BANKABLE FEASIBILITY REPORT OF

PL12236/2023 & PL/25529/2023, TANZANIA

AREA- 488.75 SQ. K.M

COMMODITY- SODA ASH

PREPARED BY

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1. EXECUTIVE SUMMARY

1. 1 BRIEF OVERVIEW OF THE PROJECT

Sl.no	Project	:	SODA ASH
1	Name of Company/Mine Owner	:	Ngaresero Valley Company Limited (NVCL)
	PL No.	:	12236/2023 and 25529/2023
	Area	:	PL12236/2023- 291.41 sq. km PL/25529/2023- 197.34 sq. km
2	**Location**		
	Geographic elongation of PL 12236/2023	:	2°10'59.56"S - 2°17'27.27"S 35°59'50.95"E- 36°9'27.22"E
	Geographic elongation of PL/ 25529/2023	:	2°15'54.01"S - 2°31'37"S 36°8'54"E - 36°1'39.01"E
	Lake	:	The Natron
	Village	:	Pinyinyi
	District	:	Ngorongoro and Longido
	Region	:	Arusha
	Country	:	Tanzania
	Ecological Significance	:	Ramsar Wetland (4 July 2001)
3	PL Area & Type of Land		Alkaline water, soda crust with alluvial
4	Surface Elevation		Lowest: 602 (Eastern area) Highest:1355msl (Western side)
5	Name of Commodity		Soda Ash
6	Team Members		Tarini Prasad Mohanty Debananda Tripathy Bibhuti Bhusan Mohanty Subhashree Subhasmita Das Shakti Prasad Dash Sonam Priyadarshini Rout Talent Princer A. Technical Professionals of NVCL

Table 1: Brief Overview of the Project

1.2 LOCATION

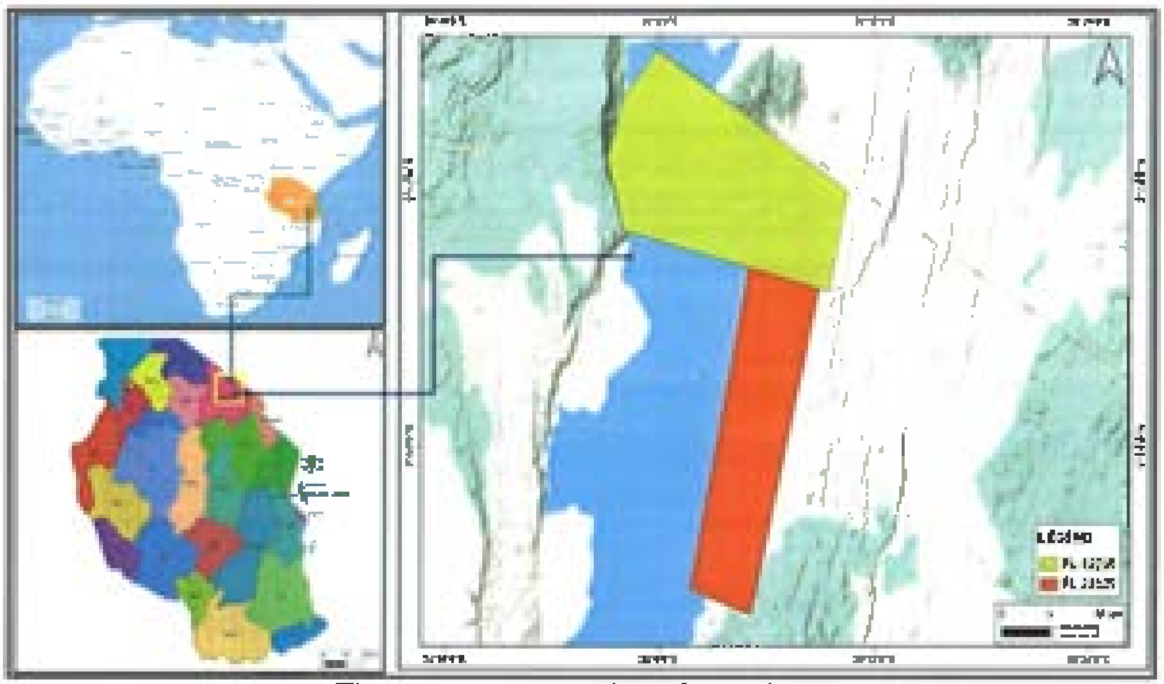

Figure 1: Location of the Study Area

Figure 2: Ideal Scene of Lake Natron captured in Sentinel 2 Images of PL 12236/2023 & PL/25529/2023

1.3 KEY FINDINGS FROM THE FEASIBILITY STUDY

Most of the Soda Ash reserves in Tanzania exist in Lake Natron which is in Arusha Region Northern Tanzania. The soda ash project in Lake Natron, Tanzania, holds significance for several reasons. It can contribute to economic development by creating job opportunities and generating revenue through exports. Additionally, the extraction of soda ash may impact the local ecosystem and biodiversity, necessitating careful environmental management. Balancing economic benefits with environmental considerations is crucial for the sustainable development of the region.

NVCL Soda Ash project, located in the Arusha Region. The project is planned to be developed in two phases.

The primary need of the proposed Soda Ash mining by the proponent is income generation from the investments made. Other benefits accruing from the project are:

- Spurring the local economy providing employment opportunities, especially during the operation.
- Putting the plot into a more socio-economic use.

1.4 MAIN CONCLUSIONS AND RECOMMENDATIONS

Natural extraction of soda ash from Lake Natron in Tanzania presents both opportunities and significant environmental challenges.

1.4.1 Conclusions

1. **Economic Viability**: While the extraction project could generate significant economic benefits, including job creation and infrastructure development, these must be weighed against the environmental costs. The sustainability of such economic benefits is questionable if the ecological integrity of the lake is compromised.

2. **Regulatory and Community Concerns**: There are concerns regarding the transparency of the environmental impact assessments conducted for the soda ash project. Many local and international environmental organizations have criticized the process, arguing that it lacks adequate public engagement and fails to address the potential long-term consequences of mining activities.

3. **Alternative Methods**. Research indicates that soda ash can be derived from Lake Natron using environmentally friendly methods that minimize ecological disruption. These methods should be prioritized over large-scale industrial extraction to preserve the lake's unique biodiversity while still.

1.4.2 Recommendations

1. **Conduct Comprehensive Environmental Assessments**: Before proceeding with extraction, thorough and independent environmental impact assessments should be conducted. These assessments must include long-term ecological studies to understand the potential impacts on local wildlife and habitats.

2. **Engage Local Communities**: It is crucial to involve local communities in the decision-making process. Their insights and traditional knowledge can provide valuable perspectives on sustainable practices and the importance of preserving the lake's ecosystem.

3. **Explore Sustainable Extraction Techniques**| Research and develop methods for soda ash extraction that are less invasive and have a lower ecological footprint. This could include small-scale, community-led initiatives that focus on sustainable practices rather than large industrial operations.

4. **Implement Strict Regulatory Frameworks**. Establish and enforce regulations that protect the lake's ecosystem while allowing for responsible resource extraction. This includes monitoring the impacts of any extraction activities and ensuring compliance with environmental standards.

5. **Promote Ecotourism**: Instead of industrial extraction, promoting ecotourism could provide an alternative economic avenue that benefits local communities while preserving the unique environment of Lake Natron. This approach would highlight the ecological and cultural significance of the region, attracting visitors interested in its natural beauty and biodiversity.

2. INTRODUCTION

2.1 BACKGROUND OF THE PROJECT

Lake Natron is a unique alkaline lake located at the border between Tanzania and Kenya. It is recognized for its ecological significance, particularly as the primary breeding site for the lesser flamingo. which constitutes over 75% of the global population of this species. The Tanzanian government has shown interest in exploiting the lake's abundant soda ash resources, primarily sodium carbonate, which is essential for various industrial applications, including glass production, detergents, and chemicals.The proposed soda ash plant, initially estimated to cost around $500 million, aimed to produce 500,000 tonnes annually, with plans for future expansion. The project was projected to generate approximately $300 million in revenue each year and create around 500 jobs directly linked to the plant's operations. However, due to mounting environmental concerns and pressure from conservation groups, the project was shelved, with the government considering alternative sites for soda ash extraction, such as the Engaruka Basin, which has generated less controversy.

2.1.1 Market Importance of Soda Ash

Soda ash is a critical raw material in several industries, making it a valuable commodity in both local and international markets. The global demand for soda ash is driven by its use in manufacturing glass, ceramics, and cleaning products. In Tanzania, the establishment of a soda ash plant could have positioned the country as a key player in the regional market, potentially reducing import dependency and enhancing local production capabilities.Furthermore, the soda ash industry could have stimulated the development of related sectors, including transportation and logistics, as well as ancillary services such as maintenance and supply chain management. The projected revenues from the soda ash plant could have significantly contributed to Tanzania's economy, enhancing its industrial base and promoting economic diversification.

2.1.2 Impact on GDP

The potential impact of the soda ash project on Tanzania's GDP is significant. The estimated annual revenue of $300 million from the soda ash plant could have provided a substantial boost to the national economy. This influx of capital would not only contribute directly to GDP but also have multiplier effects throughout the economy by increasing demand for local goods and services.Moreover, the creation of jobs—approximately 500 direct positions and additional indirect jobs in supporting sectors—would enhance household incomes and stimulate local economies. Increased employment opportunities could lead to greater consumer spending, further driving economic growth. However, the environmental implications of the project could negate these economic benefits if they lead to ecological degradation, which could ultimately harm tourism and other sectors reliant on the lake's health.

2.1.3 Job Opportunities

The soda ash project was expected to create direct employment opportunities for around 500 individuals, primarily in operational roles within the plant. Additionally, the construction phase would have generated temporary jobs, further contributing to local employment. Beyond direct employment, the project could have spurred job creation in related sectors, including transportation, logistics, and service industries, as the demand for goods and services would increase.However, the shelving of the project has shifted focus towards ecotourism and sustainable livelihoods, which may offer alternative job opportunities for local communities. Investments in ecotourism could create jobs in hospitality, guiding, and conservation efforts, potentially providing a more sustainable economic model that preserves the unique biodiversity of Lake Natron while still benefiting local populations.

2.1.4 Conclusion

The soda ash project at Lake Natron encapsulates the complex interplay between economic development and environmental conservation. While the market importance of soda ash and its potential contributions to Tanzania's GDP and job creation are clear, the ecological significance of Lake Natron cannot be overlooked. The decision to shelve the project reflects a growing recognition of the need to balance economic interests with environmental stewardship, paving the way for alternative sustainable development strategies that prioritize both the economy and the unique natural heritage of Tanzania.

2.2 OBJECTIVES AND SCOPE OF THE FEASIBILITY STUDY

A feasibility study on soda ash extraction from Lake Natron is essential to evaluate the viability of such a project, considering both the economic potential and the environmental implications. The objectives and scope of this study are crucial for making informed decisions regarding the extraction process, its impact on local communities, and the broader ecological landscape

2.2.1 Objectives of the Feasibility Study

1. **Economic Viability Assessment**: One of the primary objectives is to analyse the economic feasibility of extracting soda ash from Lake Natron. This includes evaluating the costs associated with extraction, processing, and transportation, as well as potential revenues from the sale of soda ash in local and international markets. The study aims to determine whether the project can be profitable and sustainable in the long term.

2. **Environmental Impact Evaluation**: The study seeks to assess the potential environmental impacts of soda ash extraction on Lake Natron's unique ecosystem, which is critical for the breeding of the lesser flamingo and other wildlife. This involves examining how extraction activities could affect water levels, salinity, and local biodiversity.

3. **Social Impact Analysis**: Understanding the social implications of the project is vital. The study aims to gauge local community attitudes towards soda ash extraction, potential job creation, and how the project may affect their livelihoods. It will also explore whether the benefits of the project align with the interests and needs of local residents

4. **Regulatory Compliance Review**: The feasibility study will include an examination of the legal and regulatory framework governing resource extraction in Tanzania. This involves identifying necessary permits, environmental regulations, and compliance with international treaties, such as the Ramsar Convention on Wetlands, which emphasizes the conservation of wetlands like Lake Natron.

5. **Alternative Resource Management Strategies**: The study will explore alternative approaches to resource management that could mitigate

environmental impacts while still providing economic benefits. This includes evaluating ecotourism and sustainable practices as viable alternatives to large-scale extraction.

2.2.2 Scope of the Feasibility Study

1. **Technical Feasibility**: The study will assess the technical aspects of soda ash extraction, including the methods to be employed (e.g., solar evaporation and calcination) and the technological requirements for processing the extracted material. It will also evaluate the infrastructure needed to support the extraction and distribution processes.

2. **Market Analysis**: A comprehensive market analysis will be conducted to understand the demand for soda ash both locally and internationally. This includes identifying potential buyers, market trends, and pricing strategies, which are critical for forecasting revenue and profitability.

3. **Environmental Studies**. Detailed environmental studies will be part of the scope, focusing on the ecological characteristics of Lake Natron, including its flora and fauna, hydrology, and geological features. This will help in understanding the potential risks associated with extraction activities.

4. **Community Engagement**: The feasibility study will involve engaging with local communities to gather their insights and concerns regarding the project. This engagement will help ensure that the study reflects the perspectives of those most affected by the extraction activities.

5. **Financial Analysis**: A thorough financial analysis will be included, which will cover initial investment costs, operational expenses, revenue projections, and potential funding sources. This analysis will help in determining the financial sustainability of the project.

2.3 METHODOLOGY USED FOR THE STUDY

The methodology used for prospecting and preliminary exploration of soda ash from Lake Natron involves a systematic approach to assess the viability of extracting this valuable mineral while considering environmental and economic factors. The following outlines the key components of this methodology.

2.3.1 Literature Review and Preliminary Research

The initial phase of the methodology includes a comprehensive literature review to gather existing data on Lake Natron's geological and hydrological characteristics. This involves analysing previous studies, geological surveys, and reports on soda ash extraction methods. The review helps identify the potential for soda ash deposits and informs the selection of appropriate exploration techniques.

2.3.2 Site Visits and Field Surveys

Field surveys are essential to understand the physical characteristics of Lake Natron. This phase includes:

- Site Visits: Conducting extensive site visits to observe the lake's conditions, including water chemistry, salinity levels, and the presence of brine deposits. Researchers typically walk significant distances across the lake to assess areas of interest and collect samples.
- Sampling: Collecting water and sediment samples from various locations within the lake to analyze the concentration of sodium carbonate and other minerals. This data is crucial for determining the quality and quantity of soda ash available for extraction

2.3.3 Geochemical Analysis

Once samples are collected, they undergo rigorous geochemical analysis in laboratories. This analysis includes:

- Chemical Composition Testing: Determining the concentration of soda ash and other relevant minerals in the samples. This helps in understanding the economic viability of the extraction process.

- Physical Properties Assessment: Evaluating the physical properties of the brine and sediment samples, such as pH, density, and temperature, to inform the extraction method.

2.3.4 Evaluation of Extraction Methods

Based on the findings from the field surveys and geochemical analyses, various extraction methods are evaluated. The methodology typically considers:

- Solar Evaporation: This is often the preferred method due to its lower operational costs and environmental impact. The feasibility of using solar evaporation techniques to concentrate and crystallize soda ash from brine is assessed.

- Calcination Processes: Investigating the potential for calcination of harvested brine to produce high-quality soda ash. This involves evaluating the energy requirements and potential emissions associated with this process.

2.3.5 Environmental Impact Assessment

A critical component of the methodology is conducting an environmental impact assessment (EIA). This assessment aims to evaluate the potential ecological consequences of soda ash extraction, focusing on:

- Biodiversity Impact: Analyzing how extraction activities may affect local wildlife, particularly the lesser flamingo population, which relies on Lake Natron for breeding.

- Water Quality Monitoring: Assessing how extraction processes could alter the lake's water chemistry and overall ecosystem health.

2.3.6 Economic Feasibility Study

The economic feasibility of the soda ash project is evaluated through:

- Cost-Benefit Analysis: Estimating the costs associated with extraction, processing, and distribution of soda ash, and comparing these with potential revenue from sales.

- Market Analysis: Investigating local and international demand for soda ash, identifying potential buyers, and understanding market trends to forecast profitability.

2.3.7 Community Engagement

Engaging with local communities is vital to the methodology. This involves:

- Surveys and Interviews: Conducting surveys to gauge local opinions on soda ash extraction and its potential impacts on their livelihoods.
- Stakeholder Meetings: Organizing meetings with community leaders and stakeholders to discuss the project, address concerns, and explore potential benefits for local residents.

The methodology for prospecting and preliminary exploration of soda ash from Lake Natron is comprehensive, integrating scientific research, environmental considerations, and community engagement. By following this structured approach, stakeholders can make informed decisions regarding the feasibility of soda ash extraction while balancing economic interests with ecological preservation.

3. PROJECT DESCRIPTION

3.1 OVERVIEW OF LAKE NATRON AND ITS SIGNIFICANCE

Lake Natron, located in northern Tanzania near the border with Kenya, is a unique salt or alkaline lake that plays a crucial role in the region's ecology and economy. It is situated in the Gregory Rift, part of the East African Rift System, and serves as a vital habitat for various species, particularly the lesser flamingo.

3.1.1 Overview of Lake Natron

Geographic and Physical Characteristics

Lake Natron is characterized by its extreme alkalinity and high temperatures, with water temperatures often exceeding 40 °C (104 °F). The lake stretches approximately 57 kilometers (35 miles) in length and varies in width, reaching up to 22 kilometers (14 miles) at its widest point. Its depth is generally shallow, typically less than three meters (9.8 feet). The lake is primarily fed by the Southern Ewaso Ng'iro River, which originates in central Kenya, and mineral-rich hot springs contribute to its unique chemical composition. The lake's high evaporation rates leave behind significant deposits of sodium carbonate (natron) and sodium sesquicarbonate (trona), which are essential for various industrial applications. The extreme conditions of the lake create a vibrant ecosystem dominated by halophilic microorganisms, including cyanobacteria, which give the lake its striking red coloration.

Ecological Significance

Lake Natron is renowned as the only regular breeding ground for Africa's lesser flamingos, with over two million birds flocking to the area to nest between September and April. The caustic environment, characterized by high salinity and temperature, provides a natural barrier against predators, making it an ideal location for flamingo breeding. The lake's unique ecosystem supports a variety of other species, including endemic algae and invertebrates, and attracts numerous bird species, making it a prime destination for birdwatchers.

3.1.2 Economic and Cultural importance

Resource Potential

The lake's high concentrations of soda ash and other minerals present significant economic opportunities. Investigations have revealed substantial reserves of soda ash, which is a critical raw material for industries such as glass manufacturing, detergents, and chemicals. The potential for sustainable extraction of these resources could contribute to local and national economic development.

Tourism and Community Engagement

Lake Natron is increasingly recognized for its tourism potential, offering visitors unique landscapes, opportunities for hiking, and cultural experiences with the local Maasai communities. The dramatic scenery, including the backdrop of the active Ol Doinyo Lengai volcano, enhances its appeal as a tourist destination. However, the area remains relatively untouched by mass tourism, providing a more authentic experience for visitors.

Cultural Significance

The lake and its surroundings hold cultural importance for the Maasai people, who have historically inhabited the region. Their traditional practices and knowledge of the land contribute to the area's cultural heritage, which can be integrated into sustainable tourism initiatives.

Lake Natron is a remarkable natural feature with significant ecological, economic, and cultural importance. Its unique environment supports vital wildlife populations, particularly the lesser flamingo, while also offering potential resources for economic development. Balancing the conservation of this fragile ecosystem with sustainable resource extraction and tourism will be essential for ensuring the long-term health of Lake Natron and the communities that depend on it.

3.2 DESCRIPTION OF SODA ASH AND ITS IMPORTANCE

Soda ash is a common name for the technical grade anhydrous sodium carbonate having the chemical formula Na_2CO_3 by achieving the goal of 10^{th} most consumed inorganic compound. It is a diazonium salt of carbonic acid. Basing upon the appearance, it is white, finely crystalline, hygroscopic powder. The solubility property of Soda ash increases the alkalinity of water. Incurrent scenario, soda ash is produced in two different processes. The natural production of soda ash includes purified trona or brine by using the monohydrate or sesquicarbonate process. On the other hand synthetic soda ash is produced by Solvay or Leblanc process by using common salts, sulphuric acid, limestone and coal. The natural soda ash acquire 30% of world soda ash production from which 90% of this is from U.S alone and the rest 70% of soda ash is dominated by synthetic production.

3.2.1 SODA ASH APPLICATIONS

Soda ash is composed of Sodium and Carbonate having the formula (Na, CO).n H2O, where n is the number of molecules per formula unit. It has some amount of NaOH. In present industrialization soda ash has a major role to play. Starting with manufacturing of glass to paper, textiles, medicine, cleansing products it has a huge impact on today's civilization.

Production of Glass

Soda ash is used in glass making as an ingredient during the molten glass forming process. This process includes silicon dioxide and calcium oxide present in raw glass are metamorphosed into silica, calcium oxide and sodium carbonate through a series of reactions that occur at high temperature which allows for more efficient extraction of soda ash from raw glass.

Soap and detergent Production

Soda ash is used in making both soaps and detergent. The first of these components is the process whereby the fats and oils are converted into fatty acids and glycerol. The reaction comprises of mixing of soda ash with sodium hydroxide, water and fatty material together in a process known as saponification. In other part of the soap production called alkali washing, soda ash is used as an ingredient in removing excess glycerol from fatty acids by a process called soda ash.

Dying agent

Soda ash can also be used as a drying gent in industrial equipment that needs to be dried after cleaning. When washed or rinsed off of industrial equipment or machinery this chemical agent evaporates taking with its excess water still left on the surface to dry completely.

Food

Soda ash has various use in edible industry. As an ingredient. it dehydrates the material such as table salt, crackers and pretzels.

Paper

Soda ash is also used in paper manufacturing process, improving the strength of paper pulp by increasing its water retention capabilities.

Waste air cleaning

Soda ash is used in waste water cleaning to remove dust through a process called ozonation. In this process the ozone is added to the hydrocarbon gasses present in waste air and is converted into ozone via electrolysis.

Soap analysis

Soda ash is used as an ingredient in the analysis of some soaps which helps determine their chemical composition and determine if they contain any additives or impurities.

To clean grease off concrete

Soda ash is used to clean build up off the concrete floors by a process called hydro-blasting where by water is mixed with special soda ash and blasted against floor.

Textile Industry

Sodium carbonate is a common ingredient in textile manufacturing which improves the life span of textile fibers as a result it allows the fabric to last longer.

As an ingredient in dying process, soda ash reacts with fatty acid and converts it into soap. This reaction occurs during dyeing and washing

Tile Descale

Soda ash is used as to remove build up off textiles and bath tubs.

Soda ash in our daily life

Soda ash is used for making soft drinks as well as wine and other beverages. It is also used to produce fizzy drinks and baking products.

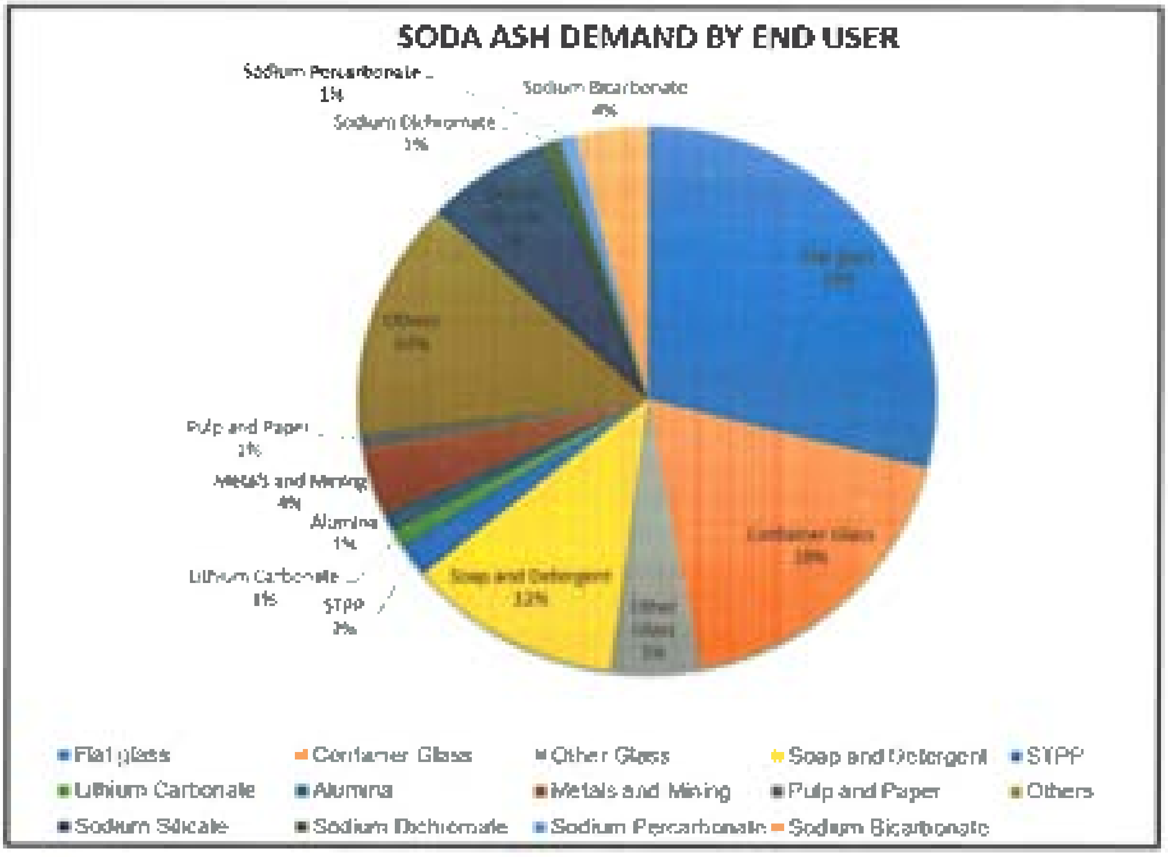

Figure 3: Soda Ash demand in Global Market

3.3 OUTLINE OF THE PROPOSED EXTRACTION PROCESS AND TECHNOLOGIES

Efficient processing technology is crucial for maximizing yield, minimizing costs, and maintaining environmental sustainability in natural soda ash exploration and production operations. For soda ash extraction, here the adopted processing technology depends upon the monohydrate method. Processing technology for natural soda ash production involves several key stages:

a) Calcination

b) Dissolving

c) Clarification

d) Evaporation and Crystallisation

e) Centrifugation

f) Drying

g) Packaging

a) Calcination:

Calcination is a thermal treatment process used in various industries, including soda ash production. In the context of soda ash manufacturing, calcination refers to the heating of sodium carbonate (Na_2CO_3) or bicarbonate ($NaHCO_3$) to high temperatures to drive off volatile components, such as water and carbon dioxide, resulting in the formation of anhydrous sodium carbonate, commonly known as soda ash (Na_2CO_3).

The calcination process typically involves heating the sodium carbonate or bicarbonate ore in a rotary kiln or a furnace at temperatures ranging from around 400°C to 800°C (752°F to 1472°F), depending on the specific requirements of the process and the desired properties of the final product.

