindh, Pakistan. *International Journal of Economic and Environmental Geology*, 33-40.

Ministry of Finance. (FY22). *Economic Survey of Pakistan.*

Mineral Commodity Summaries 2022

Trade Map, I. (2021). *ITC Trade Map*. Retrieved from ITC Trade Map: https://www.trademap.org/

Sutanto. J. (2022) Retrieved from yukami : https://www.yukami.co.id/