During calcination, the following chemical reactions occur:

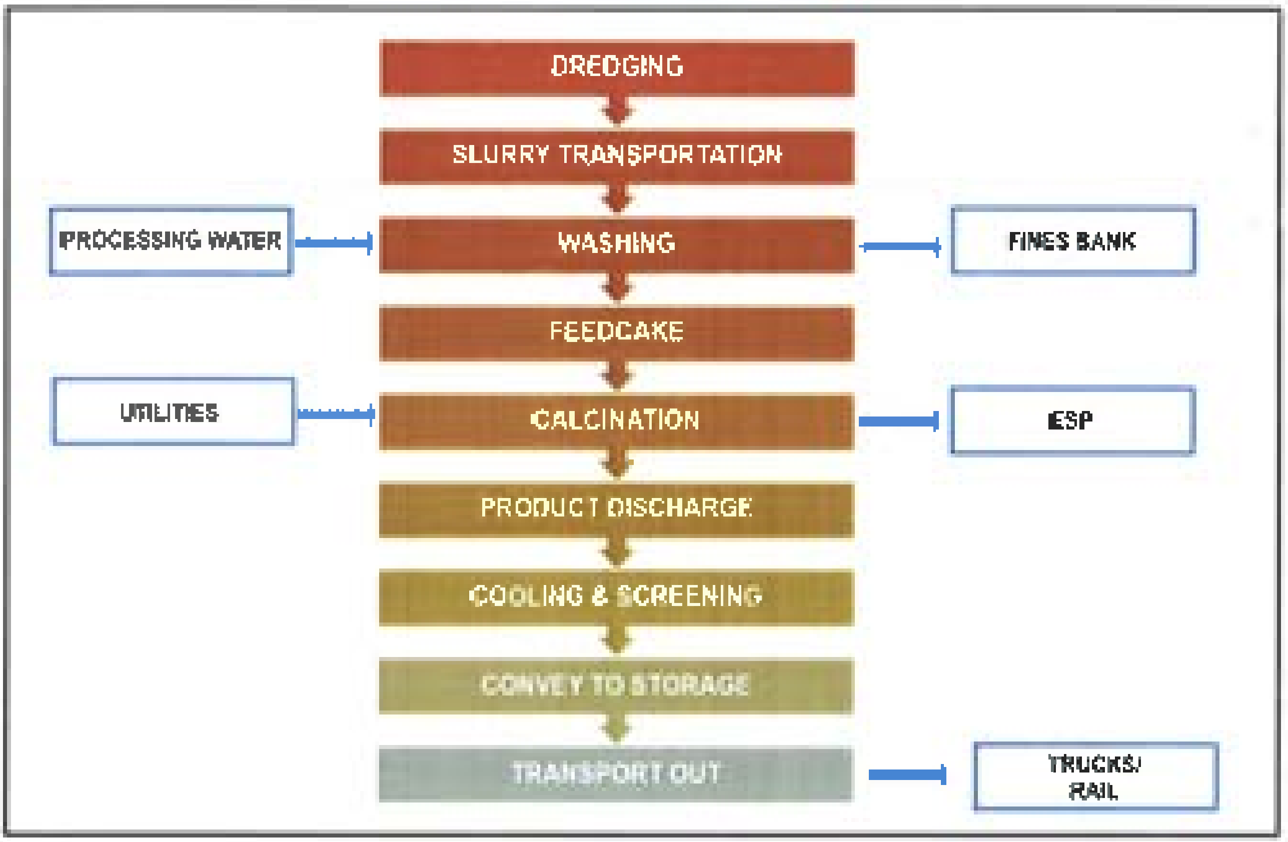

Figure 4: Monohydrate Procedure for Natural Soda Ash Extraction

b) Dehydration:

Sodium carbonate decahydrate ($Na_2CO_3 \cdot 10H_2O$), commonly known as trona, or sodium bicarbonate ($NaHCO_3$) loses water molecules as steam when heated, resulting in the formation of sodium carbonate monohydrate ($Na_2CO_3 \cdot H_2O$) or anhydrous sodium carbonate (Na_2CO_3).

Example reaction for trona:

$$Na_2CO_3 \cdot 10H_2O \rightarrow Na_2CO_3 \cdot H_2O + 9H_2O\uparrow$$

Decarboxylation: Sodium bicarbonate undergoes thermal decomposition to release carbon dioxide gas and form anhydrous sodium carbonate.

Example reaction for sodium bicarbonate:

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2\uparrow + H_2O$$

c) Dissolving

In this process, the calcined soda ash, often in the form of dense soda ash (sodium carbonate anhydrous) or light soda ash (sodium carbonate monohydrate), is dissolved in water to form a saturated sodium carbonate solution. This solution serves as the raw material for subsequent processing stages for the production of soda ash.

The dissolving process is a critical stage in soda ash production, as it converts the calcined soda ash into a soluble form that can be further processed to obtain the desired purity and particle size characteristics as required.

The dissolving process generally involves the following steps:

d) Mixing

The calcined soda ash is mixed with water in a dissolving tank or vessel. The ratio of soda ash to water is carefully controlled to achieve the desired concentration of the sodium carbonate solution.

e) Heating

In some cases, the dissolving process may involve heating the water to facilitate the dissolution of soda ash, particularly if the soda ash has a high density or if the dissolution rate needs to be accelerated.

f) Agitation

Agitation or stirring is employed to promote the dissolution of soda ash and ensure uniform mixing of the solution. This helps to maximize the contact between the soda ash particles and water, leading to faster dissolution.

g) Clarification

In soda ash production, clarification is a process used to remove impurities and solid particles from the sodium carbonate solution obtained during the dissolving stage. The clarification process is essential for achieving the desired purity and quality of soda ash, which is crucial for various industrial applications.

The clarification process typically involves Coagulation and Flocculation processes. In some cases, coagulation and flocculation agents may be added to the soda ash solution to help agglomerate fine particles and suspended solids, making them easier to remove during filtration. Common coagulants include alum (Aluminium Sulphate) or polymeric flocculants.

h) Evaporation and Crystallisation

Evaporation and crystallization are key processes in soda ash production, typically occurring after the dissolving and clarification stages.

These processes involve concentrating the sodium carbonate solution obtained from dissolving the calcined soda ash and then crystallizing it to produce solid soda ash crystals or granules.

The sodium carbonate solution, obtained after dissolving the calcined soda ash and clarifying it to remove impurities, is fed into evaporation ponds. In these evaporation ponds, the water gets evaporated from the solution, leaving behind a concentrated sodium carbonate solution.

Once the sodium carbonate solution reaches a desired level of concentration, it is transferred to crystallizers or crystallization tanks. In these tanks, the concentrated solution is cooled slowly under controlled conditions to induce the formation of soda ash crystals or granules.

i) Centrifugation

In soda ash production, centrifugation is a common separation technique, to separate solid particles from liquid solutions or suspensions, allowing for the recovery of high-purity soda ash crystals or granules.

Centrifuges are rotating devices that apply centrifugal force to the suspension, causing the solid particles to migrate toward the outer wall of the centrifuge and form a cake, while the liquid is expelled through the openings in the centrifuge basket.

j) Drying

After the crystallization process and subsequent centrifugation process, the soda ash crystals contain residual moisture that needs to be reduced to meet the required moisture content for the final product.

These soda ash crystals or granules are then transferred to drying equipment. These dryers utilize hot air or other drying mediums to evaporate the moisture from the soda ash particles.

During drying, the moisture content of the soda ash is monitored continuously to ensure that it meets the specified requirements for the final product. The drying process is carefully controlled to ensure that the soda ash is dried to the desired moisture content without overheating or damaging the product.

Drying is a crucial step in soda ash production, as it helps to improve the shelf life, handling properties, and quality of the final product. Proper drying ensures that the soda ash meets the stringent specifications required for various industrial applications, such as glass manufacturing, detergents, pulp and paper, and chemicals.

k) Packaging

Once the soda ash crystals or granules have been dried to the desired moisture content, they are packaged into various types of containers suitable for storage, transportation, and handling.

Packaging is the final stage in soda ash production before the product is ready for distribution and use.

Packaging plays a crucial role in soda ash production, as it ensures that the product reaches customers safely and in optimal condition| Proper packaging also helps to protect the soda ash from moisture, contamination, and damage during storage and transportation, ensuring its quality and performance in industrial applications

3.4 ENVIRONMENTAL CONSIDERATIONS SPECIFIC TO LAKE NATRON

The ESIA baseline work has found that there is indeed change occurring, both near the Lake and in the catchments of the rivers feeding Lake Natron. This change will accelerate exponentially the accessibility of roads and logistics as well

There have been many concerns expressed due to the location of the proposed project in a wetland of international concern, the Lake Natron Ramsar Site. The importance of the Lake to certain bird populations and the transboundary importance of the lesser flamingo population which, although breeding at Lake Natron, moves about and Feed in most of the Rift Valley Lakes has been identified as an important trans frontier concern and thus potentially affects countries in addition to Tanzania.

Birds, particularly internationally threatened species that are large and well known, will have large-scale international support if the wider public feels there is any threat to them from the project. This makes decision-making move from being based on environmental and economic criteria to that of the political arena

1.1.1 Summary of Impact Rankings on Administrative and Planning Impacts

No.	Component	Specific Activity and Aspects	Impact	Rank
P/C 1	Changes in groundwater quality/quantity	Water abstraction for plant and housing	Depletion of fresh groundwater	
		Seepage of effluent into groundwater	Groundwater pollution and loss of aquifer	
		Solid waste management	Leachate from solid water reaching groundwater or seeping into the Lake	
P/C 2	Changes in crop and grazing areas	Establishment of plant, housing, and access corridors	Loss of grazing land	

	(productive land)			
			Loss of critical dry season grazing along SE shores of Lake Natron	
P/C 3	Changes in pollution discharges	Operation of plant	Emissions and discharges that will negatively impact on the Lake	
P/C 4	Changes to Lake water quality	Encroachment of used water within the lake after usage at the soda ash site	The impact will not be significant at the preliminary stage.	
		Use of fresh water in the soda ash abstraction process. Use of surface water flows that enter the Lake	Lake water composition changed due to soda ash abstraction and the increase of fresh water from the process	
		Removal of soda ash from the Lake	Lake chemical composition significantly changed due to Soda Ash abstraction	

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P/C 5	Change in sound levels	Operation of the plant, steam, and power plants will create noise	High noise levels will reduce the wilderness value of the Lake environment and disturbance to biota	
P/C 6	Change in air quality	Air quality	No significant pollution as any sort of impact at the preliminary stage of work, but later it may be impactful and require precautions, control, and measures.	

Table 2: Summary of Impact on Administrative and Planning

1.1.2 Summary of Changes to the Biological/Ecological Environment

No.	Component	Specific Activity and Aspects	Impact	Rank
B/E 1	Changes to fish populations	Change in water composition due to removal of soda ash or changes of freshwater inflows	Threat to the viability of endemic fish populations	
B/E 2	Changes in biodiversity	Change in water composition due to removal of soda ash or	Potential threat to endemic species of fish. Threat to lesser flamingo populations	

		changes of freshwater inflows		
B/E 3	Changes in disease vector populations	Domestic waste attracts pests. Abandoned borrow pits providing mosquito breeding sites. Increase in the introduction of vectors through human and vehicle movement	Introduction of animal pests and pathogens	
B/E 4	Changes in aquatic biota	Abstraction of surface water	Loss of freshwater habitats in the Lake due to dry season abstraction	
B/E 5	Changes to wetlands	Abstraction of fresh water from west shore rivers entering the Lake	Loss of freshwater wetlands.	
B/E 6	Changes to areas of natural habitat (including protected areas)	Abstraction of fresh water from rivers entering the Lake	The lake surface and the wetlands provide feeding, shelter, and nesting sites for several water birds, reptiles, and amphibians that are important to the Lake ecosystem. Any changes that would dry out the wetlands would adversely impact this important ecosystem	

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B/E 7	Changes to the Ramsar ecological character criteria	The influence of conservation status of wildlife and habitats. Suggestions to strengthen the legal basis for protecting the area by banning hunting in the Ramsar site		

Table 3: Summary of Biological and Ecological Environment

4. MARKET ANALYSIS

The global soda ash market is experiencing significant growth, projected to reach approximately USD 36.2 billion by 2032, with a compound annual growth rate (CAGR) of 6.6% from 2024 to 2032. The market was valued at around USD 21.5 billion in 2023, indicating a robust demand driven by various industries, particularly glass manufacturing and detergents. The rising trends in construction and automotive industries are major contributors to this demand, as soda ash is a key ingredient in producing glass products used in these sectors. While synthetic soda ash dominates the market, accounting for about 67.8% of total production, naturally extracted soda ash is gaining traction due to its lower production costs and environmental benefits. The natural extraction process typically requires less energy and results in fewer impurities compared to synthetic methods, making it an attractive alternative in regions with accessible resources like Lake Natron.

The extraction and utilization of soda ash from natural sources like Lake Natron could significantly impact Tanzania's economy. The potential for job creation in extraction, processing, and ancillary industries is substantial. A soda ash project could generate hundreds of direct jobs and many more indirectly, contributing to local economic development. Furthermore, the revenue generated from soda ash sales could provide a significant boost to Tanzania's GDP, particularly if the country positions itself as a key supplier in the global market. The natural extraction of soda ash aligns with the global shift towards sustainable practices, allowing Tanzania to leverage its natural resources responsibly while meeting international demand.

4.1 GLOBAL AND REGIONAL DEMAND FOR SODA ASH

The global soda ash market was valued at approximately USD 21.5 billion in 2023 and is projected to grow to USD 38.2 billion by 2032, reflecting a compound annual growth rate (CAGR) of 6.6% during the forecast period from 2024 to 2032. This growth is driven by the increasing demand for soda ash across various industries, particularly glass manufacturing, which accounts for over 70% of total consumption.

Key Drivers of Demand

1. **Glass Manufacturing**: The primary driver of soda ash demand is the glass industry, which utilizes soda ash to lower the melting point of silica sand, a key ingredient in glass production. The growth in construction and automotive sectors, especially in emerging economies, has led to a surge in glass demand for windows, containers, and automotive applications.
2. **Detergents and Chemicals**: Soda ash is also a critical ingredient in the production of detergents and various chemicals. The rising consumer demand for cleaning products, coupled with the growth of the chemical industry, further propels the need for soda ash.
3. **Urbanization and Industrialization**: Rapid urbanization and industrial development in regions such as Asia-Pacific are creating significant opportunities for soda ash consumption. The construction boom in countries like China and India is a major contributor to increased soda ash demand.
4. **Sustainable Practices**: There is a growing trend towards adopting environmentally friendly production methods in soda ash manufacturing. Innovations aimed at reducing carbon emissions and enhancing production efficiency are becoming increasingly important, influencing market dynamics.

Regional Demand for Soda Ash

Asia-Pacific

The Asia-Pacific region dominates the global soda ash market, accounting for approximately 55% of the total market share in 2023. The demand in this region is primarily driven by:

- **Construction Activities**: The booming construction sector in countries like China and India is a significant factor, as these countries invest heavily in infrastructure development, leading to increased glass production.
- **Detergent and Chemical Industries**: The growing population and rising consumer incomes in emerging economies are boosting the demand for detergents and chemicals, further driving the need for soda ash.

North America

North America, particularly the United States, is a key player in the soda ash market, primarily due to its large deposits of trona, a natural source of soda ash. The region's demand is supported by:

- **Strong Glass and Detergent Industries**: The U.S. has a well-established glass manufacturing sector, which relies heavily on soda ash. Additionally, the detergent industry contributes significantly to soda ash consumption.
- **Sustainability Initiatives**: U.S. manufacturers are increasingly focusing on sustainable production practices, which may influence the demand for both natural and synthetic soda ash.

Europe

In Europe, the soda ash market is experiencing moderate growth, influenced by stringent environmental regulations that affect production methods. The demand is primarily driven by:

- **Glass and Chemical Industries**: Similar to other regions, the glass and chemical sectors are the main consumers of soda ash. However, the market faces challenges from regulatory pressures that encourage more sustainable practices.

Despite the positive growth outlook, the soda ash market faces challenges such as price volatility due to fluctuations in raw material costs and geopolitical tensions that can disrupt supply chains. However, the increasing focus on sustainability and the development of innovative production technologies present opportunities for market expansion.

4.2 PRICE TRENDS AND MARKET FORECAST

The price trends of the soda ash market have been influenced by various factors, including supply and demand dynamics, production costs, and global economic conditions. This note provides an overview of the current price trends, historical fluctuations, and future projections for soda ash prices.

Current Price Trends

As of late 2023, soda ash prices have exhibited a fluctuating pattern across different regions. For instance, in the Asian market, prices saw a significant decline, with a sharp fall of over 5% in futures contracts due to weak demand and high inventory levels. The average price of soda ash in the Chinese market dropped from approximately $392 per metric ton in October to about $389 per metric ton by December 2023.In North America, similar trends were observed, where prices varied within a narrow range. The average price stood at around $360 per metric ton in October 2023, reflecting a consistent but cautious market response to inventory levels and demand from end-user sectors.

4.2.1 HISTORICAL FLUCTUATIONS

Historically, soda ash prices have been subject to volatility due to several factors:

1. **Supply and Demand Imbalance**: Prices have often declined during periods of oversupply when production outpaced demand, particularly in regions like Asia and North America. For example, the latter half of 2023 saw a rebound in prices as supply and demand dynamics improved after a period of high inventory.

2. **Raw Material Costs**: The prices of raw materials, such as trona and sodium chloride, directly impact soda ash production costs. Fluctuations in these raw material prices, driven by geopolitical factors and weather conditions, can lead to variations in soda ash prices.

3. **Energy Costs**: Energy prices significantly affect the production costs of soda ash. Increases in energy costs due to global tensions or supply chain disruptions can lead to higher soda ash prices, while stabilization in energy prices may help in price recovery.

4.2.2 FUTURE PROJECTIONS

Market analysts predict that soda ash prices are likely to rise in the coming years. This expectation is driven by several factors:

- **Increasing Demand**: The demand for soda ash is anticipated to grow, particularly from the glass manufacturing industry, which is experiencing a resurgence due to construction and automotive sector growth. This demand is expected to push prices upward, with projections estimating prices could reach between $400 and $450 per metric ton by 2030.

- **Sustainability Trends**: The shift towards sustainable practices in production and packaging, particularly in the food and beverage sector, is likely to increase the demand for glass packaging, further driving the need for soda ash.

- **Market Recovery**: As production stabilizes in regions like China, which has faced equipment malfunctions and adverse weather conditions, a rebound in production could lead to more balanced supply and demand dynamics, supporting higher prices.

4.2.3 ESTIMATION OF FUTURE MARKET GROWTH

- **Short Term (2023-2026)**- The rising demand of Soda ash is observed because of the increasing population, growing urbanization and increase in cleaning home requirements.
- **Middle Term (2026-2029)**- the manufacturers are increasing the adaptation of the soda ash to develop organic and natural products.
- **Long term (2029-2033)**- the growing advance technologies, soap and detergent industry and government initiatives policies may drive the market in long run.

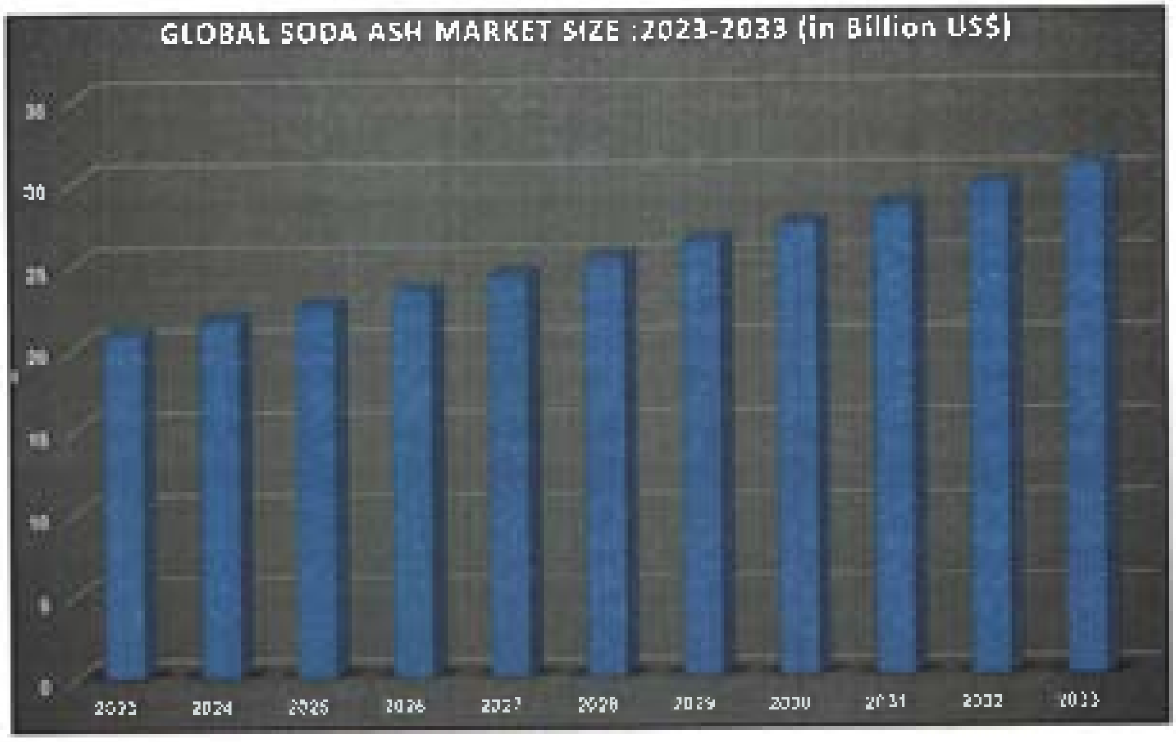


Figure 5: Future Forecast of Global Soda Ash Market

The soda ash market is currently experiencing fluctuating prices influenced by supply-demand imbalances, raw material costs, and energy prices. While recent trends have shown some decline in prices due to high inventory levels and weak demand in certain regions, future projections indicate a potential rise in prices driven by increasing industrial demand and sustainability initiatives. Understanding these price trends is crucial for stakeholders in the soda ash market, including producers, consumers, and investors, as they navigate the complexities of this essential commodity.

According to the current global market statistics, the construction sector shows an inflation of 37.5% since 2020-2023 and may occupy double of markets till the end of 2030. The glass industry and ceramic industry consumes the 50% global soda ash production followed by construction and automotive manufactures. Constructions, preparation of household things, doors, increase demand for container glasses in hotels and restaurants, flat glasses is significantly growing in the market.

The other end users of food industry, pharmaceutical and cosmetic manufactures are constantly growing their market in their forecast period. To maintain the sustainability of the environment. the rechargeable batteries, metallurgical process shows the emerging uses of Soda ash for the manufacture of Lithium carbonate and extraction of smelting of various metals especially alumina products.

Increasing consumer demand for dyes and reducing pollution to improve the environment boosts market share. On the flip side, the demand for soda ash in water treatment, eliminating corrosion and use for making baking powder in the food sector propels market size. The adaptation of soda ash to develop various chemicals such as sodium bicarbonate and silicate in the glass industry is driving the market growth.

4.3 COMPETITORS AND ALTERNATIVE SOURCES OF SODA ASH

The soda ash market is characterized by its diverse applications, significant economic impact, and competition between natural and synthetic sources. As industries worldwide increasingly rely on soda ash for various processes, understanding the competitive landscape and alternative sources is crucial for stakeholders in the market. This essay explores the key competitors in the soda ash market, alternative sources of soda ash, and the implications for producers and consumers.

4.3.1 COMPETITORS IN THE SODA ASH MARKET

4.3.1.1 Major Producers

The global soda ash market is dominated by several key players, each contributing to the supply chain through different production methods. Some of the notable companies include:

- **Solvay**: A leading producer of both natural and synthetic soda ash. Solvay operates several plants worldwide, leveraging its extensive experience in chemical manufacturing.

- **Ciner Resources Corporation**: This company is known for its natural soda ash production from trona, primarily in the United States. Ciner is one of the largest producers in North America, benefiting from the region's abundant natural resources.

- **Tata Chemicals Ltd**: Based in India, Tata Chemicals is a significant player in the soda ash market, producing both light and dense soda ash for various applications, including glass and detergents.
- **GHCL Limited**: Another major Indian producer, GHCL focuses on the production of soda ash from natural sources and has a strong presence in the domestic market.
- **Lianyungang Soda Ash Co. Ltd**: This Chinese company is a key player in the Asia-Pacific region, contributing to the high demand for soda ash driven by industrial growth in China.

These companies compete based on production capacity, cost efficiency, product quality, and sustainability practices. The competition is further intensified by the growing emphasis on environmentally friendly production methods, as consumers and regulators increasingly demand lower carbon footprints.

4.3.2 Alternative Sources of Soda Ash

4.3.2.1 Natural Sources

1. **Trona**: The most significant natural source of soda ash, trona is a mineral composed of sodium carbonate and sodium bicarbonate. Major deposits are found in the United States, particularly in Wyoming, where companies like Ciner Resources extract soda ash through mining operations. Natural soda ash from trona is favored for its lower environmental impact compared to synthetic production methods.
2. **Lake Brines**: Soda ash can also be extracted from alkaline lakes, such as Lake Natron in Tanzania. The evaporation of brine from these lakes results in the precipitation of sodium carbonate. This method is less energy-intensive and can be more sustainable than synthetic production, making it an attractive alternative for regions with suitable natural resources.

4.3.2.2 Synthetic Sources

1. **Solvay process**: The most common synthetic method for producing soda ash, the Solvay process utilizes sodium chloride and limestone. This method is prevalent in regions with limited natural resources but requires significant

energy input and generates carbon dioxide as a byproduct, raising environmental concerns.

2. **Dual-Process:** Some manufacturers employ a dual-process approach, combining natural and synthetic methods to optimize production efficiency and reduce costs. This hybrid approach allows for flexibility in response to market demand and resource availability.

4.3.2 IMPLICATIONS FOR PRODUCERS AND CONSUMERS

The competition between natural and synthetic sources of soda ash has significant implications for both producers and consumers:

- **Cost Dynamics:** Natural soda ash production often has lower operational costs, particularly in regions with abundant trona or alkaline lakes. This cost advantage can lead to competitive pricing for natural soda ash, benefiting consumers in price-sensitive markets.
- **Sustainability**: As environmental regulations become stricter, producers are increasingly pressured to adopt sustainable practices. Natural sources of soda ash generally have a lower environmental impact, making them more appealing to consumers and companies focused on sustainability.
- **Market Trends**: The growing demand for soda ash in emerging markets, particularly in Asia-Pacific, is driving competition. Producers must adapt to changing consumer preferences and regulatory landscapes, which may favor natural sources over synthetic production.

The soda ash market is shaped by a competitive landscape that includes major producers and various sources of supply. Natural sources, such as trona and lake brines, present significant opportunities for sustainable production, while synthetic methods continue to play a vital role in meeting global demand. As industries increasingly prioritize sustainability and cost-effectiveness, understanding the dynamics between competitors and alternative sources will be crucial for stakeholders navigating the evolving soda ash market.

4.4 POTENTIAL CUSTOMERS AND OFF TAKE AGREEMENTS

4.4.1 Potential Customers

1. Glass Manufacturing Industry

The glass industry is the largest consumer of soda ash, accounting for over 40% of global demand. This sector includes manufacturers of flat glass for buildings, automotive glass, and container glass. Key customers in this industry typically include:

- **Automotive Manufacturers**: Companies producing laminated and tempered glass for vehicles.
- **Construction Firms**. Builders requiring glass for windows, facades, and other architectural elements.
- **Glass Container Producers**: Manufacturers of bottles and jars for food and beverages.

2. Detergent and Cleaning Products

Soda ash is a vital ingredient in the production of detergents and cleaning agents. The increasing awareness of hygiene and cleanliness among consumers drives demand in this sector. Potential customers include:

- **Consumer Goods Companies**: Firms producing laundry detergents, dishwashing liquids, and household cleaners.
- **Industrial Cleaning Suppliers**: Companies providing bulk cleaning solutions for commercial and industrial applications.

3. Chemical Manufacturing

Soda ash is used in various chemical processes, including the production of sodium bicarbonate, sodium silicate, and other chemicals. Key customers in this segment include:

- **Chemical Producers**: Manufacturers of specialty chemicals that require soda ash as a raw material.

5. RESOURCE ESTIMATION

5.1 DETAILED GEOLOGICAL SURVEY OF LAKE NATRON

5.1.1 GEOLOGICAL MAPPING

Geological exploration involves studying the Earth's structure and composition to understand its history. Mapping helps to create representations of geological features, aiding in resource identification and environmental management. This can include fieldwork, remote sensing, and geophysical surveys.

As the licensed areas are part of Lake Natron, they are considered to be rich in well-established geological structures. The geological structures are formed due to the diverging moments of the Nubian African Plate (Containing a large part of Africa) and Somalian Plate by giving rise to the East African Rift Valley. The major geological structures that are found in that area are Minor Faults, Major Faults, Salt Pan Deposits, and volcanoes (rich in carbonatite plumes), etc.

In the process of geological mapping, the geologists visited the licensed area and recorded the geological information. Information related to lithotypes, structures such as folds, faults, joints, and the evidence of rocks undergoing deformation were inscribed.

In the period of Geological mapping conducted by the team of geologists, focused and recorded the ore mineral evidence, catchment area, source of the deposit, medium of transportation, and other related facts related to the deposits. Depending upon the scale and extent of the mapping, the detailed geology of the area was demonstrated.

5.1.2 GEOLOGICAL SAMPLING

Geological sampling before mining is crucial for assessing the potential mineral deposits and understanding the geological conditions of a site. Samples are collected to analyse the composition, mineralogy, and distribution of resources. This data helps in designing efficient mining plans, estimating reserves, and implementing environmentally responsible extraction methods.

To satisfy the project objectives, the identification of the mineral and the estimation of mineral resources will be conducted in phases. In the first phase, it is proposed to collect samples at a 2 km grid pattern (Fig.19). The team started collecting samples in PL-12236, and as per field condition and accessibility there are some changes in the sample location. Due to the failure of auger drilling which hardly pierces 0.3m, a proposal for pitting was recommended along with systematic sampling at different depths. Further, the water was collected and the time for accumulation of water in the field with temperature and pH were recorded and the water samples were also sent for analysis. It was proposed to dissolve the raw sample in warm water so that all chemical precipitates are collected as solutions after the dissolution of the precipitate in water. Then the water is kept for evaporation to get back the precipitate for analysis.

It was observed that the resemblance of the water was red in colour due to the presence of cyanobacteria (The colour of the cyanobacteria was red). While moving in the field site; the team of geologists, fellow workers, and locals experienced a higher thickness of mud as well as geothermal heat from the base.

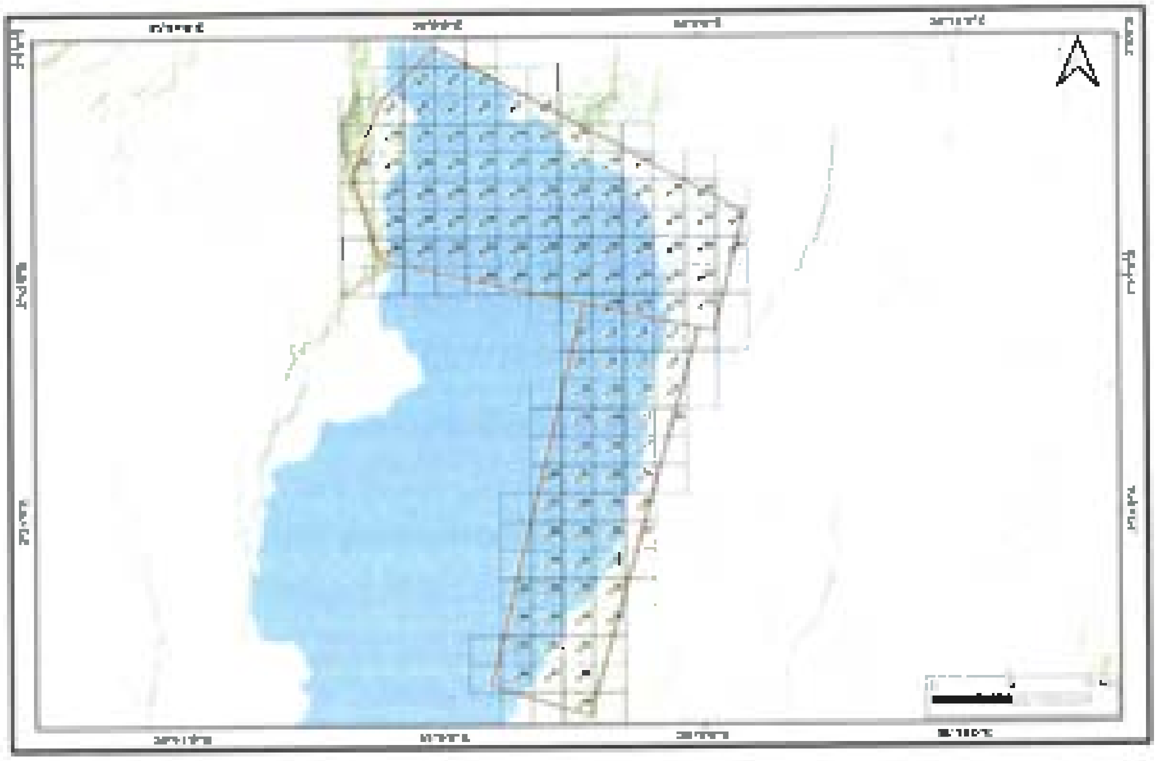


Figure 6: Proposed prospecting locations for sample extraction.

Figure 7: Trona sample collected in the Project Area

Geological structural features such as fault plane (Western side of Gregory rift) exist on the western side which makes a steep area in the western part of PL- 12236. It is also extended towards the South-west. Due to the major Gregory rift system, many second-order / third-order small rift systems are developed in the lake which are present as hot springs and also facilitate the flow of alkali carbonatite magma from Ol-Doniyo Lengai volcano situated at a distance of 20 km south of the Project Area.

The points that existed on the alluvial fans were their prime target in the initial phase of sampling due to easy access. It was proposed to collect the sample in depth for which locally arranged hand-auger drilling was deployed (Fig. 18). The drilling cannot be executed beyond 0.3m which was not able to solve our problem. In addition to that, the team collected water samples from the hot springs in the nearby area along with the estimation of temperature, pH, and elevation. According to the field observation of the team geologist, there are many hot springs present in the area.

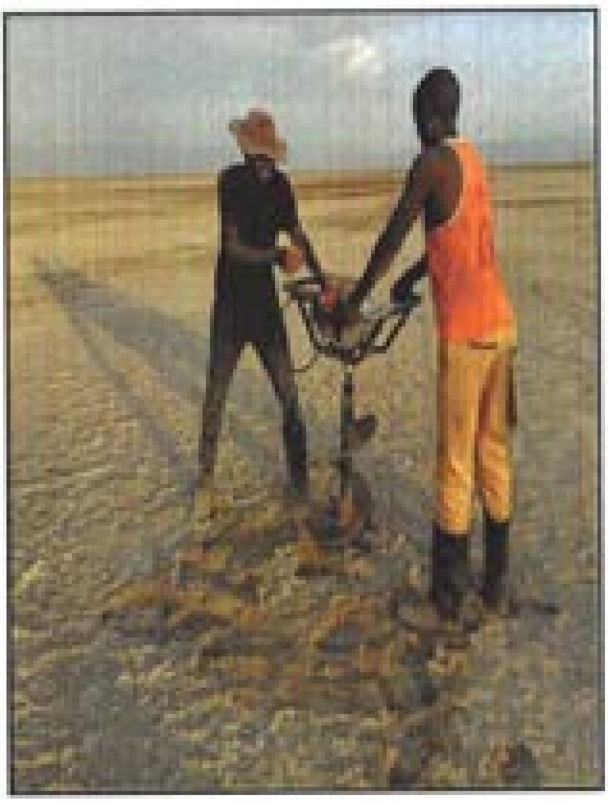


Figure 8: Sampling by hand auger drilling

The Lens-thinned soda ash deposits were marked just on the surficial exposure, below that mud including clay of black colour was present. By footsteps during our movement for exploration, the black clay became exposed comprehensibly. That area of the lake was surrounded by plenty of mud. The team collected a clustered crystallized trona sample in the Project Area as well. Thin lenses of trona and isolated deposits were recorded as precipitated. The Lens-thinned soda ash precipitate was marked above the detrital mud sediments (black colour clay). The extension of black clay is throughout the lake area which is deposited by the rivers. The precipitation of chemical and detrital sediments is in sequence for which the soda is found in deltas. Moving progressively, the geologists found the crystallized chemical sediment (trona) layer deposit, along with the detrital mud showing mud which was a positive indicator for our exploration team.

As the team cannot collect samples in-depth, the advisory committee suggested digging pits of 1.5 m or to the depth possible. The samples were collected at 0.5 m. interval in depth to assess the solubility of the alkali carbonate deposited and the percentage of alkali carbonates. Sections are drawn in north-south and north-east south-west directions.

Thin lenses of Trona deposit.

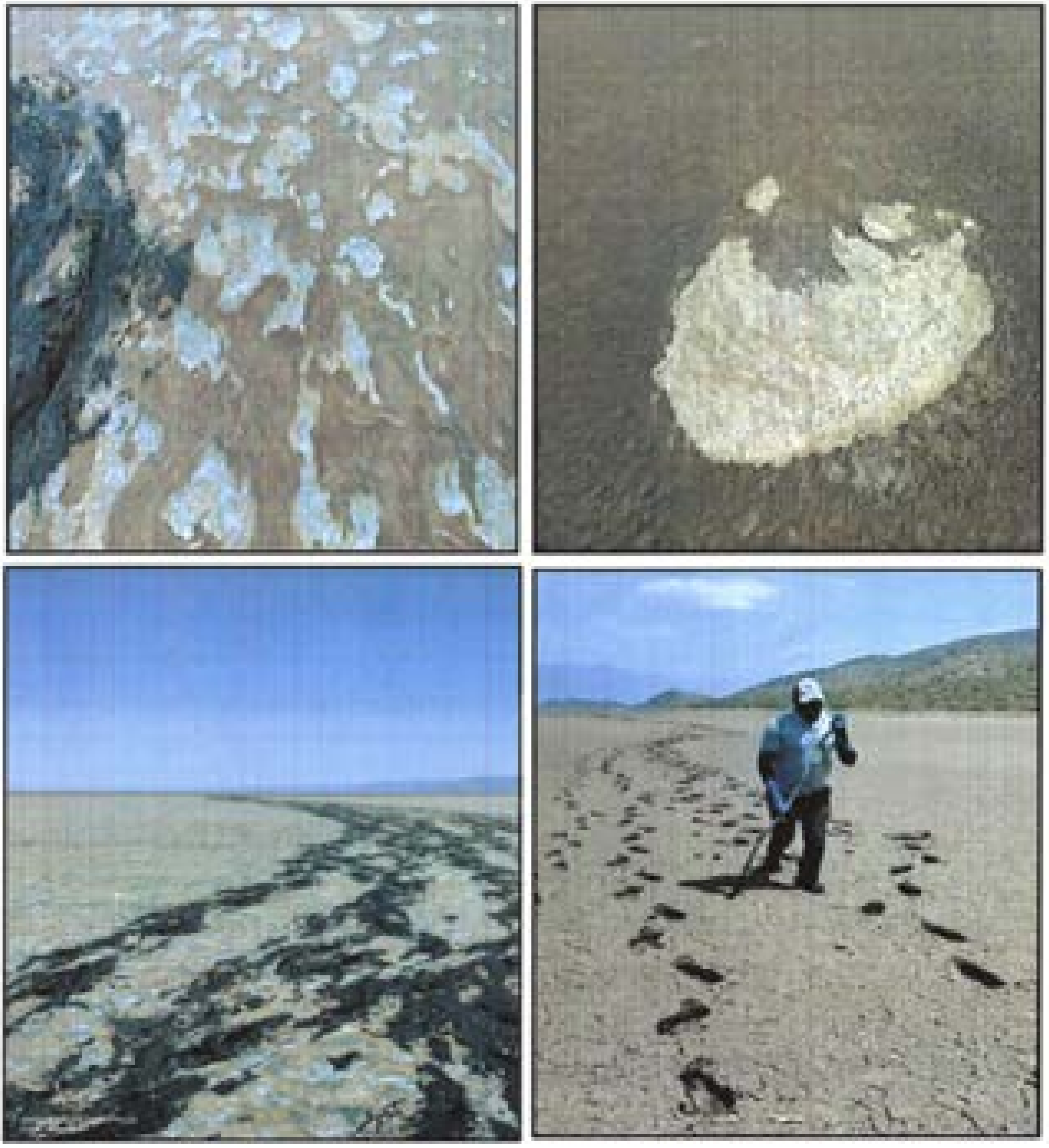


Figure 9: Lense-thinned Soda ash deposit

Figure 10: A clustered crystallized trona sample.

Figure 11| Mud cracks and crystallized chemical sediment (trona) layer.

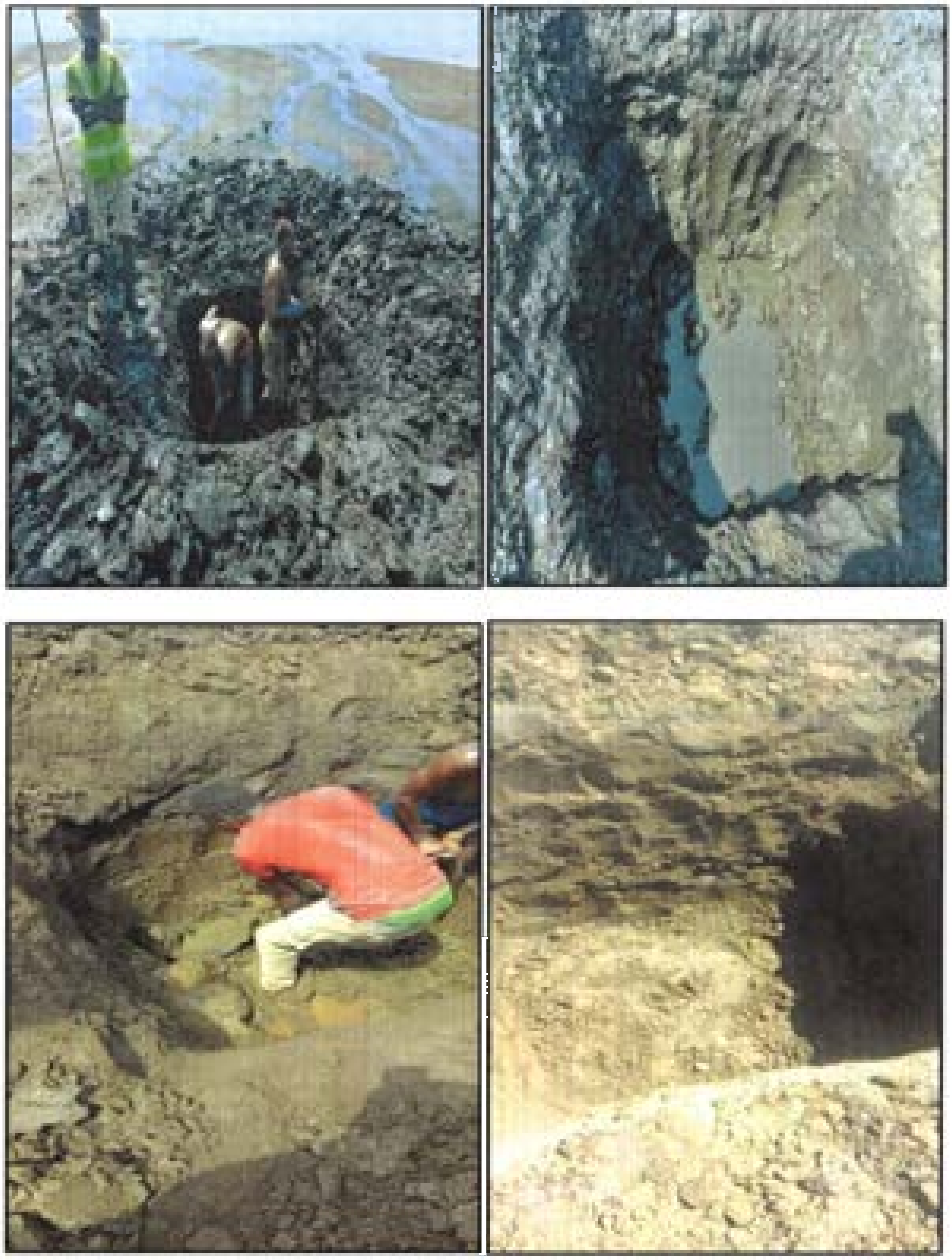
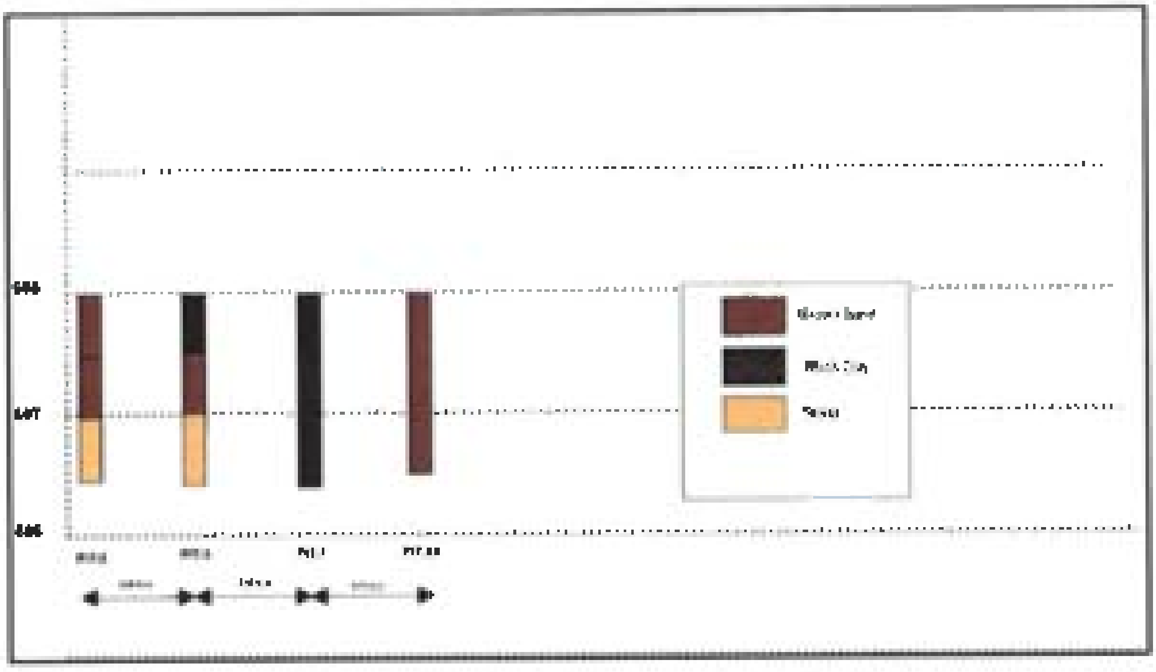


Figure 12: Sampling by pitting technique.



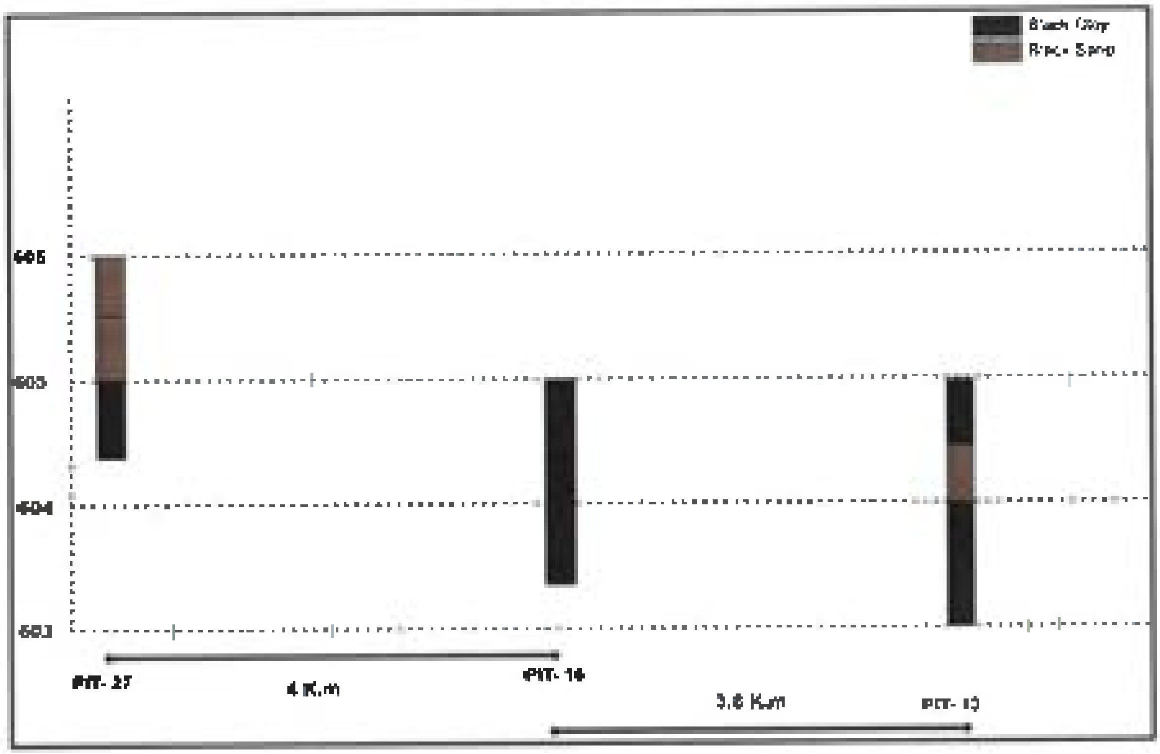


Figure 13: Graphical representation of lithology in section.

Figure 14: Trona bed deposit beneath the surface in the Project Area

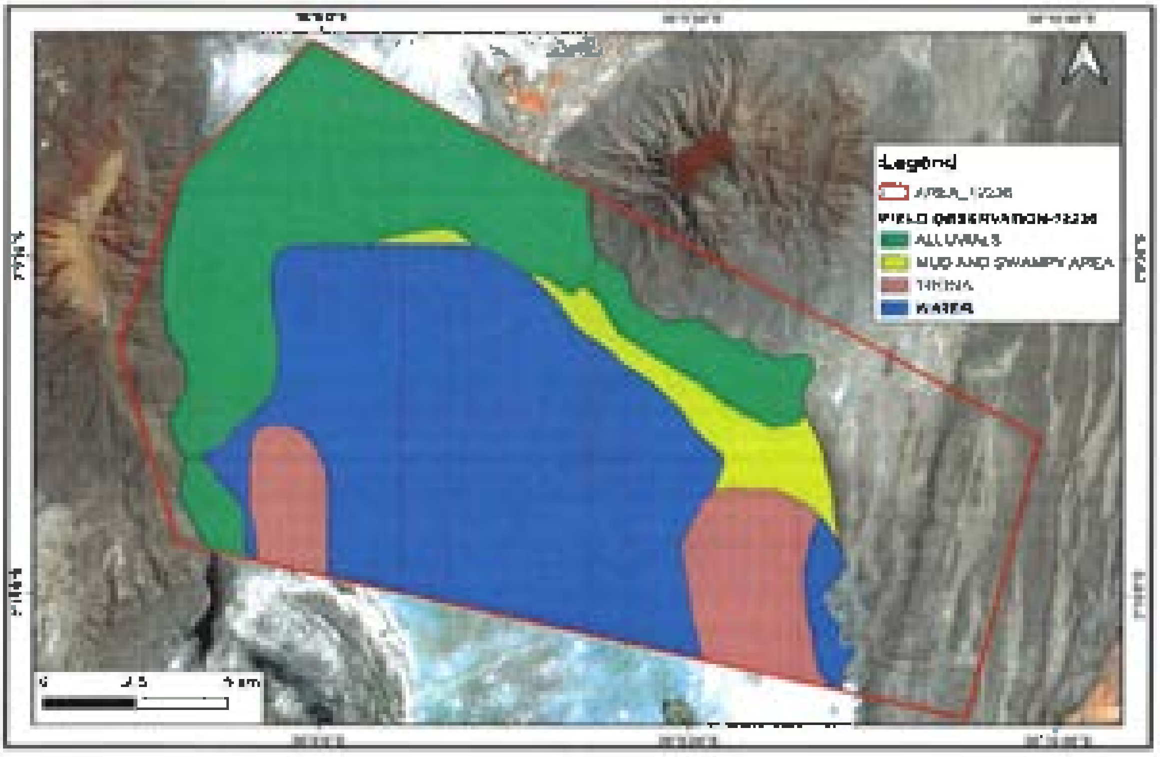


Figure 15: Detailed Geological map of PL-12236/2023

5.1.3 GEOCHEMICAL ANALYSIS

A 2 km grid was developed to collect rock, soil, and water samples from Lake Natron to analyse soda ash content and associated geochemical indicators.

Geochemical analysis for Soda Ash exploration involves determining the composition and quality of the potential Soda Ash deposit. Here are the steps involved in conducting this analysis:

Sample collection:

Samples were collected from different locations within the soda ash deposit while conducting Geological mapping. The samples cover different areas and depths of the deposits to account for variations in composition. Appropriate sampling techniques were followed to minimize the contamination.

Sample preparation:

Soda ash samples were prepared for analysis by crushing and homogenizing them. This ensures that representative subsamples can be taken for future analysis.

For the treatment of the sample, we provided heat to the extracted sample from the respective locations, then mixed it with 2L of water (before putting it on heat, we kept it for natural drying by natural evaporation, then we added water of 2L to it, and after that, we separated the water from suspended deposited materials, and again we rinsed two times the remaining residue sediment, then we collected the water sample altogether and added heat to it). Then we dried the boiled sample, and after crystallization of the same sample, we kept the crystallized sample safely for further chemical analysis in the lab.

Figure 16: Sampling treatment for chemical analysis.

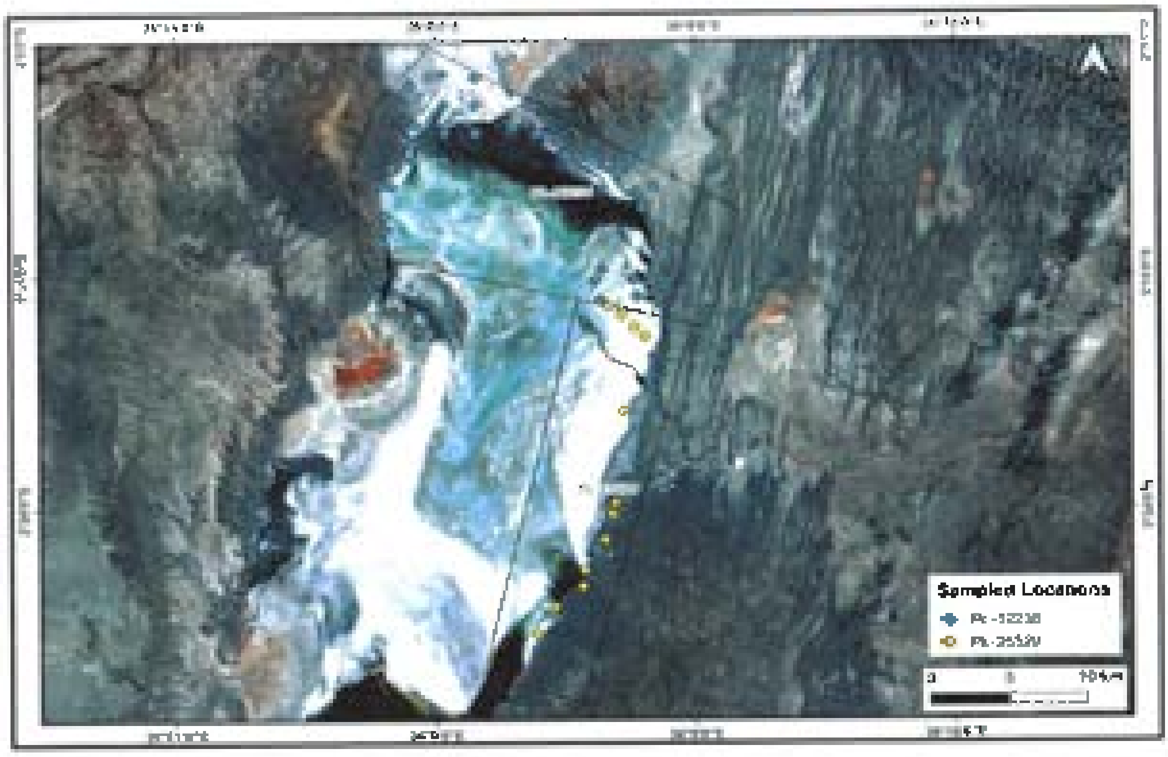


Figure 17: Collected sample location map of the Project Area

5.1.4 DRILLING

Drilling for soda ash involves various drilling techniques depending on factors such as the depth of the deposit, the geological characteristics of the formation, and environmental considerations. The selection of the appropriate method for the drilling technique depends on factors such as geological conditions, project requirements, and environmental considerations. Effective drilling operations are essential for accurately assessing soda ash reserves and optimizing the extraction process while minimizing environmental impact.

Core drilling is used to obtain cylindrical rock samples (cores) from the subsurface. This technique provides valuable information about the geological structure, mineral composition, and quality of the soda ash deposit. The core after drilling, is then retrieved and analysed to determine the presence and grade of soda ash. These methods allow geologists to collect samples and assess the quality and quantity of the soda ash reserves.

Samples obtained during drilling are analysed in laboratories to determine the concentration of soda ash and assess the economic viability of the deposit. This information is crucial for estimating the size of the resource and planning future extraction activities. Using data from drilling and sample analysis, resource estimation calculations are performed to determine the total volume of soda ash reserves in the deposit. This information helps in long-term planning and investment decisions.

Drilling Set-up Information:

- The drilling process is executed by TC bit.
- Casing length: 14m
- Diameter: 5 inches
- Drilling Rod Length: 70m
- Diameter: 3 inches
- No. of core barrels available: 2
- Length. 2m each
- Diameter: 3.5 inches

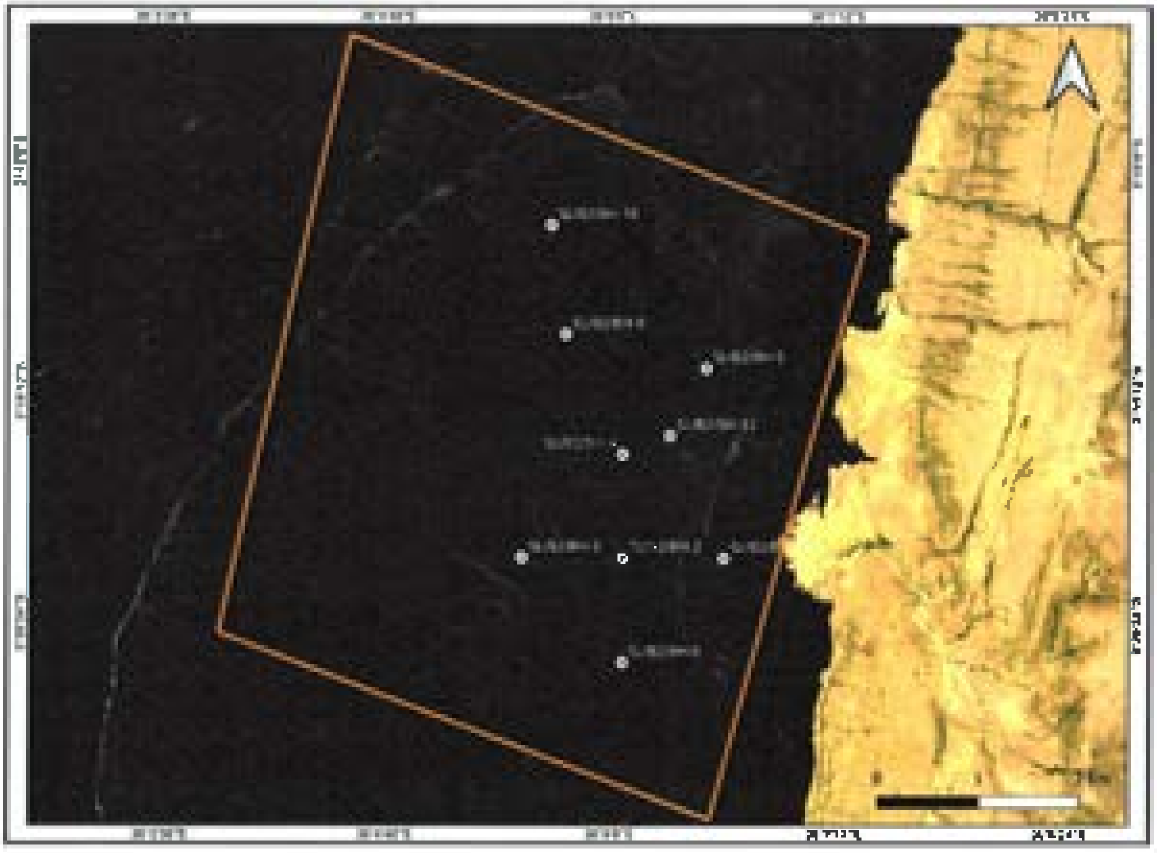


Figure 18: BH location in Block 2 of PL/25529/2023

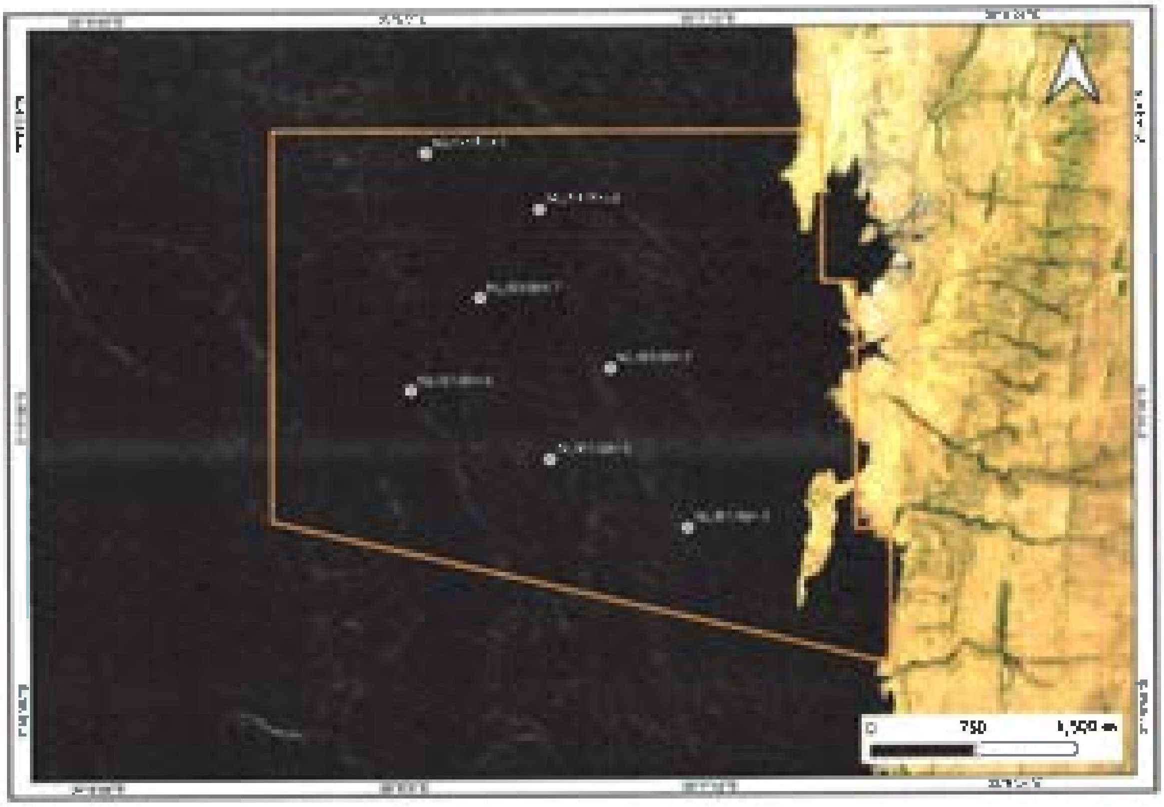


Figure 19: BH location in Block 1 of PL/12236/2023

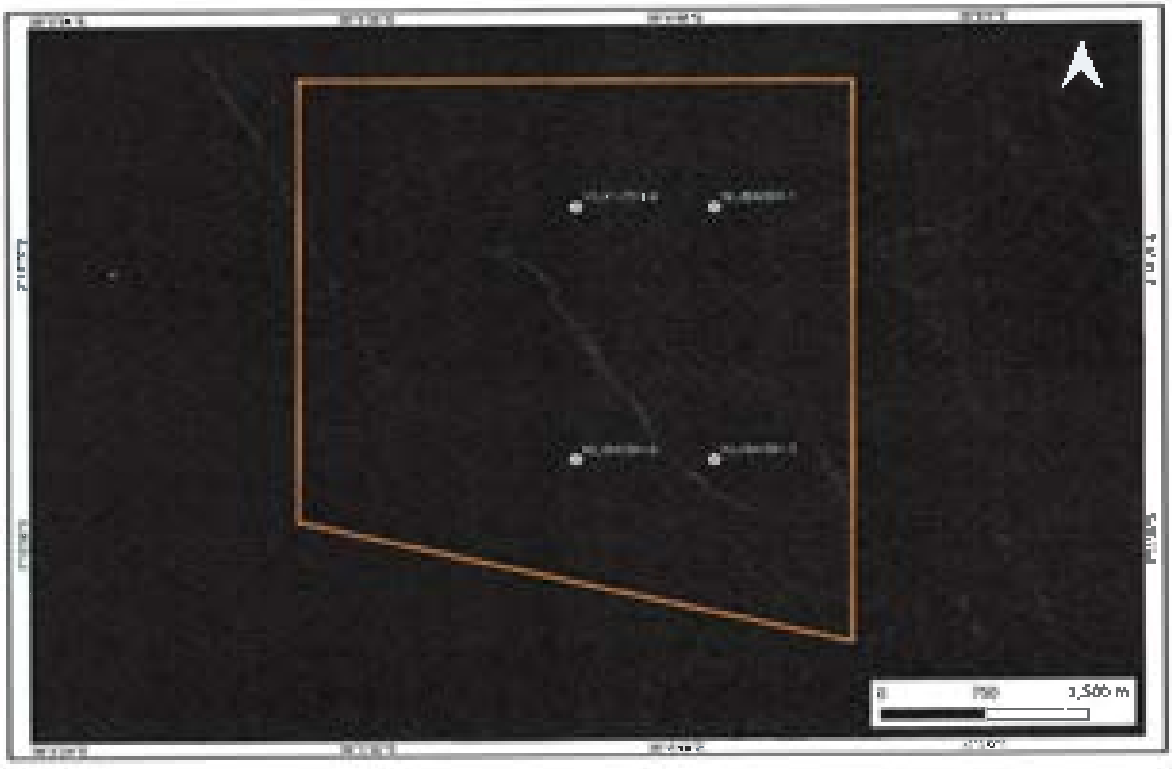


Figure 20: BH location in Block 4 of PL/12236/2023

5.2 ESTIMATION OF SODA ASH RESERVES

The total resource estimated in the explored area is 243.7Million Ton covering an area of 60 Sq. K.m. The Prospecting licences are divided into certain blocks and the resource has been estimated. The details of the blocks representing their resources are given below.

SL.NO	BLOCK ID	AREA (Sq km.)	RESOURCE (In million ton)
1	BLOCK-2, PL/25529/2023	30	93.58
2	BLOCK-1, PL/12236/2023	14.562	53.88
3	BLOCK-4, PL/12236/2024	15.948	96.3
TOTAL	243.7 million Ton		

Table 4: Estimated Resource

5.2.1 BLOCK-2, PL/25529/2023

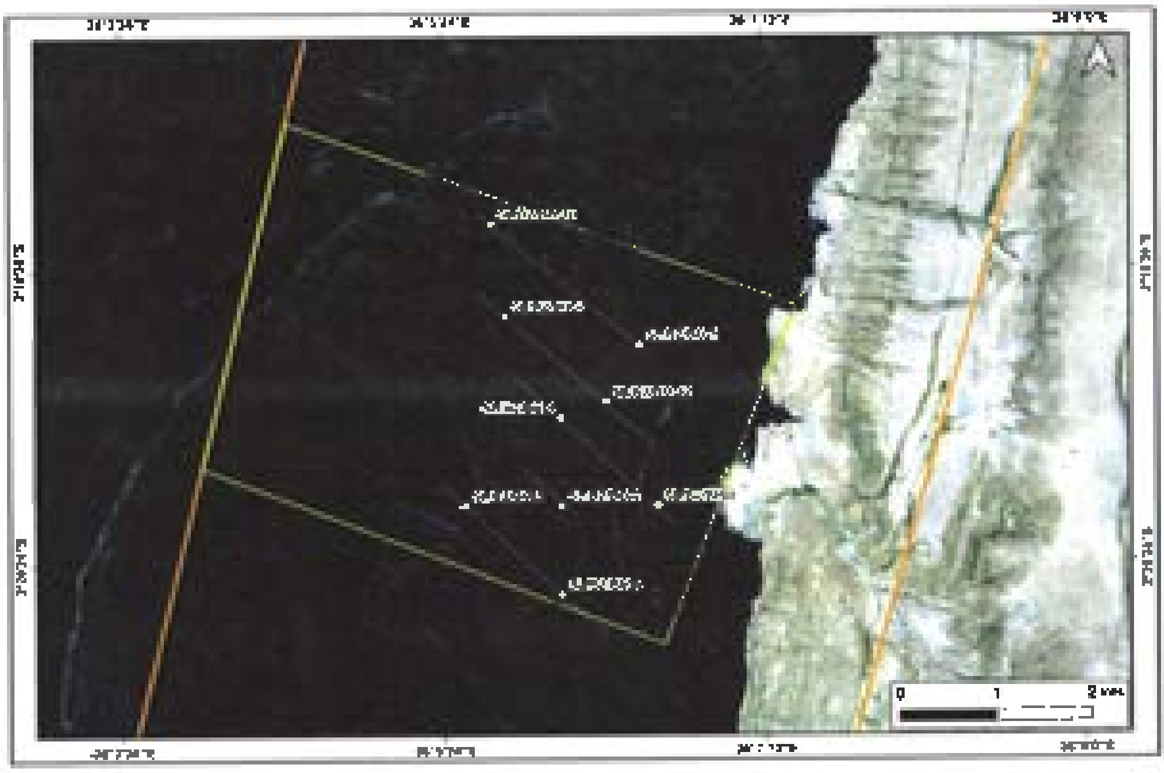


Figure 21| Section line and Bore Hole performed at Block-2, PL/25529/2023

Section Line	Contained Bore Holes
A-A'	SL/B2/BH-10 & SL/B2/BH-5
B-B'	SL/B2/BH-9 & SL/B2/ BH-12
C-C'	SL/B2/BH-4 & SL/B2/BH-1
D-D'	SL/B2/BH-2
E- E'	SL/B2/BH-3 & SL/B2/BH-6

Table 5: Borehole containing Section line of Block-2

The Block-2 of PL-25529/2023 has been divided in 5 cross sectional area such as A-A', B-B', C-C', D-D' & E- E'. The area has been calculated by taking the distance between the two bore holes and their influential distance (Usually the influential distance has been calculated on the basis of the half of the distance between two bore holes). Again, the cross-sectional area is designed by taking the presence of soda contained in their respective bore holes. The cross-sectional areas are given below. The trona blocks are showing the soda content of >80% where the trona and clay blocks are showing the soda content of 60-80%.

The resource for the Block-2, PL-25529/2023 is represented by

SECTION A -A':

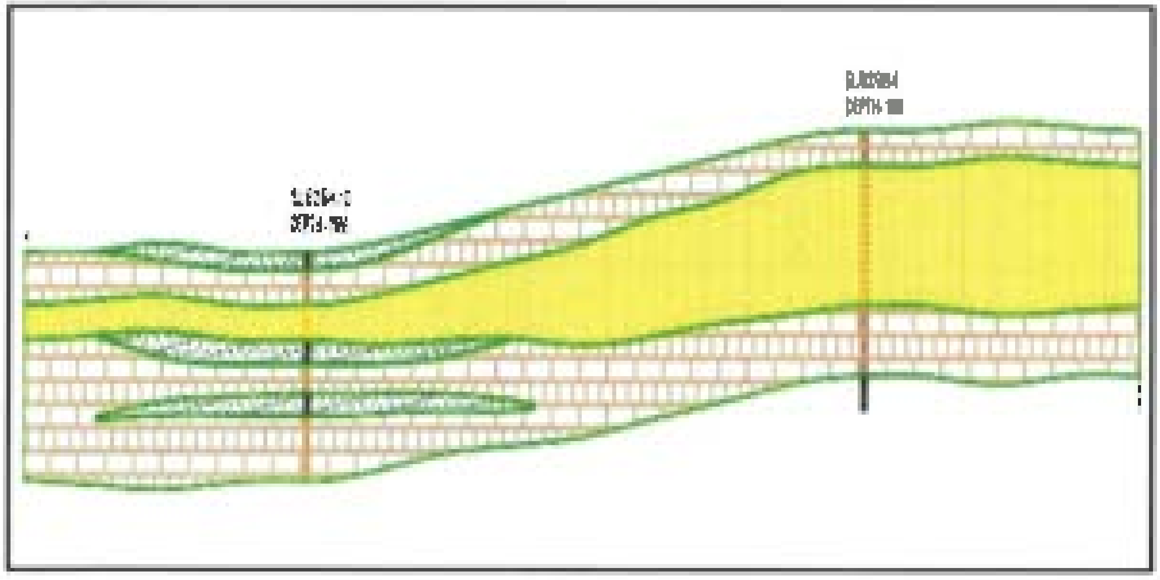


Figure 22: Sectional area A - A' of Block 2

SECTION B – B':

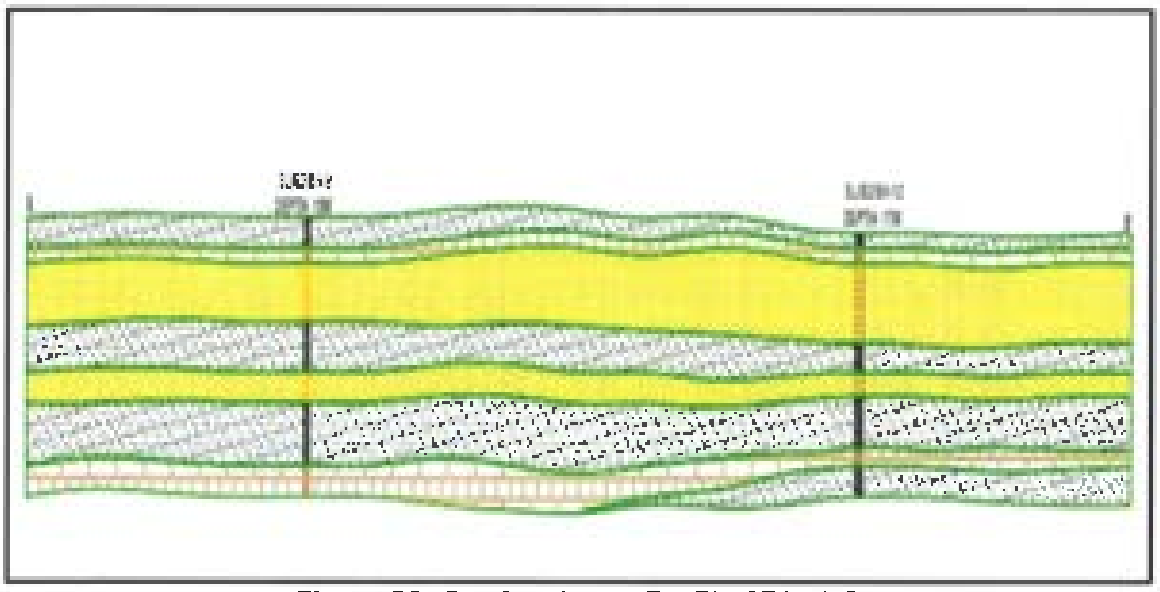


Figure 23: Sectional area B - B' of Block 2

SECTION C – C':

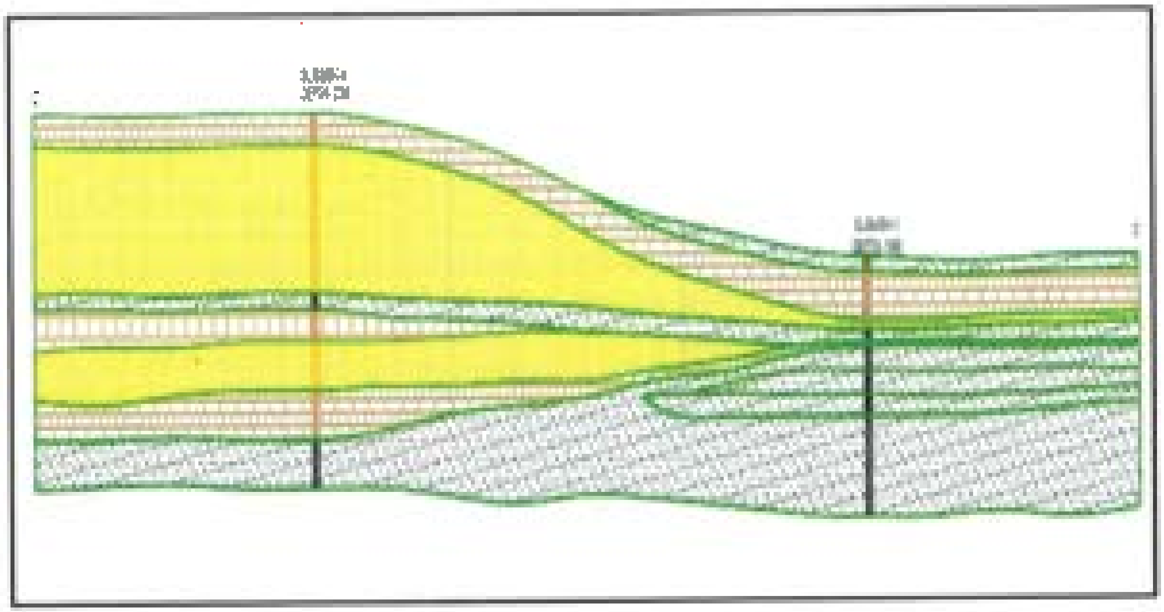


Figure 24: Sectional area C - C' of Block 2

SECTION D – D':

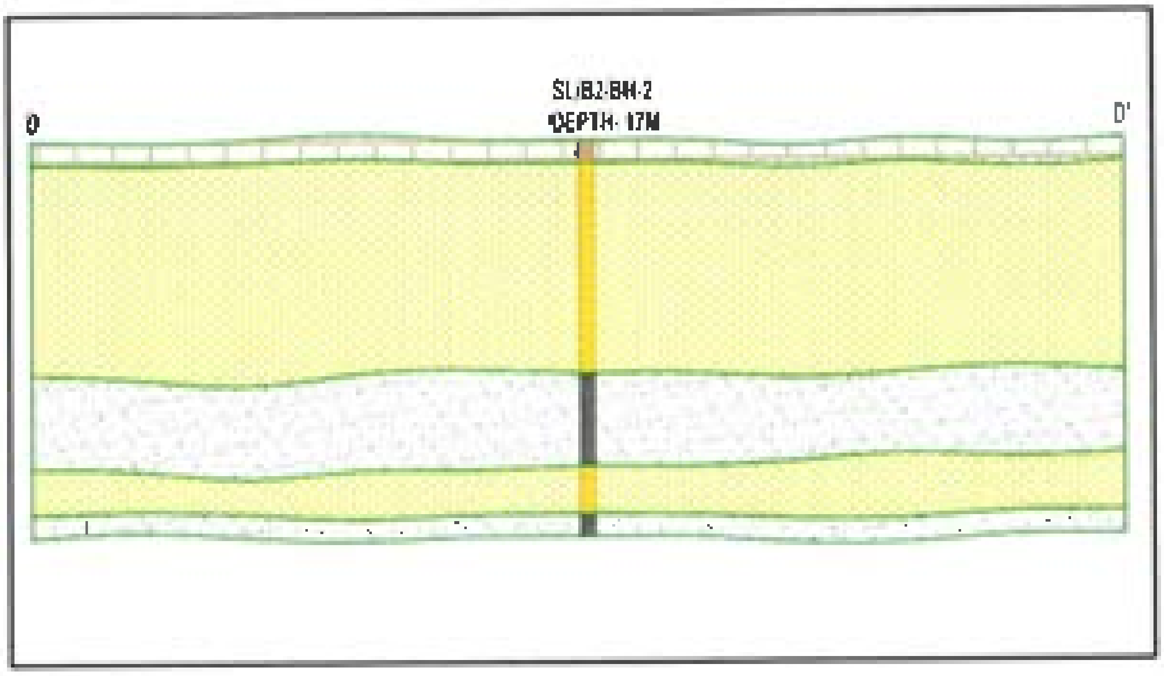


Figure 24: Sectional area D - D' of Block 2

SECTION E – E':

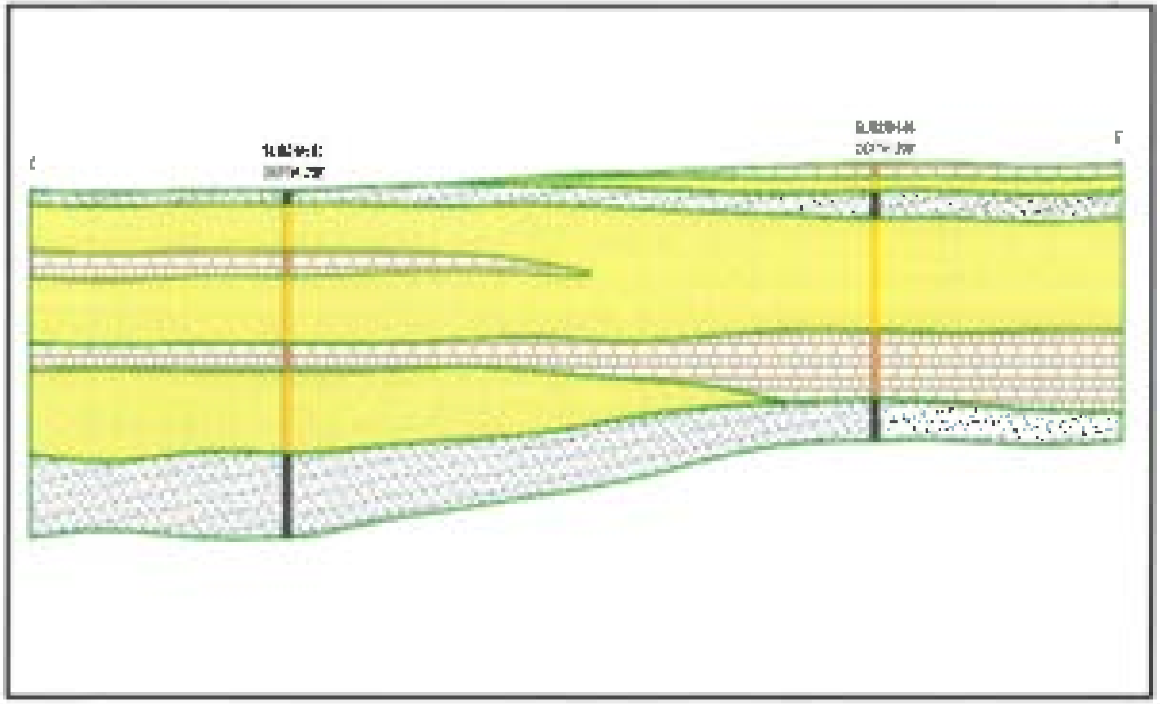


Figure 25: Sectional area E - E' of Block 2

BLOCK - 2, PL - 25529/2023

Section Line (A)	Sectional Area (m^2) (B)	Grade represented by Total Soda (%) (C)	Influence(m) (D)	Volume(m3) (E=BXD)	Specific Gravity	Tonnage (MT)
A-A'	32515.219	60-80	660	21460044.54	1	21460044.54
	19106.893	>80	660	12610549.38	1	12610549.38
B-B'	8151.158	60-80	581	4735822.798	1	4735822.798
	16993 766	>80	581	9873378.046	1	9873378.046
C-C'	6952.78	>80	599	4164715.22	1	4164715.22
	23536.84	60-80	599	14098567.16	1	14098567.16
D-D'	2826.45	>80	701	1981341.45	1	1981341.45
	2805.12	60-80	701	1966389.12	1	1966389.12
E-E'	18175.434	60-80	705	12813680.97	1	12813680.97
	14009.539	50-60	705	9876724.995	1	9876724 995
Total						**93581213.68**

Grade	Tonnage (MT)	
>80%	**28629984.1**	
60-80%	**55074504.59**	
50-60%	**9876724.995**	
Total	**93581213.68**	**Or 93.581 million ton**

Table 6: Estimated Resource of Block-2

5.2.2 BLOCK-1, PL 12236/2023

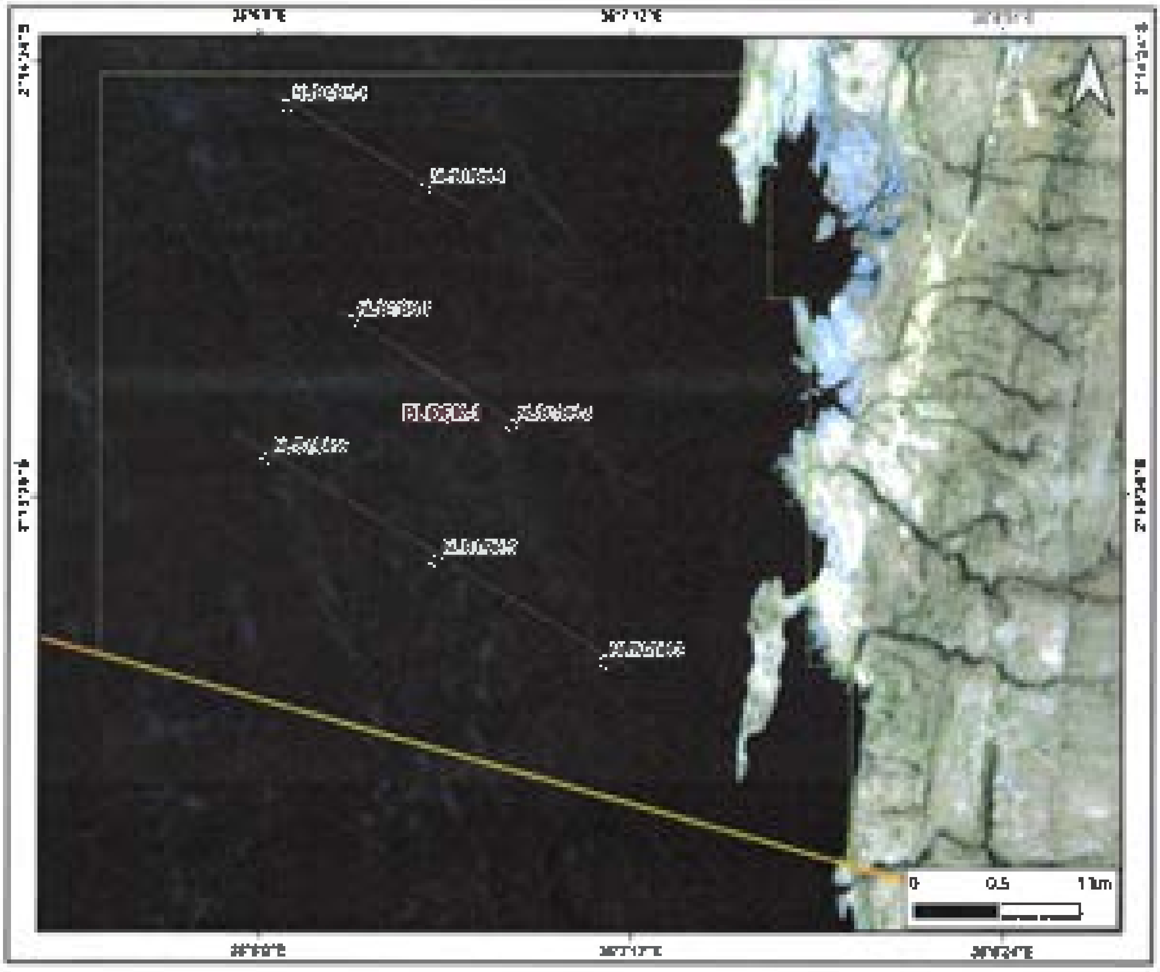


Figure 26: Section line and Bore hole locations on Block-1, PL 12236/2023.

The Block-1 of PL 12236/2023 is covered with 7 no. of Bore holes. The sectional areas are A- A', B- B', C- C'. For the purpose of resource estimation, the distance between boreholes and their respective influential has been taken into account.

Section Line	Contained Bore Holes
A-A'	NL/B1/BH-1 & NL/B1/BH-4
B-B'	NL/B1/BH-7 & NL/B1/BH-2
C-C'	NL/B1/BH-6, NL/B1/BH-5, NL/B1/BH-3

Table 7: Borehole containing Section line of Block-1

The resource has been calculated by taking the grade of soda and the area covered by it presented in the sectional area.

The sections and their estimated resource basing on the assay result is presented in the table given below.

SECTION A – A':

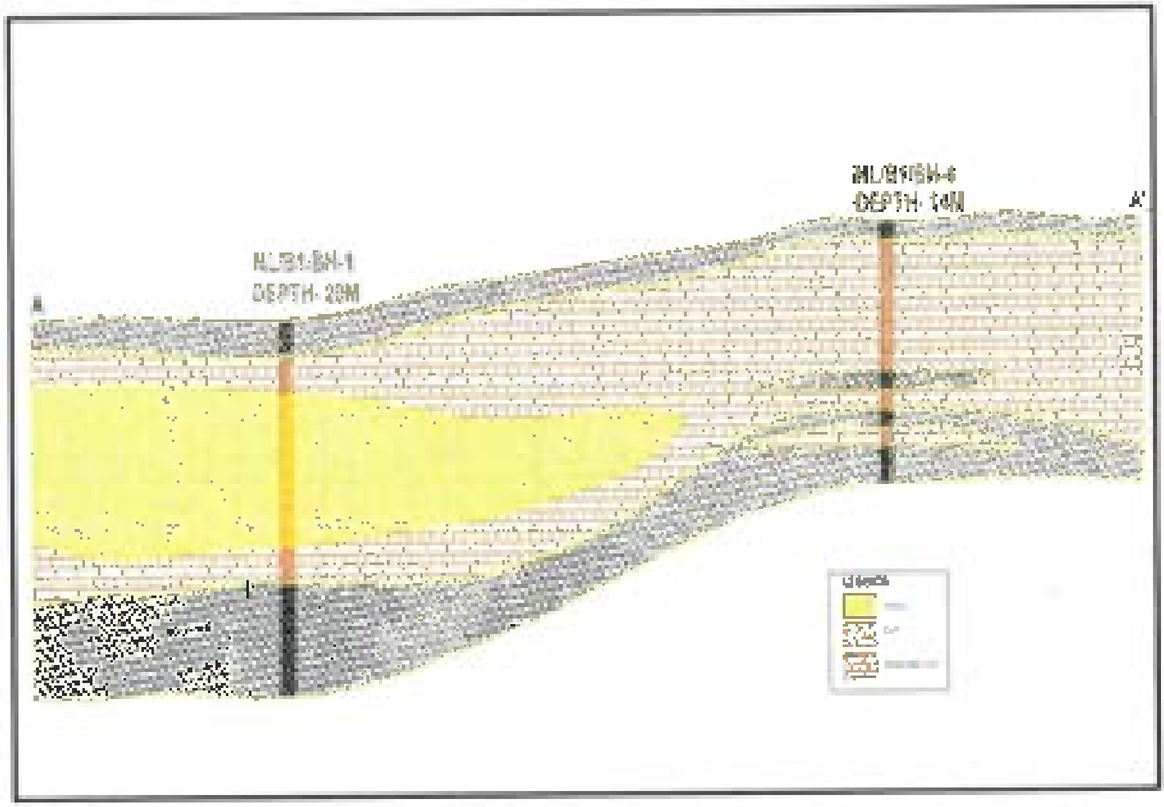


Figure 27: Sectional area A - A' of Block 1

SECTION B – B':

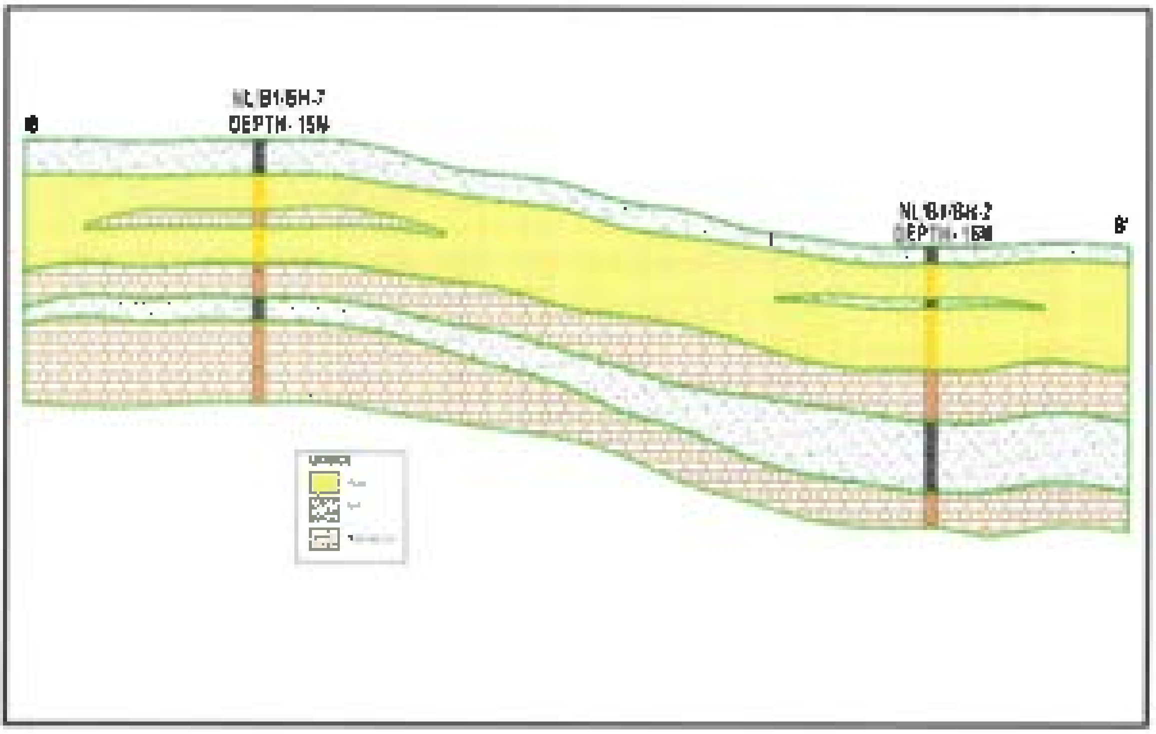


Figure 28: Sectional area B - B' of Block 1

SECTION C – C':

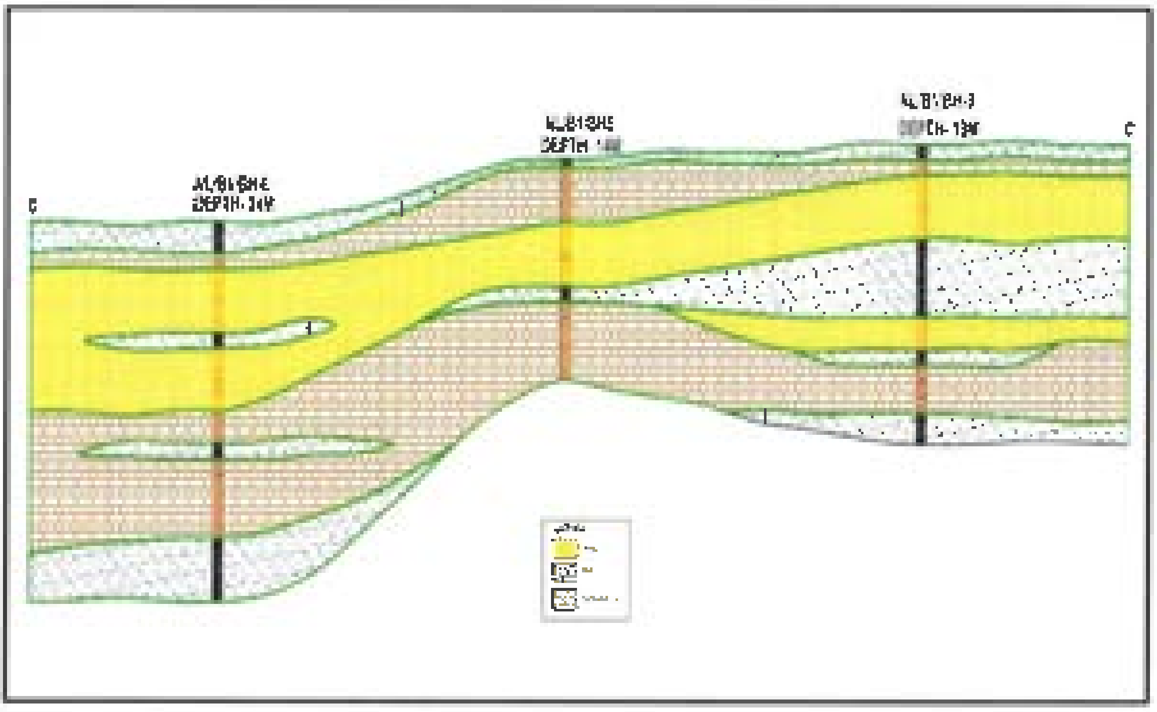


Figure 29: Sectional area C - C' of Block 1

BLOCK - 1 , PL - 12236/2023						
Section Line (A)	Sectional Area (m^2) (B)	Grade represented by Total Soda (%) (C)	Influence(m) (D)	Volume(m3) (E=BXD)	Specific Gravity	Tonnage (MT)
A-A'	3022.468	60-80	792	2393794.656	1	2393794.656
	5915.419	>80	792	4685011.848	1	4685011.848
B-B'	14673.912	60-80	821	12047281.75	1	12047281.75
	10665.792	>80	821	8756615.232	1	8756615.232
C-C'	28811.115	60-80	848	24431825.52	1	24431825.52
	1855.191	>80	848	1573201.968	1	1573201.968
Total						53887730.98

Grade	Tonnage (MT)	
>80%	15014829.05	
60-80%	38872901.93	
Total	53887730.98	Or 53.887 million ton

Table 8: Estimated Resource of Block-1

5.2.3 BLOCK- 4, PL 12236/2023

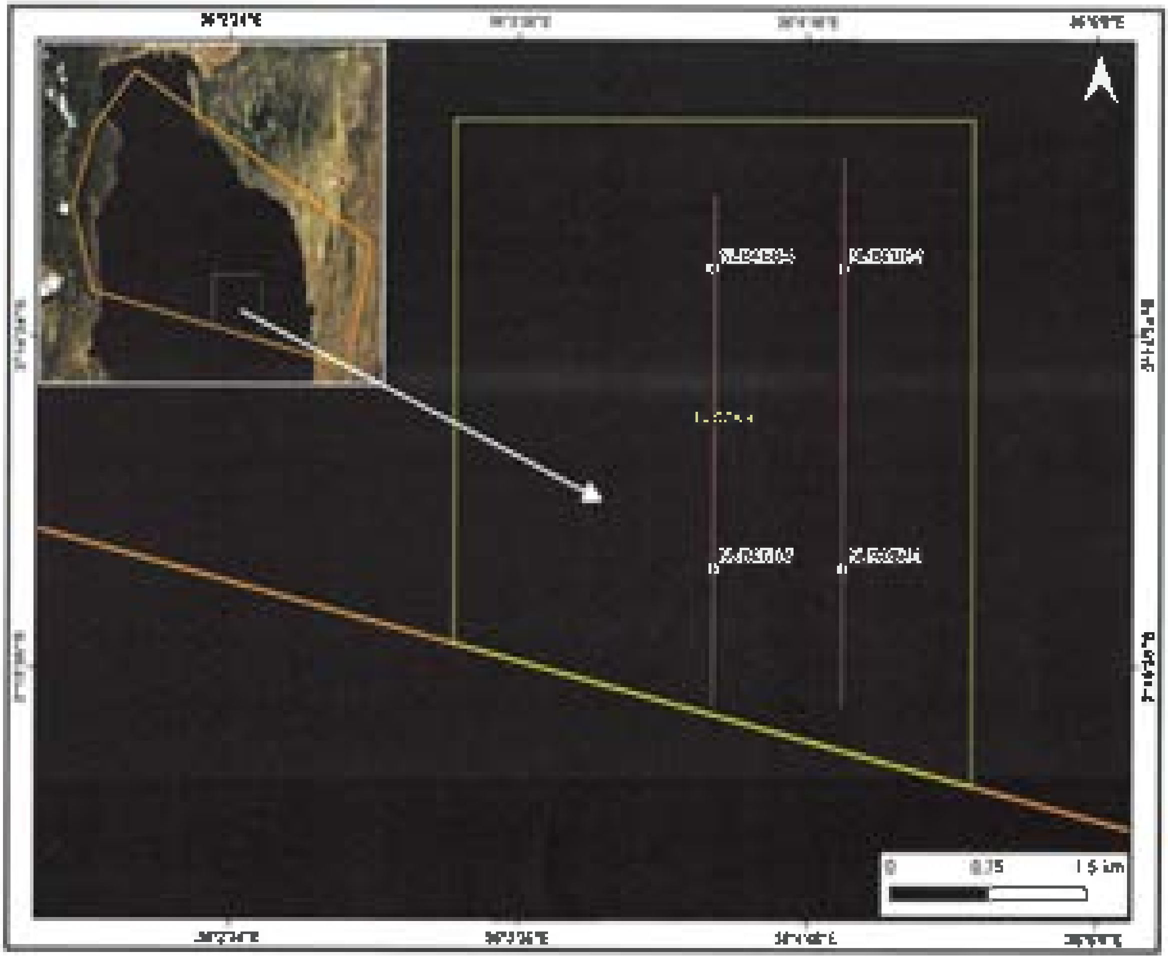


Figure 30: Section line and Bore hole locations on Block-4, PL 12236/2023

The block-4 of PL 12236/2023, have 2 section lines, A- A' and B- B'.

Section Line	Contained Bore Holes
A-A'	NL/B4/BH-1 & NL/B4/BH-3
B-B'	NL/B4/BH-4 & NL/B4/BH-6

Table 9: Borehole containing Section line of Block-4

Resource of the explored area has been calculated by using the distance between two bore holes and the influential area. By taking the individual bore holes in consideration and the assay result the resource of the block is given below.

SECTION A – A':

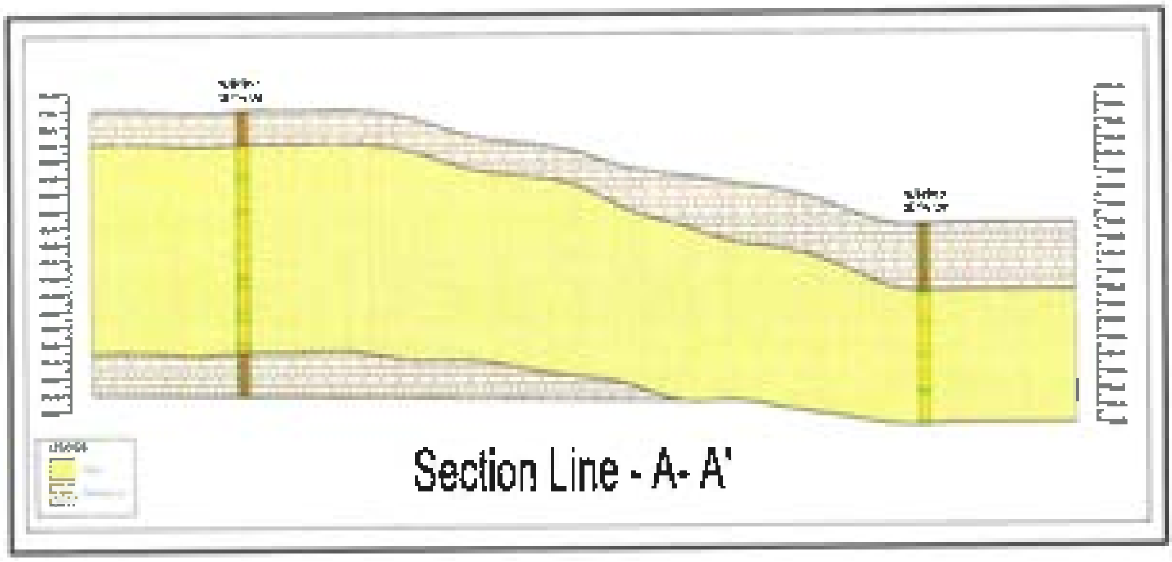


Figure 31: Sectional area A - A' of Block 4

SECTION B – B':

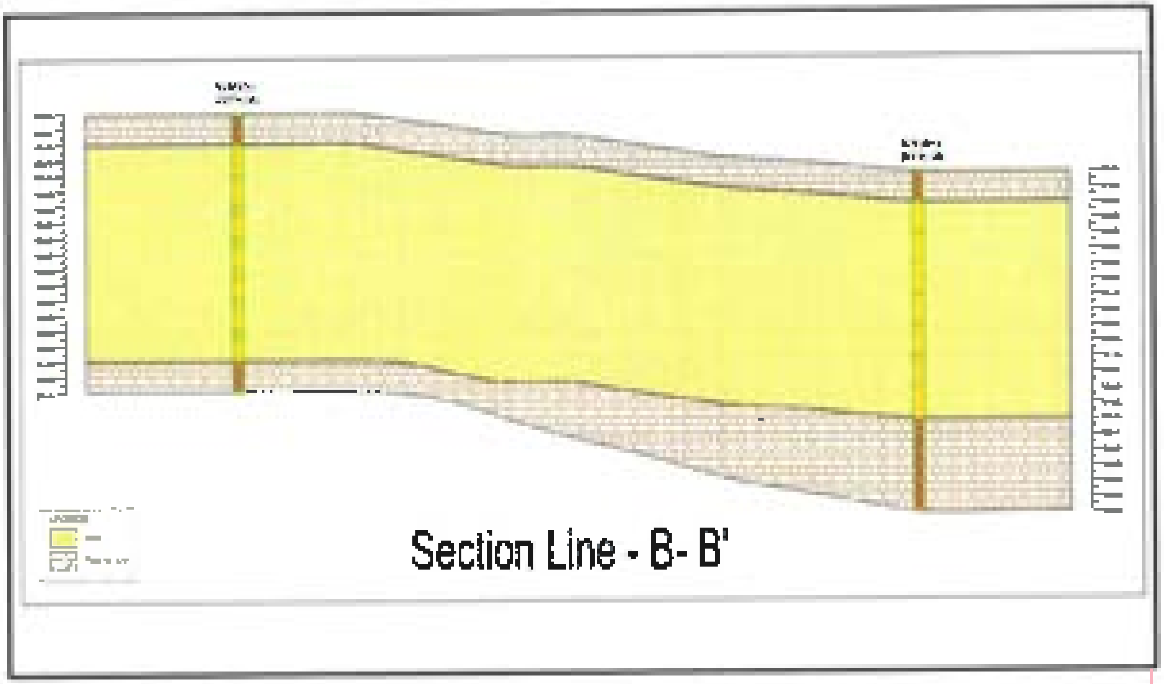


Figure 32: Sectional area B - B' of Block 4

BLOCK - 4 , PL - 12236/2023						
Section Line (A)	Sectional Area (m^2) (B)	Grade represented by Total Soda (%) (C)	Influence(m) (D)	Volume(m3) (E=BXD)	Specific Gravity	Tonnage (MT)
A-A'	3590.402	60-80	1000	3590402	1	3590402
	30747.194	>80	1000	30747194	1	30747194
B-B'	19969.712	60-80	1000	19969712	1	19969712
	41996.165	>80	1000	41996165	1	41996165
Total						96303473
Grade			Tonnage (MT)			
>80%			23560114			
60-80%			72743359			
Total			96303473			Or 96.303 million ton

Table 10: Estimated Resource of Block-4

5.3 QUALITY AND COMPOSITION ANALYSIS OF THE SODA ASH DEPOSITS

Trona ($Na_2CO_3.NaHCO_3. 2H_2O$) is one of the complex salts that occur naturally as white crystalline hydrated salt. It also contains over 90% of a mixture of sodium carbonate and bicarbonate.

Chemical analysis of trona is vital for understanding its composition, purity, and potential application.

The chemical analysis of trona is divided into 3 subparts such as:

i. Sample Collection and Preparation

ii. Chemical Analysis

iii. Result and Interpretation

Sample Collection and Preparation

The samples that were sent to the lab are mainly derived from the drilled cores. Using the splitters, the samples were divided longitudinally. The split half of the samples are sent to the lab keeping the other half in the core box.

Chemical Analysis

The chemical analysis of trona elucidates its composition, properties, and potential application across various industries. By employing Calorimetric, Titrimetric, and Flame Photometric valuable insights can be gained into the nature of trona and its suitability.

Calorimetric Method:

It is chemical analysis that involves measuring the heat changes associated with chemical reactions to determine the composition or the concentration of a substance.

Titration Method

In titrimetric, materials or groups of materials are quantified by measuring the volume of a reagent solution with the known concentration of a substance in the titrimetric solution. The titrimetric solutions are used for a defined, complete chemical conversion with the material that area to be measured.

Flame Photometry

Flame photometry is a useful analytical technique for determining the concentration of alkali or alkaline earth metals (Group-II) such as sodium, potassium, calcium, and lithium.

This method relies on the principle of emission spectroscopy where atoms or ions in a sample emit light at specific wavelengths when subjected to high temperature.

Result and Interpretation:

Borehole samples were sent to the School of Mines and Geosciences, University of Dar-Es-Salaam for chemical analysis. The chemical analysis of Trona includes Na2CO3. The Percentage with the content of CO3-, Cl-, SO4-, and Na+. The result of the analysis is given below:

PL-25529/2023, BLOCK-2, SL/B2/BH-1									
SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO3	SO4	CL
	FROM	TO							
1	1	2	CL & T	SL/B2/BH-1/S1	70.31	76.01	5.64	3.87	2.67
2	2	3	CL & T	SL/B2/BH-1/S2	83.54	85.22	1.62	4.17	2.61
3	3	6.5	CL & GV	SL/B2/BH-1/S3	85.27	90.79	5.73	3.02	3.01
PL-25529/2023, BLOCK-2, SL/B2/BH-2									
SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO3	SO4	CL
	FROM	TO							
1	2	3	T	SL/B2/BH-2/S1	87.34	96.79	1.73	4.02	3.15
2	3	4	T	SL/B2/BH-2/S2	90.73	98.37	2.58	3.57	2.44
3	6.8	9	T	SL/B2/BH-2/S3	85.72	91.79	1.73	3.92	2.01

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4	14	16	T	SL/B2/BH-2/S4	60 3 1	66.01	4 23	3.87	2.8 7

PL-25629/2023, BLOCK-2, SL/B2/BH-3

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							
1	2	4.3	T	SL/B2/BH-3/S1	90.4 4	96 21	5.94	3 68	2.7 5
2	6 2	9	T	SL/B2/BH-3/S2	66.8 3	73.97	7.08	4 03	2.3 3
3	13	15	T & CL	SL/B2/BH-3/S3	50 3 1	56 56	6 19	3.87	2.8 7
4	17	19	T	SL/B2/BH-3/S4	71 3 3	78 62	7 23	3 57	2 2 7

PL-25629/2023, BLOCK-2, SL/B2/BH-4

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							
1	4	6 3	T	SL/B2/BH-4/S1	93 0 3	98 51	5 42	4.01	3.1 1
2	6 3	8 3	T	SL/B2/BH-4/S2	91 4 2	94 26	2 76	2 86	2 7 5
3	8.3	10	T	SL/B2/BH-4/S3	81.3 3	78.67	6.34	2 65	1.9 7
4	15 3	17	T	SL/B2/BH-4/S4	81 4 5	86.51	5	4.71	1 8

PL-25629/2023, BLOCK-2, SL/B2/BH-5

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							
1	2	4	T	SL/B2/BH-5/S1	92.4 4	95 17	2 67	3 25	2.8 8
2	4	6	T	SL/B2/BH-5/S2	93.4 2	94.38	1.47	4 16	2 9 1

3	8	9	T	SL/B2/BH-5/S3	70.25	74.96	4.65	3.55	2.56
4	12	14	CL & T	SL/B2/BH-5/S4	50.61	52.01	1.34	2.87	1.87
PL-25529/2023, BLOCK-2, SL/B2/BH-6									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**	**CO3**	**SO4**	**CL**
	FROM	**TO**							
1	4	6	T	SL/B2/BH-6/S1	90.25	93.76	2.11	3.26	2.53
2	6	8	T	SL/B2/BH-6/S2	89.75	92.33	2.25	3.35	2.86
3	8	10	T	SL/B2/BH-6/S3	91.82	96.45	4.63	3.21	2.63
4	12	14	T	SL/B2/BH-6/S4	76.95	81.92	5.23	3.17	2.9
5	14	16	T	SL/B2/BH-6/S5	94.53	96.21	2.09	3.44	2.05
PL-25529/2023, BLOCK-2, SL/B2/BH-9									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**	**CO3**	**SO4**	**CL**
	FROM	**TO**							
1	2	3	T & CL	SL/B2/BH-9/S1	71.11	74.11	4.14	3.84	2.07
2	3	5	T	SL/B2/BH-9/S2	82.96	70.17	2.01	4.66	2.17
3	5	7	T	SL/B2/BH-9/S3	70.15	80.01	2.66	5.14	1.99
4	10	12	T	SL/B2/BH-9/S4	79.16	85.33	1.76	4.56	2.69
5	16	18	T & CL	SL/B2/BH-9/S5	90.22	80.39	4.48	4.11	3.22
PL-25529/2023, BLOCK-2, SL/B2/BH-10									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**			**CL**

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	FROM	TO					CO 3	SO 4	
1	1	3	T & CL	SL/B2/BH-10/S1	81 4 5	84.61	4	4 72	1.8
2	3	5	T & CL	SL/B2/BH-10/S2	79 6 9	83 1	2.25	4.06	2 1 1
3	5	8	T & CL	SL/B2/BH-10/S3	81 1 8	90 19	2 56	3 22	2 8 9
4	10	11	T	SL/B2/BH-10/S4	66.1 8	83 12	3 33	3 76	3 0 8
5	11	12	T &CL	SL/B2/BH-10/S5	82.1 8	87 12	4 18	4.81	1.8 2
6	12	14	T &CL	SL/B2/BH-10/S6	84 1 5	87.62	3 45	4.66	1 7 8

PL-25529/2023, BLOCK-2, SL/B2/BH-12

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							
1	0	2	T & CL	SL/B2/BH-12/S1	92.3 3	90 76	2 56	2 86	2.7 5
2	2	4	T	SL/B2/BH-12/S2	88.9 8	89.09	3 08	3 04	2.5 6
3	4	6	T	SL/B2/BH-12/S3	89.4 5	94 25	2.29	2.77	2.9 8
4	6	7	T	SL/B2/BH-12/S4	91 6 6	93.59	2 58	2 93	3 0 7
5	9	10 5	T	SL/B2/BH-12/S5	92 3 3	90 76	2.56	2.86	2 7 5
6	13 5	15	T	SL/B2/BH-12/S6	88.9 8	89 09	3 08	3 04	2.5 6

PL-12236/2023, BLOCK-1, NL/B1/BH-1

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							

1	2	4	T & CL	NL/B1/BH-1/S1	87.33	91.01	3.12	1.5	2.01
2	4	6	T	NL/B1/BH-1/S2	85.13	87.1	2.47	2.14	1.67
3	6	8	T	NL/B1/BH-1/S3	78.47	81.35	1.29	4.52	3.87
4	8	10	T	NL/B1/BH-1/S4	90.65	94.45	2.58	2.93	3.07
5	10	12	T & CL	NL/B1/BH-1/S5	92.33	94.76	3.65	1.67	2.03
6	12	14	T & CL	NL/B1/BH-1/S6	75.73	80.73	2.16	1.11	3.13

PL-12236/2023, BLOCK-1, NL/B1/BH-2

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO3	SO4	CL
	FROM	TO							
1	1	3	T	NL/B1/BH-2/S1	89.57	91.16	2.24	4.56	1.02
2	3	5	T	NL/B1/BH-2/S2	76.48	82.17	2.13	2.14	2.71
3	5	7	T	NL/B1/BH-2/S3	80.45	84.25	4.29	2.37	1.9
4	7	9	T	NL/B1/BH-2/S4	90.16	94.43	3.18	1.43	1.67
5	9	10	T	NL/B1/BH-2/S5	78.33	80.46	2.36	2.26	1.75

PL-12236/2023, BLOCK-1, NL/B1/BH-3

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO3	SO4	CL
	FROM	TO							
1	0	2	T & CL	NL/B1/BH-3/S1	90.43	93.65	2.49	1.65	2.62
2	2	4	T	NL/B1/BH-3/S2	82.48	87.64	2.34	2.04	2.81

3	4	6	T	NL/B1/BH-3/S3	74.98	79.35	5.29	0.37	3.1
4	11	13	T	NL/B1/BH-3/S4	91.76	94.93	2.11	1.71	1.58
5	13	15	T & CL	NL/B1/BH-3/S5	79.85	83.75	3.37	1.24	1.65
6	15	16	T & CL	NL/B1/BH-3/S6	90.47	93.15	2.25	3.58	2.48
7	16	17	T & CL	NL/B1/BH-3/S7	80.57	86.16	3.24	1.58	1.82
PL-12236/2023, BLOCK-1, NL/B1/BH-4									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**	**CO3**	**SO4**	**CL**
	FROM	**TO**							
1	1	3	T & CL	NL/B1/BH-4/S1	86.49	89.44	3.14	1.04	1.86
2	3	5	T & CL	NL/B1/BH-4/S2	90.16	93.35	2.10	1.39	1.16
3	5	7	T & CL	NL/B1/BH-4/S3	70.41	74.83	2.71	1.09	1.34
4	7	8	T & CL	NL/B1/BH-4/S4	75.67	78.96	2.37	1.12	1.72
5	8	10	T & CL	NL/B1/BH-4/S5	91.42	93.2	2.35	1.38	1.48
6	11	12	T & CL	NL/B1/BH-4/S6	79.57	83.16	2.14	1.52	2.62
PL-12236/2023, BLOCK-1, NL/B1/BH-5									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**	**CO3**	**SO4**	**CL**
	FROM	**TO**							
1	0	2	T & CL	NL/B1/BH-5/S1	79.39	83.25	2.11	1.74	1.45
2	2	4	T & CL	NL/B1/BH-5/S2	81.48	85.49	3.24	1.64	1.88

3	4	6	T	NL/B1/BH-5/S3	70 5 3	74 15	2 39	1 27	2 1
4	6	8	T	NL/B1/BH-5/S4	81 7 6	84.23	3 14	2 71	1.3 6
5	8	10	T & CL	NL/B1/BH-5/S5	86 1 5	89.46	2 57	1.77	1.6 2
6	10	12	T & CL	NL/B1/BH-5/S6	70 4 7	73 74	1 15	3 68	1.4 8
7	12	14	T & CL	NL/B1/BH-5/S7	81.5 7	82.16	2.44	1.59	1.8 9
PL-12236/2023,BLOCK-1, NL/B1/BH-6									
	DEPTH (m)								
SL.NO.	FROM	TO	LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
1	2	3	T & CL	NL/B1/BH-6/S1	90 2 9	93 15	3 11	1.63	1.5 1
2	3	5	T	NL/B1/BH-6/S2	78 4 8	85.49	3.49	1.45	1.6 9
3	5	7	T	NL/B1/BH-6/S3	75 5 7	79.82	2.59	1.33	2
4	8	10	T	NL/B1/BH-6/S4	80 7 6	84 67	2 09	2.41	2 1 9
5	10	12	T	NL/B1/BH-6/S5	89.9 5	93.06	3.72	1.87	1.4 2
6	12	14	T & CL	NL/B1/BH-6/S6	81 6 7	83.34	1.98	2.18	1.9 8
7	14	16	T & CL	NL/B1/BH-6/S7	82 5	80 79	1 04	3 59	2 8 9
8	16	18	T & CL	NL/B1/BH-6/S8	75 3 9	78.35	1 11	1.58	1.6 3
9	18	20	T & CL	NL/B1/BH-6/S9	79 4 8	80.42	2 24	1.44	1.2 6
PL-12236/2023,BLOCK-1, NL/B1/BH-7									
	DEPTH (m)			SAMPLE ID	NA				CL

SL.N O.	FRO M	TO	LITHOCOD E			NA2CO 3	CO 3	SO 4	
1	2	4	T	NL/B1/BH-7/S1	90 5 7	91 23	3 89	1 25	2 6 7
2	4	5	T	NL/B1/BH-7/S2	81.7 6	84 03	2.18	2 61	1.1 7
3	5	7	T	NL/B1/BH-7/S3	79.4 2	82.16	3.01	2 47	1.1 2
4	7	9	T	NL/B1/BH-7/S4	88 3 7	90.35	2.1	1.17	1.2 5
5	13	15	T & CL	NL/B1/BH-7/S5	80.5	78 01	1 74	3.69	2 0 1

PL-12236/2023,BLOCK-4, NL/B4/BH-1

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							
1	2	4	T	NL/B4/BH-1/S1	92.3 3	90.76	2.56	2 66	2.7 5
2	4	6	T	NL/B4/BH-1/S2	88 9 8	89 09	3.08	3.04	2.5 6
3	6	8	T	NL/B4/BH-1/S3	89 4 5	94.25	2 29	2.77	2 9 8
4	8	10	T	NL/B4/BH-1/S4	91.6 6	93 59	2 58	2.93	3 0 7
5	10	12	T	NL/B4/BH-1/S5	90 8 5	95 09	2 79	3 03	2 6 7
6	12	14	T	NL/B4/BH-1/S6	89.7 7	94.79	3.01	2 79	2.8 7
7	16	17	T & CL	NL/B4/BH-1/S7	91.4 2	94 73	2.99	2 69	2 5 5

PL-12236/2023,BLOCK-4, NL/B4/BH-3

SL.NO.	DEPTH (m)		LITHOCODE	SAMPLE ID	NA	NA2CO3	CO 3	SO 4	CL
	FROM	TO							

8	2	4	T & CL	NL/B4/BH-3/S1	77.35	94.17	1.66	4.12	3.22
9	4	6	T	NL/B4/BH-3/S2	80.88	91.69	1.66	3.9	2.99
10	6	8	T	NL/B4/BH-3/S3	76.88	82.62	3.03	3.88	3.08
11	8	10	T	NL/B4/BH-3/S4	80.48	86.51	5.06	4.71	1.8
12	10	12	T	NL/B4/BH-3/S5	83.45	87.66	3.55	4.88	1.86
PL-12236/2023,BLOCK-4, NL/B4/BH-4									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**	**CO3**	**SO4**	**CL**
	FROM	**TO**							
13	0	2	T& CL	NL/B4/BH-4/S1	81.91	86.16	3.28	3.33	2.73
14	2	4	T	NL/B4/BH-4/S2	88.77	96.45	4.63	3.21	2.63
15	4	6	T	NL/B4/BH-4/S3	90.98	76.55	3.99	3.09	2.77
16	6	8	T	NL/B4/BH-4/S4	92.6	85.49	3.66	2.99	1.89
17	8	10	T	NL/B4/BH-4/S5	91.18	96.66	5.01	3.55	2.78
18	10	12	T	NL/B4/BH-4/S6	92.62	92.09	4.03	3.04	2.09
19	12	14	T	NL/B4/BH-4/S7	90.58	92.19	4.66	3	2.44
20	14	16	T	NL/B4/BH-4/S8	91.17	95.63	4.09	3.08	2.98
PL-12236/2023,BLOCK-4, NL/B4/BH-6									
SL.NO.	**DEPTH (m)**		**LITHOCODE**	**SAMPLE ID**	**NA**	**NA2CO3**			**CL**

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	FROM	TO					CO_3	SO_4	
21	2	4	T	NL/B4/BH-6/S1	70.31	76.01	5.64	3.87	2.87
22	4	6	T	NL/B4/BH-6/S2	81.64	77.27	1.81	4.66	2.17
23	6	8	T	NL/B4/BH-6/S3	73.54	88.26	2.62	5.14	1.99
24	8	10	T	NL/B4/BH-6/S4	83.64	85.33	1.62	4.56	2.69
25	10	12	T	NL/B4/BH-6/S5	91.03	79.51	4.42	4.11	3.16
26	12	14	T	NL/B4/BH-6/S6	81.45	86.51	5	4.71	1.6
27	14	16	T	NL/B4/BH-6/S7	79.69	88.09	1.55	4.07	2.7
28	16	18	T & CL	NL/B4/BH-6/S8	83.64	85.33	1.7	4.56	3.06

Table 11: Result of Chemical analysis of Borehole data

6. TECHNICAL FEASIBILITY

The technical feasibility of a soda ash project, particularly one focused on natural extraction from sources like Lake Natron, involves a comprehensive assessment of various factors that determine the viability of the project. This note outlines the key components of technical feasibility, including resource availability, production processes, infrastructure requirements, environmental considerations, and economic viability.

6.1 ENGINEERING PROCESS AND DESIGN

The engineering and process design of a natural soda ash extraction project from Lake Natron involves several critical components that ensure the efficient and sustainable production of soda ash.

6.1.1 Extraction Methods

Solar Evaporation Process

The primary method for extracting soda ash from Lake Natron is solar evaporation, which is both cost-effective and environmentally friendly. The process involves the following steps:

1. **Brine Collection**: Brine is collected from the lake and transported to shallow evaporation ponds. The design of these ponds is critical; they must be large enough to maximize surface area for evaporation while minimizing water loss.
2. **Evaporation**: Utilizing the region's high temperatures and low humidity, the brine is allowed to evaporate naturally. This process can take several weeks, during which sodium carbonate crystals form as the concentration of the brine increases.
3. **Harvesting**: Once sufficient evaporation has occurred, the crystallized soda ash is harvested from the ponds. The engineering design must include appropriate equipment for efficient harvesting without damaging the crystals.
4. **Calcination**: The harvested soda ash may undergo calcination, a thermal treatment process that enhances its purity and quality. This step involves heating the soda ash to drive off impurities and improve its properties for industrial applications.

Alternative Extraction Methods

While solar evaporation is the primary method. the engineering design should also consider alternative extraction methods, such as:

- **Direct Crystallization**: This method involves cooling the brine to promote crystallization at lower temperatures, which may be more efficient under certain conditions.
- **Chemical Precipitation**: In some cases, chemical processes can be employed to precipitate soda ash from brine, although this may involve higher operational costs and environmental considerations

6.2 INFRASTRUCTURE REQUIREMENT

The infrastructure requirements for a natural soda ash extraction project, such as one based at Lake Natron, are critical for ensuring efficient operations, sustainability, and economic viability. This note outlines the essential infrastructure components, including transportation (roads), water supply, and power requirements, necessary for the successful implementation of the project.

6.2.1 TRANSPORTATION INFRASTRUCTURE

Roads

Efficient transportation infrastructure is vital for the extraction and distribution of soda ash. Key considerations include:

- **Access Roads**: Well-constructed access roads are essential for connecting the extraction site to main highways and markets. These roads facilitate the movement of raw materials, equipment, and personnel to and from the site The design should consider durability to withstand heavy vehicle traffic and local weather conditions.

  The ports and airports nearer to the project location are connected through state and national highways up to Mto Wa Mbu. For better connectivity the all-weather road should be constructed from Mto Wa Mbu to project area.

- **Logistics and Distribution**: Proximity to major transportation hubs, such as ports or railways, can enhance the efficiency of transporting finished soda ash to customers. The logistics plan should encompass routes for both inbound and outbound logistics, ensuring timely delivery and reducing transportation costs.

- **Maintenance**: Regular maintenance of roads is necessary to ensure safe and efficient transport. This includes addressing wear and tear, managing seasonal weather impacts, and ensuring accessibility during adverse conditions.

6.2.2 WATER SUPPLY

Water Requirements

Water is a crucial resource for soda ash extraction, particularly in the solar evaporation process. The infrastructure for water supply must address the following:

- **Source of Water**: Identifying a reliable source of water is essential. This could include direct extraction from Lake Natron or nearby freshwater sources. The project must ensure that water extraction does not negatively impact the lake's ecosystem or local communities.

  Ground water extraction is included in the soda ash extraction plant for processing. In addition to that, the major river water will be diverted to the water storage for future extraction.

- **Water Management System**: A well-designed water management system should be implemented to optimize water use, including storage facilities for managing water supply during periods of low availability. This system should also incorporate measures for recycling and reusing water where possible to minimize waste.
- **Quality Control**: Regular monitoring of water quality is necessary to ensure that it meets the required standards for the extraction process and does not introduce contaminants into the lake.

3. POWER SUPPLY

Energy Requirements

The energy needs of a soda ash extraction project can vary based on the extraction and processing methods employed. Key aspects include:

- **Power Sources**: The project should identify reliable energy sources, which could include grid electricity, diesel generators, or renewable energy options such as solar or wind power. Given the location near Lake Natron, solar energy could be a viable option, leveraging the region's high solar irradiance.
- **Energy Efficiency**: Implementing energy-efficient technologies and practices can reduce operational costs and minimize environmental impact. This includes using energy-efficient pumps and equipment in the extraction and processing phases
- **Backup Power Systems**: Establishing backup power systems is essential to ensure continuous operations, especially during outages or maintenance periods. This could involve the use of generators or battery storage systems.

The infrastructure requirements for a natural soda ash extraction project at Lake Natron encompass critical components such as transportation (roads), water supply, and power. Developing robust and efficient infrastructure is essential for ensuring the project's operational success, sustainability, and economic viability. By strategically planning and investing in these infrastructure elements, the project can effectively harness the natural resources of Lake Natron while minimizing environmental impact and supporting local communities.

6.3 TECHNOLOGY SELECTION AND PROCESS FLOW DIAGRAMS

6.3.1 MINING OPERATIONAL METHODS

In Lake Natron, Tanzania, for the extraction of Soda Ash for the ongoing project, the Monohydrate method has to be adopted as the Mining Operational Method. Operational technology for natural soda ash exploration and production typically includes:

a) Dredging

b) Crushing

c) Slurry Transport

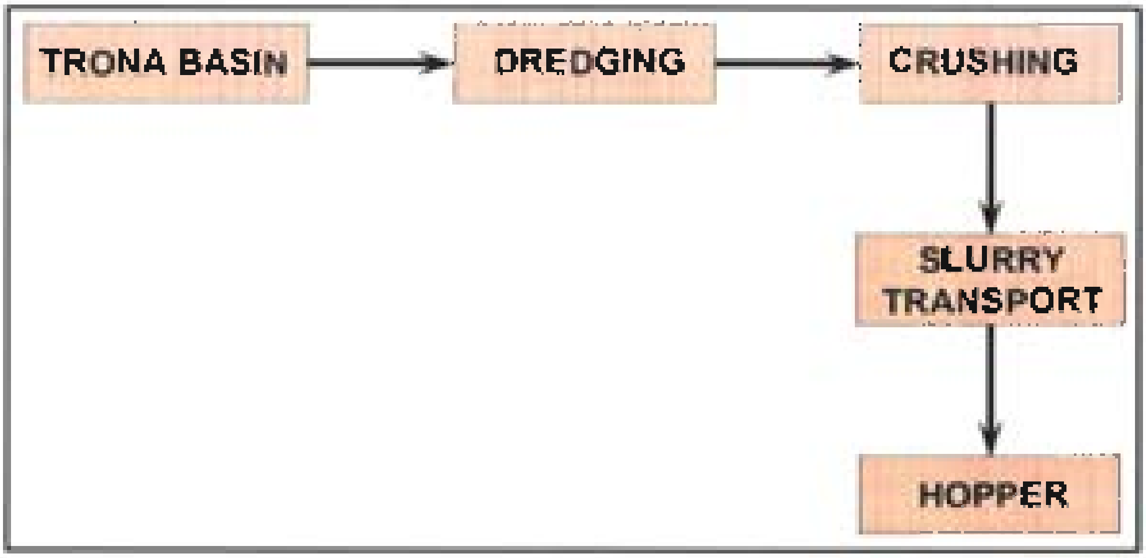

Figure 33: Flow Chart of Stages of Mining Operation

Dredging

Dredging for Soda Ash production typically involves extracting trona ore, a naturally occurring mineral containing sodium carbonate, from underground deposits or shallow surface mines. The trona ore is then processed to extract Soda Ash, which is used in various industrial applications.

Crushing

The crushing process typically involves breaking down trona ore into smaller fragments or particles. This crushed trona is then further processed to extract soda ash through various processes including chemical processes. The crushing stage is essential for reducing the size of the ore to a manageable level for subsequent processing steps, which ultimately yields soda ash as the final product.

Slurry Transport

The saturated brine solution, containing trona is pumped to the surface (to the hopper). This process is performed through the slurry of trona and brine, which is transported via pipelines to the hopper (at the surface) for further processing of the raw material to produce Soda Ash.

6.3.1.1 Equipment for Mining Operations

For the execution of this mining operation, the required types of equipment and infrastructure include:

a) Dredger

b) Sizer Crusher

c) Slurry Pipeline (PVC)

d) Pump

e) Booster Pump

f) Hopper (Infrastructure)

Dredger

A dredger is a machine used to remove sediment, debris, or other materials from the bottom of the bodies of water.

Here, the Suction dredger will be used; its mechanism is that it is equipped with a rotating cutting head a cutter suction dredger (CSD) cuts and loosens material on the seabed, which is then pumped through a pipeline to the disposal area.

For the cutting of trona, a cutter suction dredger would be suitable. Trona is the soft, crystalline mineral commonly found in evaporite deposits and a CSD is effective for dredging such materials.

The rotating cutting head of CSD can efficiently break up the trona deposits on the lakebed, allowing it to be suctioned up through the dredging pipeline for transportation to the desired location.

Additionally, the adjustable depth and precise control capabilities of a CSD make it well-suited for dredging operations in varying water depths, which may be encountered in trona mining areas.

Size Crusher

This equipment is used to crush large pieces of soda ash ore into smaller particles for further processing.

Typically, this equipment could include jaw crushers, or cone crushers, depending on the specific requirements of the operation and the size of the ore being processed.

Slurry Pipeline

Using a slurry pipeline for soda ash transportation during mining operations can be an efficient method. The process involves mixing soda ash with water to form a slurry, which is then pumped through a pipeline to the desired destination.

Advantages of using a slurry pipeline for transportation in soda ash mining include:

i. Cost-effectiveness

ii. Reduced Environmental Impact

iii. Continuous Operation providing a steady flow of raw material.

iv. Lower maintenance is required including the reduction of downtimes and costs associated with maintenance.

Apparently, the challenges in this aspect can be countered, such as:

i. Pipeline corrosion and abrasion

ii. The need for efficient pumping systems, must be addressed to ensure the successful operation of a soda ash slurry pipeline.

iii. Environmental considerations, including potential spills or leaks, need to be carefully managed to minimize any adverse impacts on the surrounding ecosystem.

Pump

Pumps are used to transport the soda ash slurry from the mining site to the further processing destination.

When selecting pimps for soda ash mining operation, the factors must be prioritized include:

i. Viscosity and abrasiveness of the slurry

ii. Flowrates

iii. Head requirements.

iv. Environmental Conditions

Additionally, pumps need to be properly maintained to ensure reliable and efficient operation throughout the mining process.

Booster Pump

In soda ash mining operations, a booster pump is typically used to increase the pressure of the slurry being transported through pipelines over long distances or uphill sections.

Booster pumps are essential for maintaining the flow and pressure required to efficiently move the soda ash slurry from the mining site to the further processing destination.

Proper sizing, installation, and maintenance of the booster pumps are essential to ensure optimal performance and efficiency in soda ash mining operations

Key considerations for selecting a booster pump for soda ash mining include:

Flow Rate:

The flow rate is required to ensure continuous transportation of the soda ash slurry.

Pressure Requirements:

The pump should be able to generate sufficient pressure to overcome friction losses in the pipeline and elevation changes along the route.

Abrasion Resistance:

The construction materials of the pumps should be resistant to wear and corrosion to ensure long-term reliability.

Efficiency:

High efficiency can help to minimize energy consumption and operating costs over the lifespan of the equipment.

Reliability and Maintenance Requirements:

The booster pump should be designed for reliable operation with minimal downtime and maintenance requirements, particularly in remote or challenging environments typical of mining operations.

Hopper:

In the context of soda ash mining, a hopper is a container of funnel-shaped structure used to store or dispense soda ash ore or other materials.

The hopper undergoes an infrastructure, but not a piece of equipment

Here, the hopper is used to store soda ash ore before it is transported to the processing unit. This allows for a controlled and continuous supply of ore to the processing equipment.

It can be used for transferring soda ash between different stages of the mining and processing operations.

Proper design, sizing, and maintenance of hoppers are essential to ensure smooth and reliable material handling in soda ash mining operations. They play a critical role in optimizing the overall efficiency and productivity of the mining and processing processes.

6.3.2 PROCESSING METHODS FOR SODA ASH PRODUCTION

Efficient processing technology is crucial for maximizing yield, minimizing costs, and maintaining environmental sustainability in natural soda ash exploration and production operations. For soda ash extraction, here the adopted processing technology depends upon the monohydrate method. Processing technology for natural soda ash production involves several key stages:

h) Calcination

i) Dissolving

j) Clarification

k) Evaporation and Crystallisation

l) Centrifugation

m) Drying

n) Packaging

Calcination

Calcination is a thermal treatment process used in various industries, including soda ash production. In the context of soda ash manufacturing, calcination refers to the heating of sodium carbonate (Na2CO3) or bicarbonate (NaHCO3) to high temperatures to drive off volatile components, such as water and carbon dioxide, resulting in the formation of anhydrous sodium carbonate, commonly known as soda ash (Na2CO3).

The calcination process typically involves heating the sodium carbonate or bicarbonate ore in a rotary kiln or a furnace at temperatures ranging from around 400°C to 800°C (752°F to 1472°F), depending on the specific requirements of the process and the desired properties of the final product.

During calcination, the following chemical reactions occur:

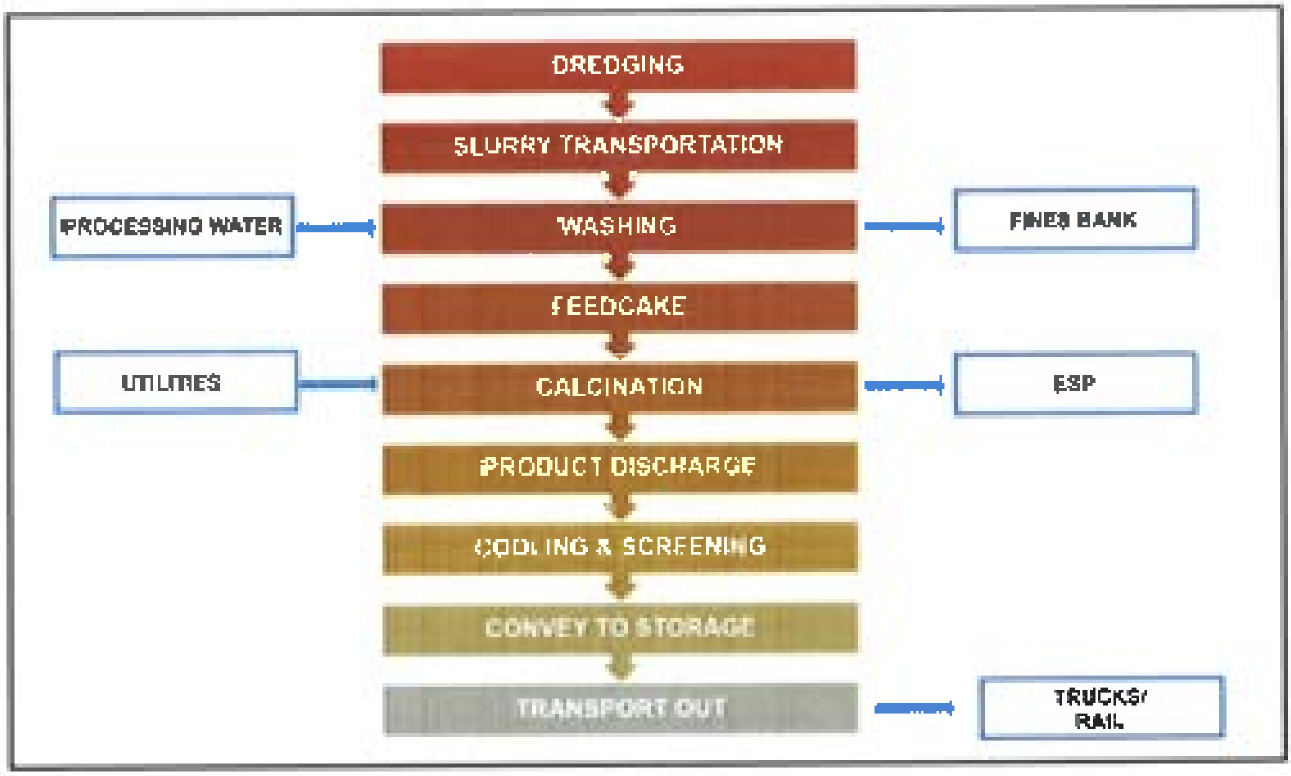

Figure 34: Flow Chart of Stages of Processing for Soda Ash Production

Dehydration

Sodium carbonate decahydrate ($Na_2CO_3 \cdot 10H_2O$), commonly known as trona, or sodium bicarbonate ($NaHCO_3$) loses water molecules as steam when heated, resulting in the formation of sodium carbonate monohydrate ($Na_2CO_3 \cdot H_2O$) or anhydrous sodium carbonate (Na_2CO_3)

Example reaction for trona:

$$Na_2CO_3 \cdot 10H_2O \rightarrow Na_2CO_3 \cdot H_2O + 9H_2O\uparrow$$

Decarboxylation: Sodium bicarbonate undergoes thermal decomposition to release carbon dioxide gas and form anhydrous sodium carbonate.

Example reaction for sodium bicarbonate:

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2\uparrow + H_2O$$

Dissolving

In this process, the calcined soda ash, often in the form of dense soda ash (sodium carbonate anhydrous) or light soda ash (sodium carbonate monohydrate), is dissolved in water to form a saturated sodium carbonate solution. This solution serves as the raw material for subsequent processing stages for the production of soda ash.

The dissolving process is a critical stage in soda ash production, as it converts the calcined soda ash into a soluble form that can be further processed to obtain the desired purity and particle size characteristics as required.

The dissolving process generally involves the following steps:

Mixing

The calcined soda ash is mixed with water in a dissolving tank or vessel. The ratio of soda ash to water is carefully controlled to achieve the desired concentration of the sodium carbonate solution.

Heating

In some cases, the dissolving process may involve heating the water to facilitate the dissolution of soda ash, particularly if the soda ash has a high density or if the dissolution rate needs to be accelerated.

Agitation

Agitation or stirring is employed to promote the dissolution of soda ash and ensure uniform mixing of the solution. This helps to maximize the contact between the soda ash particles and water, leading to faster dissolution.

Clarification

In soda ash production, clarification is a process used to remove impurities and solid particles from the sodium carbonate solution obtained during the dissolving stage. The clarification process is essential for achieving the desired purity and quality of soda ash, which is crucial for various industrial applications.

The clarification process typically involves Coagulation and Flocculation processes. In some cases, coagulation and flocculation agents may be added to the soda ash solution to help agglomerate fine particles and suspended solids, making them easier to remove during filtration. Common coagulants include alum (Aluminium Sulphate) or polymeric flocculants.

Evaporation and Crystallisation

Evaporation and crystallization are key processes in soda ash production, typically occurring after the dissolving and clarification stages

These processes involve concentrating the sodium carbonate solution obtained from dissolving the calcined soda ash and then crystallizing it to produce solid soda ash crystals or granules.

The sodium carbonate solution, obtained after dissolving the calcined soda ash and clarifying it to remove impurities, is fed into evaporation ponds. In these evaporation ponds, the water gets evaporated from the solution, leaving behind a concentrated sodium carbonate solution.

Once the sodium carbonate solution reaches a desired level of concentration, it is transferred to crystallizers or crystallization tanks. In these tanks, the concentrated solution is cooled slowly under controlled conditions to induce the formation of soda ash crystals or granules.

Centrifugation

In soda ash production, centrifugation is a common separation technique, to separate solid particles from liquid solutions or suspensions, allowing for the recovery of high-purity soda ash crystals or granules.

Centrifuges are rotating devices that apply centrifugal force to the suspension, causing the solid particles to migrate toward the outer wall of the centrifuge and form a cake, while the liquid is expelled through the openings in the centrifuge basket.

Drying

After the crystallization process and subsequent centrifugation process, the soda ash crystals contain residual moisture that needs to be reduced to meet the required moisture content for the final product.

These soda ash crystals or granules are then transferred to drying equipment. These dryers utilize hot air or other drying mediums to evaporate the moisture from the soda ash particles.

During drying, the moisture content of the soda ash is monitored continuously to ensure that it meets the specified requirements for the final product. The drying process is carefully controlled to ensure that the soda ash is dried to the desired moisture content without overheating or damaging the product.

Drying is a crucial step in soda ash production, as it helps to improve the shelf life, handling properties, and quality of the final product. Proper drying ensures that the soda ash meets the stringent specifications required for various industrial applications, such as glass manufacturing, detergents, pulp and paper, and chemicals.

Packaging

Once the soda ash crystals or granules have been dried to the desired moisture content, they are packaged into various types of containers suitable for storage, transportation, and handling.

Packaging is the final stage in soda ash production before the product is ready for distribution and use.

Packaging plays a crucial role in soda ash production, as it ensures that the product reaches customers safely and in optimal condition. Proper packaging also helps to protect the soda ash from moisture, contamination, and damage during storage and transportation, ensuring its quality and performance in industrial applications.

6.2.2.1 Equipment for Processing for Soda Ash Production

Soda ash processing involves several stages, each requiring specific equipment tailored to the task. Here are some of the key equipment used in soda ash processing:

a) Calciner

b) Dissolver

c) Tailing Pond

d) Silt Pond

e) Water Storage

f) Thickener

g) Evaporation and Crystallization Ponds are made up of HDPE sheets.

h) Scraper

i) Centrifuge

j) Dryer

k) Packaging Unit

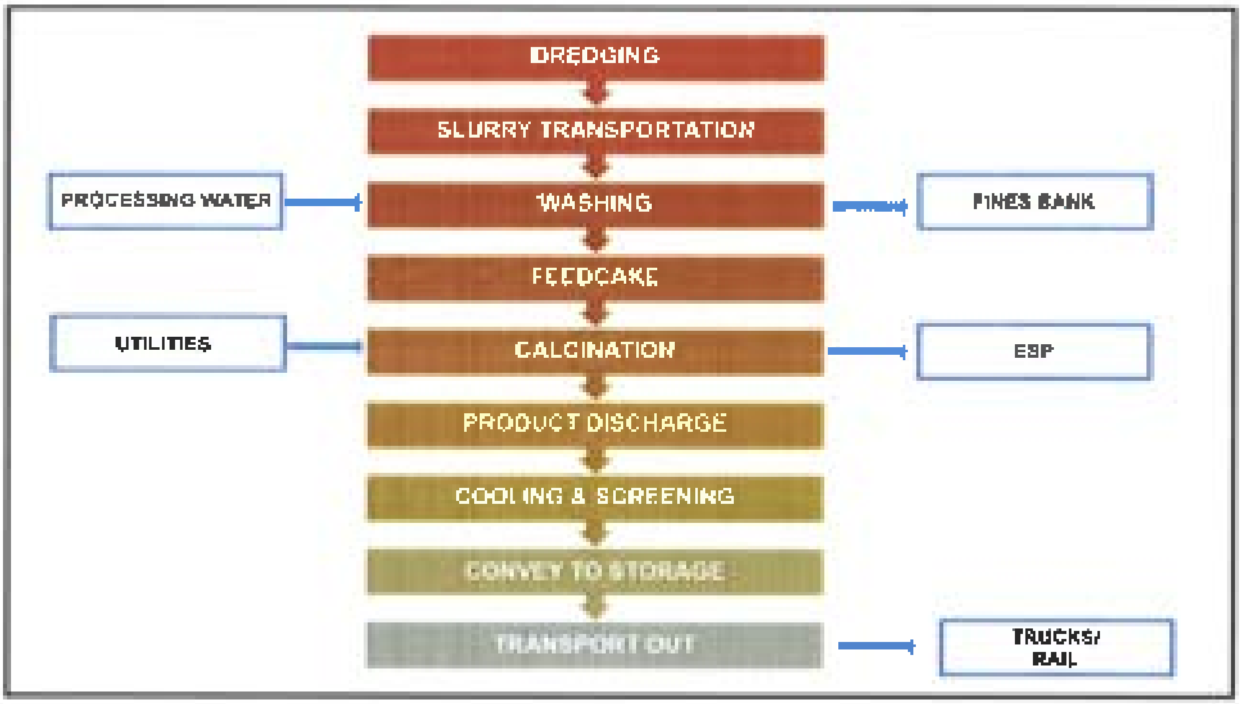

Figure 35: Flow Chart of Equipment Used in Processing Stages

a. Calciner

A calciner is a high-temperature processing vessel used in various industries, including soda ash production. In the context of soda ash production, a calciner is specifically used for the calcination of sodium bicarbonate (NaHCO3) or sodium carbonate (Na2CO3) ores to produce anhydrous sodium carbonate, commonly known as soda ash (Na2CO3).

Sodium bicarbonate or sodium carbonate ore is introduced into the calciner, either in solid form or as a slurry, depending on the specific process requirements.

The ore is subjected to high temperatures inside the calciner, typically ranging from around 400°C to 800°C (752°F to 1472°F), depending on the specific requirements of the process. This high temperature causes thermal decomposition of the sodium bicarbonate or sodium carbonate, leading to the release of water and carbon dioxide and the formation of anhydrous sodium carbonate.

The released water vapor and carbon dioxide gases are vented or captured and treated, while the resulting anhydrous sodium carbonate remains in the calciner.

After calcination, the anhydrous sodium carbonate product is cooled inside the calciner before being collected for further processing. This may involve conveying systems or other equipment to transfer the calcined soda ash to subsequent processing stages, such as dissolution, crystallization, and drying.

b. Dissolver

For dissolving the soda ash ore mixed brine for further processing to extract soda ash, a batch dissolver is an appropriate equipment for use.

In a batch dissolver, a predetermined quantity of trona mixed brine would be added to a vessel or tank containing a liquid solvent.

Agitation mechanisms like stirring paddles or impellers would be used to mix the soda ash mixed brine with the solvent, promoting dissolution.

This method allows for precise control over the dissolution process, making it suitable for smaller-scale operations or laboratory settings.

c. Tailing Pond

Tailing ponds are associated with soda ash processing and production, in terms of waste management practices, which are implemented to ensure environmental compliance and the efficient operation of production facilities

The specific methods and infrastructures used for managing waste materials in soda ash processing will depend on the individual processes, operational requirements of each facility, and the presence of impurities in the raw materials.

After dissolving trona and other raw materials to extract soda ash, the resulting solution may undergo various purification and concentration stages. During these processes, impurities may be removed or precipitated out of the solution. The waste materials generated from these purification steps are typically managed within the production facility.

In some cases, solid waste materials may be generated and separated from the solution. These solids could include impurities, precipitates, or filter cakes from purification processes. Depending on their characteristics and composition, these solids may be disposed of in designated waste disposal areas or managed following environmental regulations.

d. Silt Pond

A silt pond for soda ash processing would be a containment area designed to capture and settle out fine particles (silt) generated during the processing of soda ash. This pond helps to prevent silt from contaminating water sources and surrounding environments. Proper management and maintenance of silt ponds are crucial for environmental sustainability and regulatory compliance in industrial operations.

Purpose

Capture and contain silt particles generated during soda ash processing.

Prevent silt from contaminating water bodies and surrounding ecosystems.

Ensure compliance with environmental regulations and sustainability standards.

Recommendations

Implement regular monitoring programs to assess silt pond performance and environmental impact.

Incorporate sustainable practices, such as silt reuse or recycling, to minimize waste generation.

Continuously evaluate and improve silt pond design and management strategies based on evolving regulatory requirements and industry best practices.

References

Environmental Protection Agency (EPA) guidelines for industrial wastewater management.

Industry standards and best practices for silt pond design and management.

A well-designed and properly managed silt pond is essential for mitigating environmental sustainability. Regular monitoring, maintenance, and adherence to best practices are vital for the effective operation of the silt pond.

e. Water Storage

Soda ash processing requires significant amounts of water for various production processes. To ensure uninterrupted operations and manage water usage efficiently, the implementation of water storage systems tailored for soda ash processing plants. In the same context, the operation and maintenance include

i. Regular Inspection
ii. Cleaning and Maintenance
iii. Monitoring
iv. Emergency Preparedness

Purpose

Ensure a reliable supply of water for soda ash production processes.

Facilitate efficient water management, including storage, distribution, and recycling.

Mitigate the risk of production disruptions due to water shortages or fluctuations in supply.

Support environmental sustainability by promoting water conservation and reuse.

Recommendations

Invest in modern water storage technologies and infrastructure to improve efficiency and reliability.

Integrate water storage systems with advanced monitoring and control systems for real-time data analysis and decision-making.

Implement water conservation measures and recycling initiatives to minimize overall water consumption and environmental impact.

References

Industry standards and best practices for water storage design, operation, and maintenance.

Regulatory guidelines and environmental impact assessment related to water management in industrial facilities.

Case studies and research articles on water storage solutions and their applications in soda ash processing plants.

Water storage facilities play a crucial role in ensuring the reliable supply and efficient management of water for soda ash processing. By implementing appropriate design, operation, and maintenance practices, soda ash plants can optimize water usage, minimize environmental impact, and enhance operational resilience. By adopting sustainable practices and innovative technologies, soda ash plants can enhance water management efficiency and minimize their environmental footprint.

f. Thickener

For processing soda ash mixed brine to extract soda ash, a flocculent thickener is the appropriate equipment to employ to perform the clarification process.

Flocculent thickeners are equipped with systems for adding flocculants to the mixture of trona-mixed brine, promoting the aggregation of fine particles into larger flocs that settle more rapidly.

By enhancing the setting process, flocculent thickeners can achieve higher solid concentration and more efficient solid-liquid separation.

It is needed where brines are fine and tend to remain suspended and require chemical treatment to facilitate setting.

g. Evaporation and Crystallization Ponds are made up of HDPE sheets

Evaporation Pond

In the evaporation pond, sodium carbonate solution is pumped or transferred into the pond and spread out over the surface to maximize exposure to sunlight and promote evaporation.

As water evaporates from the surface, sodium carbonate becomes increasingly concentrated, eventually reaching super saturation and initiating the crystallization process.

Crystallization Pond

In the crystallization pond, the concentrated sodium carbonate solution undergoes further evaporation and cooling, leading to the formation of soda ash crystals or granules.

The crystals settle to the bottom of the pond, while the remaining are removed and recycled or disposed of

HDPE sheets

High-density polyethylene (HDPE) sheets are commonly used in the construction of evaporation ponds and crystallization ponds in soda ash production facilities, helping to ensure efficient operation, environmental compliance, and long-term durability of the processing facilities.

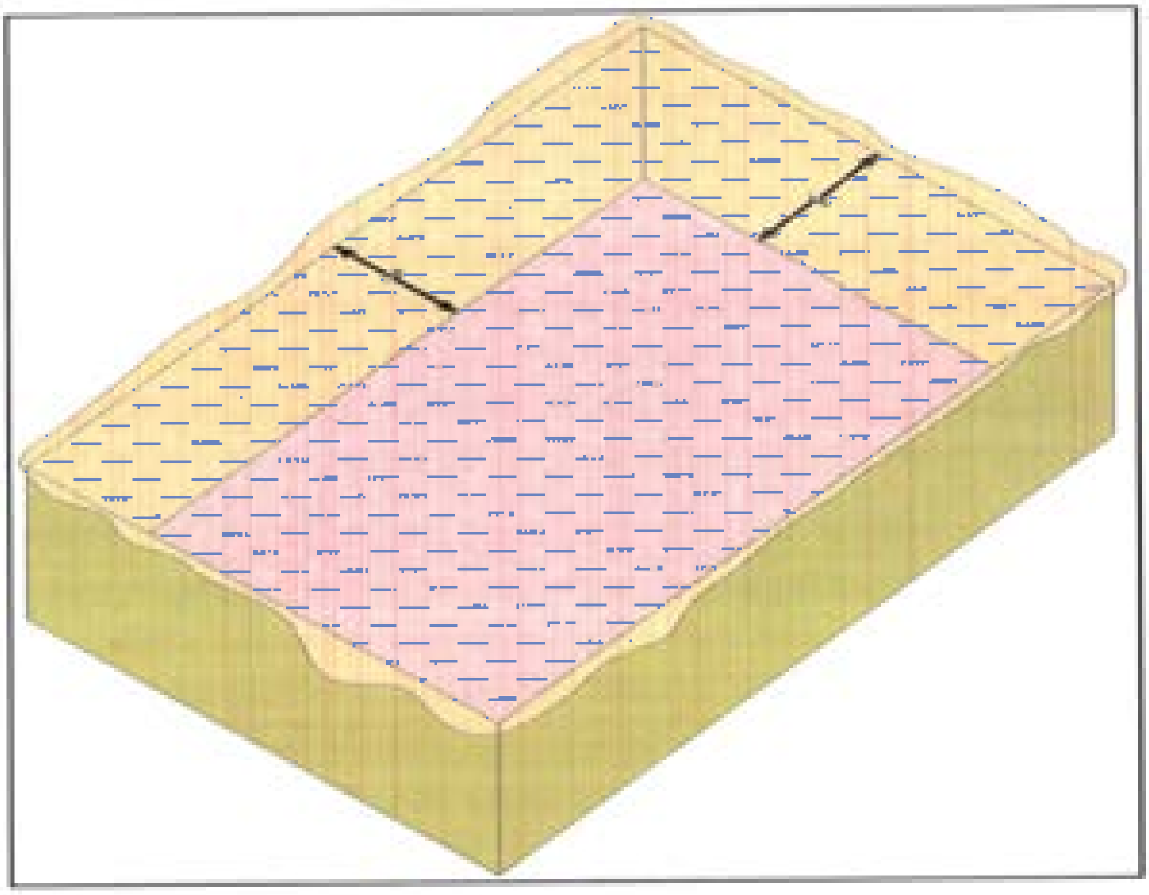

Figure 36: Evaporation Pond for Processing of Soda Ash

These ponds serve as containment structures for the treatment and processing of sodium carbonate solutions, allowing for the evaporation of water and crystallization of soda ash.

Proper design, installation, and maintenance of the HDPE liner system are essential to prevent leaks, minimize environmental impact, and optimize the performance of the soda ash production process.

HDPE sheets are often used as liner materials for evaporation and crystallization ponds due to their excellent chemical resistance, impermeability, and durability. The HDPE liner acts as a barrier to prevent leakage of sodium carbonate solution or other process liquids into the surrounding environment and groundwater.

HDPE sheets are installed on the surface and sides of the pond excavation to create a watertight enclosure. The sheets are typically laid out in overlapping sections and welded together using heat fusion techniques to create a seamless liner system. Once installed, the HDPE liner may be covered with a protective layer to prevent damage. Additionally, the liner may be anchored or secured along the edges and corners of the pond to prevent movement or displacement.

h. Scraper

In the context of soda ash production, a scraper is a type of mechanical equipment used for various purposes, including the removal of settled solids or crystallized soda ash from the bottom of the evaporation and crystallization ponds. Scrapers are designed to scrape or push material along the bottom surface to facilitate its removal and transfer to subsequent processing stages or disposal areas.

Scrapers are available in various designs and configurations to suit different applications and processing requirements in soda ash production. Common types of scrapers include continuous chain or flight scrapers, rotating drum scrapers, and hydraulic or pneumatic-driven scrapers. The selection of the appropriate scraper design depends on factors such as the size and geometry of the processing vessel, the type of solids being handled, and the desired efficiency of solids removal. The scrapers are typically involved and to be used in soda ash production:

Solids Removal

In crystallization ponds, soda ash crystals or granules settle to the bottom over time as the solution evaporates and becomes more concentrated. Scrapers are used to collect and remove the accumulated solids, known as the thickened slurry or underflow, from the bottom of the pond or tank.

Crystallizer Maintenance

Scrapers may also be used to maintain the condition of the crystallizer surfaces by preventing the buildup of scale or deposits that can impair the efficiency of the crystallization process. By continuously scraping the bottom surface, scrapers help to ensure uniform crystal growth and prevent blockages or fouling.Overall, scrapers play a crucial role in soda ash production by facilitating the efficient removal and handling of solids, ensuring smooth operation and optimal performance of processing equipment and systems.

i. Centrifuge

A centrifuge machine is a device that spins samples at high speed to separate components based on their density or molecular weight.

Industrial centrifuges are used for separating solids from liquid for clarifying and purifying the process of streams.

A decanter centrifuge is a device used in various industries including soda ash production, to separate solid from liquid.

It works by rotating a bowl at high speeds, causing the centrifugal force to push heavier solids to the perimeter while the lighter liquid phase collects in the center. The separated phrases are then discharged through different outlets.

j. Dryer

In Soda ash processing, a dryer is a crucial piece of equipment used to remove moisture from the product.

In the process of soda ash extraction, it often needs to be dried to reduce its moisture content to a suitable level for storage, transportation, or further processing.

The dryer is employed in soda ash processing, depending on the specific requirements of the operation. These dryers use heat and airflow to evaporate moisture from the soda ash, ensuring it meets the desired specifications for quality and handling

k. Packaging Unit

In Soda ash processing, packaging units are employed to efficiently package the final product for storage, transportation, and distribution.

The packaging unit for soda ash is designed to streamline the packaging process, minimize manual handling, and ensure the product is packaged safely and efficiently for distribution to customers.

The packaging unit for soda ash typically involves several components:

Bagging Machine

This machine fills bags with soda ash to the desired weight. It can be a semi-automatic or fully automatic system, depending on the scale of production.

Conveyor System

A conveyor system is used to transport the filled bags from the bagging machine to the next stage of the packaging process.

Palletizer

Once the bags are filled, they are often stacked onto pallets for easier handling and transportation. A palletizer arranges the bags neatly and stably on pallets.

Stretch Wrapping Machine

After palletizing, the pallets of soda ash bags are wrapped with stretch film to secure them during transportation and storage. This process is typically automated for efficiency.

Labelling and Coding

Labels or codes may be applied to the bags or pallets for identification, tracking, and inventory management purposes.

Quality Control

Throughout the packaging process, quality control measures may be implemented to ensure that the soda ash meets specified standards and that the packaging is intact and secure.

6.4 PLANT DESIGN LAYOUT AND EQUIPMENT SPECIFICATIONS

The monohydrate plant design for the soda ash project at Lake Natron focuses on utilizing the unique characteristics of the lake's brine while ensuring environmental sustainability and operational efficiency. Below is a detailed overview of the plant design considerations and features specific to the monohydrate extraction process.

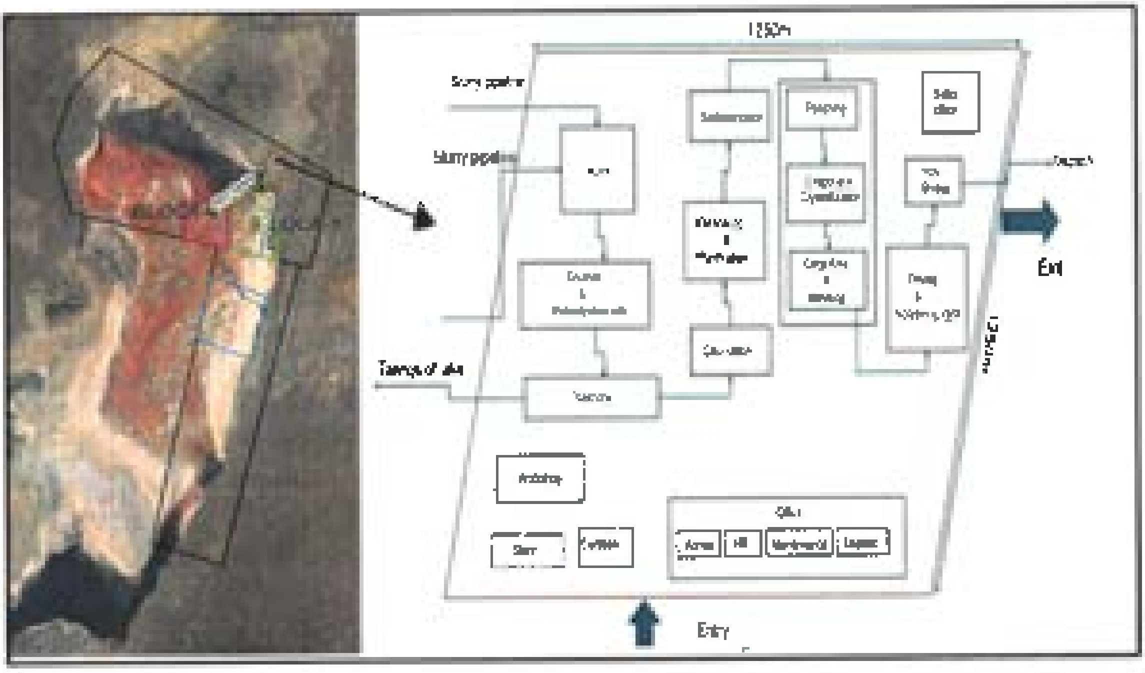

Figure 37: Plant Design

6.4.1 OVERVIEW OF THE MONOHYDRATE EXTRACTION PROCESS

The monohydrate extraction method involves the production of soda ash (sodium carbonate) from the brine found in Lake Natron. which has a high concentration of sodium carbonate. This process is characterized by the following steps:

- **Brine Collection**: Brine is extracted from the lake, which contains dissolved sodium carbonate and other minerals. The design must ensure minimal disturbance to the lake's ecosystem during extraction.
- **Solar Evaporation**: The collected brine is subjected to solar evaporation in large shallow ponds. This method takes advantage of the region's favorable climatic conditions, allowing for the natural concentration of the brine.

- **Crystallization**: As the brine evaporates, sodium carbonate monohydrate crystals begin to form. These crystals are harvested and further processed to produce soda ash.
- **Calcination**: The monohydrate crystals are heated in a calciner to remove water and convert them into anhydrous soda ash. This step is crucial for achieving the desired product quality.

6.4.2 PLANT LAYOUT AND DESIGN

The layout of the monohydrate soda ash plant is designed to optimize workflow and minimize environmental impact. Key features include:

- **Modular Design**: The plant will be designed in modular units to facilitate scalability. Each module can be expanded or upgraded independently based on production needs and market demand.
- **Separation of Processes**: Different stages of production, such as brine collection, evaporation, crystallization, and calcination, will be housed in distinct areas to enhance operational efficiency and reduce cross-contamination.
- **Efficient Water Management**: Given the significant water requirements (approximately 106 m^3/hour for plant operations), the design will incorporate water recycling systems to minimize freshwater withdrawal from Lake Natron and ensure sustainable water use.

6.4.3 ENVIRONMENTAL CONSIDERATIONS

The monohydrate plant design emphasizes environmental protection and sustainability:

- **Impact Mitigation**: The design will include measures to mitigate potential environmental impacts, such as habitat disruption and water resource depletion. This may involve creating buffer zones around extraction areas and implementing strict monitoring protocols.
- **Emission Control**: Technologies will be integrated to capture and reduce emissions during the calcination process, ensuring compliance with national and international environmental standards.

- **Biodiversity Protection**: Special attention will be given to protecting local wildlife, particularly the lesser flamingo population, by minimizing disturbances and ensuring that the extraction process does not compromise their breeding habitats.

6.4.4 EQUIPMENT AND MACHINERY

The plant will utilize specialized equipment to enhance production efficiency:

- **Evaporation Ponds**: Large, shallow evaporation ponds will be constructed to facilitate the solar evaporation process. These ponds will be designed to maximize surface area and minimize evaporation losses.
- **Crystallizers**: Efficient crystallization units will be employed to ensure optimal recovery of sodium carbonate monohydrate crystals from the concentrated brine.
- **Kilns**: High-efficiency kilns will be used for the calcination process, designed to operate at high temperatures to ensure complete conversion of monohydrate to anhydrous soda ash.

6.4.5 ECONOMIC VIABILITY

- **Cost Analysis**: A thorough economic analysis will be conducted to assess the capital investment required for the plant, operational costs, and projected revenue from soda ash sales. This analysis will help ensure the project's financial viability.
- **Market Demand**: The design will consider current and projected market demand for soda ash in various industries, including glass manufacturing, detergents, and chemicals. This will inform decisions on plant capacity and production levels.

The monohydrate plant design for the soda ash project at Lake Natron is a comprehensive framework that balances production efficiency, environmental sustainability, and economic viability. By utilizing the monohydrate extraction process, the plant aims to produce high-quality soda ash while minimizing ecological impacts and supporting the local economy. The careful integration of environmental safeguards and community engagement will be crucial in ensuring the project's success and alignment with Tanzania's development goals.

6.5 EQUIPMENT SPECIFICATION

6.5.1 CUTTER SUCTION DREDGER

Equipped with a rotating cutting head a CSD cuts and loosens material on the seabed, which is then pumped through a pipeline to the disposal area. For the cutting of a trona, a cutter suction dredger (CSD) would be suitable. Trona is a soft crystalline mineral commonly found in evaporite deposits and a CSD is effective for dredging such materials. The rotating cutting head of CSD can efficiently break up the Trona deposits on the seabed, allowing it to be suctioned up through the dredging pipeline for transportation to the desired location. Additionally, the adjustable depth and precise control capabilities of a CSD make it well suited for dredging operations in varying water depths, may be encountered in trona mining areas.

Figure 38: Cutter Suction Dredger

Brine Extraction System

- **Type**: Pumping System
- **Capacity**: Capable of extracting approximately 1,000 m³ of brine per hour.

Specifications:

- **Material**: Corrosion-resistant materials (e.g., stainless steel or high-density polyethylene) to withstand saline conditions.

- **Pump Type**: Submersible or centrifugal pumps designed for high salinity.

Brine Pre-treatment Unit

- **Function**: Remove impurities from the brine.

Components:

- **Filtration System**: Multi-stage filters (sand and activated carbon) to eliminate suspended solids and organic compounds.
- **Chemical Dosing System**: For pH adjustment and coagulation

6.5.2 DISSOLVER

For dissolving trona mixed brine for further processing to extract sodium sesquicarbonate, a batch dissolver or a reactor dissolver would be suitable options.

6.5.2.1 REACTOR DISSOLVER:

A reactor dissolver integrates the dissolution process with other chemical reactions, which may be necessary for further processing to extract sodium sesquicarbonate from trona mixed brine. The dissolution of trona mixed brine would be combined with additional chemical reactions such as precipitation or crystallization to selectively extract sodium sesquicarbonate.

6.5.3 THICKENER

For processing trona mixed brine to extract sodium sesquicarbonate a gravity thickener of flocculent thickener would be suitable options.

6.5.3.1 FLOCCULENT THICKENER

Flocculent thickeners are required with systems for adding flocculants to the mixture of trona mixed brine, promoting the aggregation of the fine particles into larger flocs that settle more rapidly. By enhancing setting process, flocculent thickeners can achieve higher solid concentrations and more efficient solid liquid separations. it is needed where brine is fine and have tendency to remain suspended & requires chemical treatment to facilitate cutting.

6.5.4 FILTER

A filter is a device or system used to separate solids from liquids or gases by passing the mixtures through a porous barrier that retains the solid particles while allowing the fluid or gases to pass through. For processing the trona mixed brine to extract sodium sesquicarbonate, a suitable type of filter would be a mechanical filter, specially a microfiltration membrane or a depth filter.

Specification

- **Type**: Flue gas treatment systems
- **Function**: Capture and neutralize emissions from the calcination process
- **Technology**: Use of scrubbers or bag filters to reduce particulate matter and CO2 emissions.

6.5.4.1 Microfiltration Filter

They are effective at removing suspended solids bacteria and large colloids from liquids. A microfiltration membrane within pore size can effectively remove these particles while allowing the dissolved sodium sesquicarbonate and other components to pass through.

6.5.5 EVAPORATOR

An evaporator is a device that is used to remove liquid from a solutions by converting it into vapor, leaving behind concentrated solute

Evaporation Ponds

- **Size**: Approximately 1,000 hectares (2,471 acres) of evaporation ponds.
- **Design**: Shallow ponds with a depth of 0.5 to 1 meter to maximize surface area for evaporation. 1
- **Material**: Lined with impermeable materials to prevent brine leakage into the groundwater

6.5.5.1 Multiple Effect Evaporator

Multiple effect evaporator are highly efficient systems that utilize multiple stages of evaporation to achieve high concentrations ratios and energy efficiency. It consumes energy. In a multiple effect evaporator, stream from one stage is used to heat and reducing the overall energy requirements. These evaporators are suitable for processing large volume of liquid, making them well suited for industrial applications such as extraction of sodium sesquicarbonate from trona mixed brine.

6.5.6 CRYSTALIZER

A crystallizer is a device used to promote the formation of crystals from a upper saturated solution by inducing controlled crystallization.

6.5.6.1 Continuous Cooling Crystallizer

A continuous cooling crystallizer allows for gradual cooling of the brine, leading to controlled crystallization of sodium sesquicarbonate. Continuous crystallizers operate continuously, making them suitable for large scale production and providing consistent crystal quality and size. Continuous cooling crystallizers can be configured as either mixed – suspension, mixed – product removal (MSMPR) crystallizers or draft – tube baffled (DTB) crystallizers.

Specifications

- **Material**: Stainless steel or other corrosion-resistant alloys.
- **Temperature Control:** Equipped with temperature monitoring and control systems to optimize crystallization conditions

6.5.7 CENTRIFUGE

A centrifuge machine is a device that spins samples at high speeds to separate components based on their density or molecular weight. Industrial centrifuges are used for separating solids from liquids or clarifying and purifying process of streams.

6.5.7.1 PUSHER CENTIFUGE:

Pusher centrifuge are continuous feed centrifuges that are highly efficient at separating solids from liquids. In a pusher centrifuge, the solid crystals are continuously fed into the centrifuge where they are subjected to centrifugal force and pushed against the centrifugal walls. As the crystals move through the centrifuge, the liquid is expelled, living behind the solid soda crystals. Pusher centrifuges are ideal for large scale continuous operation and offer high throughout rates and efficient separation of solids from liquids.

6.5.8 CALCINER

After the trona mixed brine undergoes crystallization and centrifugation to separate the solid soda ash crystals from the liquid phase, the solid soda ash crystals contain impurities and moisture. The calciner is then used to further process these solids soda ash crystals by heating them to higher temperatures. typically above 800°C(1427°F) in order to remove impurities, residual water and other volatile components.

6.5.8.1 ROTARY CALCINER:

A rotary calciner is a type of industrial furnace used for high temperature processing of materials. The calcination process in the rotary calciner involves exposing the soda ash crystals to high temperatures in a controlled environment. Typically, within a rotating drum or cylinder. Heat is supplied through burners or heating elements and the rotation of the drum ensures uniform heating and efficient processing of the soda ash crystals. Designed to process approximately 5 million tons of sodium carbonate monohydrate per year.

SPECIFICATION

- **Temperature Range**: Operates at 300°C to 600°C to effectively drive off water and convert monohydrate to anhydrous soda ash
- **Dimensions**: Length of 60 meters and diameter of 3 meters
- **Fuel Source**: Natural gas or alternative fuels for efficient heating

7. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

7.1 ESIA SCOPE OF WORK

The project proponent has commissioned the current scope of works, which includes an ESIA of the project area. The ESIA, including the provision of the environmental and social mitigation plans, has been completed following the requirements of the terms of reference and national rules and regulations for EIAs as part of the services.

7.2 HISTORY OF ESIA

The National Environmental Management Act (No. 19 of 1983) provided for the establishment of the National Environmental Management Council (NEMC), the main EIA authority to date. In 1994 NEMC developed the National Conservation Strategy for Sustainable Development. Simultaneously, the Ministry of Tourism and Natural Resources took the first step towards incorporating environmental concerns into national planning and development with the publication of the National Environmental Action Plan in 1994. The National Conservation Strategy for Sustainable Development the National Environmental Action Plan and specific sectoral policies such as those on land, mining, energy, water, agriculture, population, and fisheries recognize EIA as a means of ensuring that natural resources are soundly managed. Draft EIA guidelines were first presented in 1996 and later revised and updated in March 2002. At that moment, the country was still lacking a coherent legal basis for effective environmental management. In 2004, the parliament of Tanzania passed the Environmental Management Act (EMA) which repealed the Act of 1983. Under the EMA, the Environmental Impact Assessment and Audit Regulations of 2005 were passed. EMA promulgates both EIA and SEA.

7.3 LEGAL FRAMEWORK

Enabling Law

Environmental Management Act (EMA) No. 20 of 2004 provides the legal basis for EIA and SEA. It is commonly referred to as EMA Cap 191.

National detailed regulation

National Environmental Impact and Auditing Regulations (2005): These regulations set out procedures for conducting EIA and Environmental audits in the country.

Guidelines

NEMC issued general EIA guidelines, which comprise of three parts:

- Part 1: Elaborates the proposed EIA procedure.
- Part 2: Detailed guidelines for the following stages: registration, screening, scoping, EIA report writing, review, and monitoring.
- Part 3: Includes relevant annexes (e.g., screening lists, review criteria, checklists, flow diagrams)

The guidelines are intended to eventually become integrated into the regulation and thus become part of the legal provisions for EIA.

Sector-wise, the following guidelines exist (their status is also given):

- Roads (2005): being tested.
- National parks: In use
- Marine parks and reserve: Finalized
- Mariculture development: Inclusion of EIA in the sector's guideline
- Coastal tourism: Inclusion of EIA in sector's guideline

Sl. No.	PARTICULARS	DETAILS
1	Location	The Lake Natron
5	Nearest Villages	Wosi Wosi
		Pinyinyi
		Mlowabaga
		Monick
		Engare Sero
6	Nearest Town	Hemah
		Engare Sero
		Engaruka
		Arusha
7	District Head Quarters	Ngorongoro- Loliondo
		Longido- Madukani
8	Nearest Highway	B144 and A104

9	Nearest Airport	Arusha Airport
		Kilimanjaro International Airport
10	Nearest Railway Station	Arusha
11	Nearest Seaport	Tanga, and Dar- Es - Salaam
12	International Boundary	Yes (Kenya): Adjacent to PL/12236/2023
13	Water Bodies	The Lake Empakai
		The Lake Magadi
		The Lake Eyasi
		The Lake Manyara
		The Lake Ndutu
		The Lake Masek
		and Lake Oldupai
14	National parks	The Serengeti National Park
		The Lake Manyara National Park
		The Arusha National Park
		The Ngurdoto Crater National Park
		The Kilimanjaro National Park
15	Conservation Area	The Ngorongoro Conservation Area
16	Game Reserves	The Maswa Game Reserve
17	Forest Reserve	The Mount Meru Forest Reserve
		The Mount Longido Forest Reserve
		The Gelai Forest Reserve
		The Kitumbeine Reserve Forest
		The Monduli Reserve Forest
		The Burko Reserve Forest
		The Losiminguri Reserve Forest
18	Historical Places	N/A
19	List of other industries	Geothermal Energy, Lithium and Helium
20	Ecological Significance	Ramsar Wetland (4 July 2001)

Table 12: Environment Setting of the Project Area

7.4 ESIA BASELINE STUDY

7.4.1 Social Profile

The communities in the Lake Natron Basin are largely pastoralist Masai who are continually trying to preserve their ways in an increasingly modern world. The society is among the most notable African ethnic groups internationally. They keep up with many of their social practices while drawing in contemporary territorial and worldwide monetary, social, and political powers. Decisions are made by the elders for each Masai group being patriarchal in nature.

They live on the border of Kenya and Tanzania, moving their homes from time to time to follow their cattle, which is the main source of their livelihood. For the Masai, cattle are a significant part of their life; they drink cow's milk and blood as a sacred drink; they use the cows' dung to cover and seal their homes; they don't slaughter their cattle for food; but if a cow is killed, then the horns are used for containers; the hides are used to make shoes, clothing, ropes, and bed coverings; and the hooves and bones are made into ornaments. The Masai believe they are the rightful owners of all cattle, a source of many conflicts with other pastoral communities.

Second to the Masai are the Sonjo, who are farmers cattle breeders, and enemies of the Masai. They are the dominant tribe at Pinyinyi where they use an ingenious primitive irrigation system relying on the water from the escarpment (it is suggested that they are the first tribe in East Africa to water their fields by irrigation). Water is of significant value to them, and they have controlled water rights where fourteen 'wanamiji' elders own the rights. Their origin is not easily established with a Bantu-sounding language and Nilotic features. There is a conscious reluctance by the tribe to adopt any new technologies.

The villages that are within the project area include Engare Sero, Pinyinyi, Alaililai, and Londo Losirwa (also known as Magadini). The Sonjo are mainly found in villages on the western shore of the lake; Engasero, and Pinyinyi with some at Engaruka Village. The Masai are the majority and predominate in almost all villages in the project area. Some minority groups such as the Chagga, Sukuma, Hadza, and Iraqw are found in strategic villages where agriculture, trade, and tourism are common.

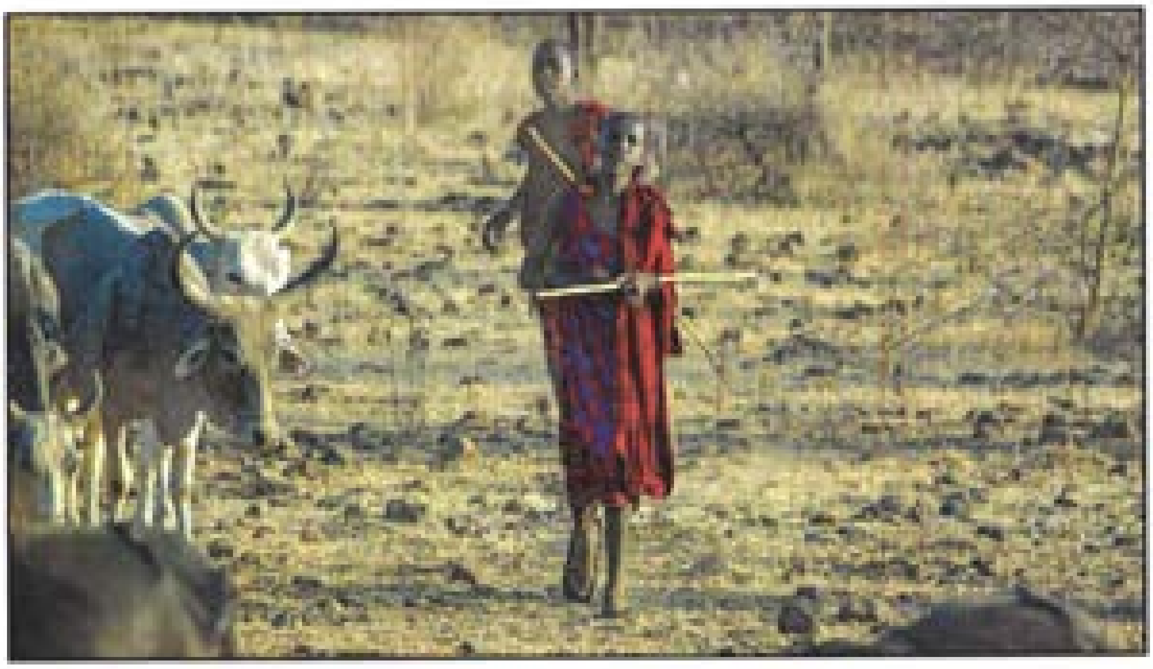

Figure 39: People from Massai Community near the Lake Natron

Figure 40

Figure 41: Tribes near the Project Area

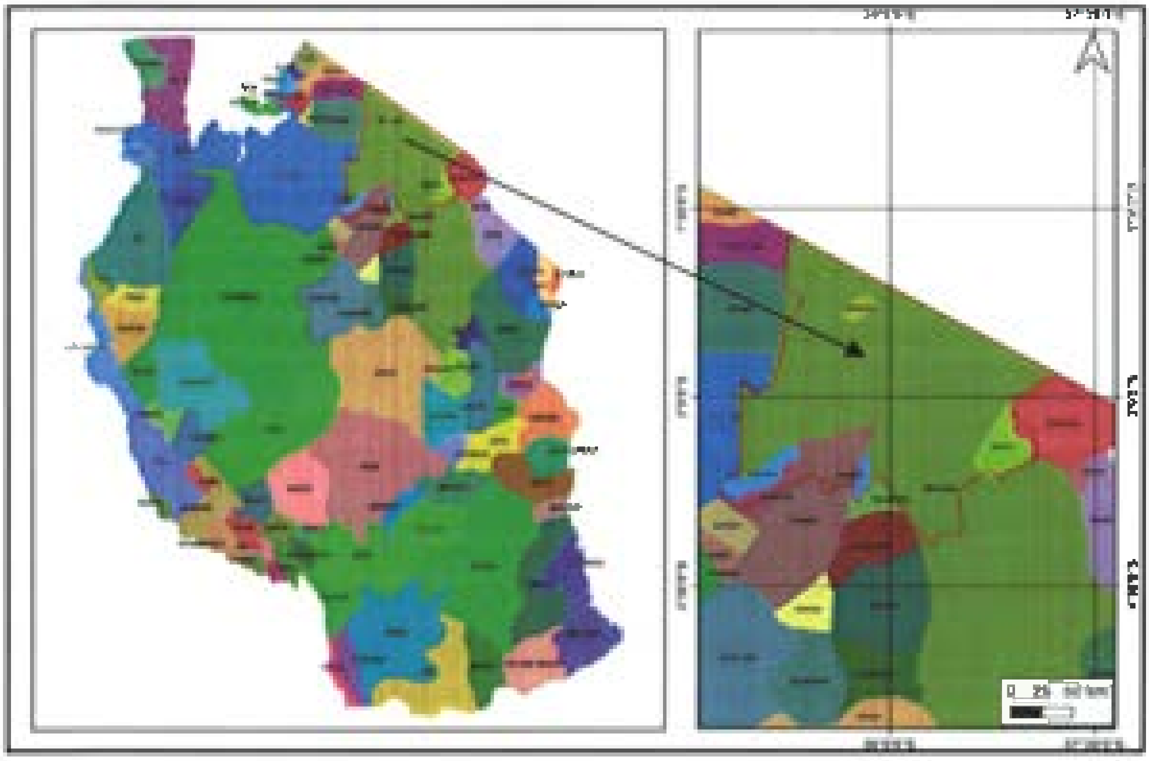

Figure 42: Communities in and around the Project Area

7.4.2 Health and Education

Ngorongoro and Longido are among the least prosperous regions in Tanzania, characterized by sparsely populated areas where the residents frequently move around due to pastoralism, which is the primary economic activity for most of the populace. The limited availability of health and education services is hindered by the long distances involved and a lack of resources, resulting in an inability to satisfy the needs of the local communities. Even in sedentary communities like the Sonjo communities and certain emerging commercial satellite villages, the services suffer from a shortage of staff, insufficient funding, and inadequate equipment. In Ngorongoro District, the typical distance to the closest healthcare facility is 22 km, with the maximum distance reaching 165 km. This contrasts with the national policy, which mandates that healthcare services should be within a range of 0 to 5 km. The situation is similar in Longido district where individuals are compelled to cover distances of up to 70km on foot to access medical services.

The villagers from Wosi-Wosi, located in the Longido district, may be favorable for this soda ash project. Social services to the local community should be offered, which are currently lacking in the region. Residents of this locality should get essential services like water, healthcare, and education from the developer of this project. Such provisions would assist them in tackling the persistent scarcity they have long been facing and promote their overall well-being. Almost every village has a deficiency or is in an extremely unfavorable state when it comes to sanitation. The lack of accessible latrines or their insufficient utilization leads to the transmission of diarrhoeal illnesses. In rural areas within Lake Natron, there are significant health concerns such as malaria, pneumonia, eye infection, acute respiratory infection, diarrhea, skin infections, sexually transmitted diseases (including HIV/AIDS), malnutrition, worms, urinary tract infections, and prenatal complications. The Ngorongoro district is currently putting into action a five-year strategy to diminish these issues, while also enhancing the available healthcare facilities by furnishing them with the necessary medications and staff. There is insufficient information available regarding the Longido district to ascertain if any proposed plan is in existence or being implemented. It is crucial for the district to carefully strategize on how to effectively manage the health concerns linked to mining and producing soda ash.

The two districts' schools are faced with a shortage of teachers, books, and classrooms. For instance, in the Longido District, the ratio between teachers and students is 1 to 236, which is remarkably high and hinders the efficacy of the teaching methods. Pastoralist communities tend to delay the enrollment of their children in schools, especially girls. The government's policy aims to create boarding schools specifically designed to provide term-time accommodation for children from pastoral communities. Additionally, the government is in the process of allocating resources to construct schools in every administrative area.

7.4.3 Land Use

The project area includes three registered land use categories which have an overall impact on the ecosystem. These are:

i. Agricultural
ii. Tourism
iii. Livestock

Most of the land is used by the local communities for livestock grazing. On the western lakeshore, agriculture is restricted to the few acres where irrigation is feasible along permanent river channels. At certain spots around the lake, commercial and photographic hunting is done for tourism.

Agriculture is limited to a few acres where irrigation is possible along permanent river channels on the western lakeshore. Based on the repeat flows of rift valley rivers that enter the valley floor, extensive and intensive irrigated agriculture and stock rearing existed approximately 600 years ago. This happened on the waters of the Engare Sero, possibly the Pinyinyi and Monic, at Engaruka (5,000ha). About 300 years ago, these developments came to an end, and Masai pastoralists largely took their place (Sutten, 1990).

With increasing land demarcation within the agricultural areas, sedentary farmers are developing a different kind of livestock production system, in which herds maintained on supplementary feeding are more important than large nomadic herds. For most people in these two districts (Ngorongoro and Longido), put forward livestock is a customary and familiar source of income. Semi-nomadic livestock production involves a permanent home and seasonal livestock movement to take advantage of the availability of essential resources such as salt, water, and grazing, as well as low disease risk. The success of livestock in the area has been based on the trans-human strategy. One of the strategies of having mobile herds, and a large land area in which to successively graze. The graze and browse resources of one of the ranches have been carefully mapped, and local personnel are available to continue to monitor the availability of the resources under yearly weather fluctuations

7.4.4 Archaeology

Lake Natron is a Salt Lake located in Northern Tanzania, close to the Kenyan border, and just NE of the Ngorongoro crater, in the eastern branch of Africa's immense Great Rift Valley. Nestled between rolling volcanic hills and deep craters, lake Natron sits at the lowest point of the Rift Valley (600msl) and is probably the world's most caustic body of water. The lake flats are surrounded by steep sloping hills with Plio-Pleistocene sediments rich in important fossils and artifacts as discussed below.

Pinyinyi is a site that is best known for the Australopithecine mandible which fits the famous Olduvai Zinjanthropus skull (OH 5, A. Boisei) as if they belonged to the same individual and also for containing the earliest Acheulean sites contemporary to Kenos Gradual sites in Ethiopia (Isaac & Curtis, 1974). Paleo-anthropological work at Pinyinyi was first initiated by R.E.F. Leakey and G.Ll. Isaac between 1963 and 1964 Isaac

1967). Between 1981 and 1983 an international team under the direction of Isaac investigated the area, followed by a hiatus until 1995, when a Spanish team resumed work in the area.

To date, a total of 27 paleontological and 8 archaeological localities have been discovered along the Western shore of the Lake. Most of the sites are located in the Humbu Formation, the lower member of the "Pinyinyi Group" at the top of the Plio-Pleistocene stratigraphical sequence. Archaeological materials and fossil bones appear unevenly distributed in the three main areas around the modern Pinyinyi River Type section (Mantanane, Kamare & Kipalagu). Southern Escarpment (Bayasi, Karonga North South and East Mugure and Northern Escarpment (Mgudulu) are among the better-known localities.

7.4.5 Aquatic biology

The Lake is fed by numerous mineral-rich hydrothermal springs and several perennial rivers such as Enwase Ng'iro in the North direction, Engare Sero in the southern part, and Peninj as well as Monik in the western region of Lake Natron. It is quite shallow, less than 3m (10 feet) deep, and varies in width depending on its water level, which –

changes due to the high level of evaporation, leaving a concentration of salt and other minerals, notably sodium carbonate (Natron).

The size and shape of the rivers Enwase Ng'iro, Engare Sero, Peninj, and Monik; as well as Lake Natron change constantly in the cycle of dry and rainy seasons and between dry and wet years. The lake is also influenced by thermal springs due to its recent history of volcanic activity. The constantly flowing spring water is the main contributor to the formation of brine and soda crust in the lake. These hydrological dynamics of the Lake's springs add an extra dimension to the riparian ecosystem as well as to the water resource management issues.

There are numerous permanent springs situated in the vicinity of the lake or in the lake itself, including hot water springs that feed salt-rich water into the lake. The constantly flowing spring water is the main contributor to the formation of brine and soda crust in the lake. According to Guest and Steven (1951), about 28 hot alkaline springs are flowing into Lake Natron. The temperature of the spring water is in the range of 30 - 50°C.

There are several wetland patches associated with the lake: two relatively small Typha domingensis-dominated wetland patches on the western shore and two medium-sized to large partially freshwater wetlands on the eastern side. The wetlands are a source of water for wild and domestic animals.

During the fieldwork, microalgae were studied from various sites located within Lake Natron. The dominant microalgae were pinnate diatoms Navicula ssp. (especially Navicula scolipleura and Navicula sphaerophora). Other microalgae found in the water column in Lake Natron included cyanobacteria of the genera Pseudoanabaena, Chroococcus, and Microcystis as well as a diatom Navicula oblonga although these occurred at relatively low numbers. These results suggest that in addition to Arthrospira fusiformis, there must be other important food sources for resident Lesser Flamingo in Lake Natron allowing for food diversity.

7.4.6 Lake Natron as a Key Site for Lesser Flamingo

Lake Natron is the only known successful breeding site for the Lesser Flamingo in East Africa and is globally the most significant breeding site for this species. Most of the breeding occurs during October – November although breeding to a lesser degree of success can occur throughout the year. There are several significant reasons why Lake Natron is preferred by this species. There are five main conditions that the flamingo require to successfully breed at Lake Natron:

1) Isolation of nesting sites from mammalian and avian predators. There is no other site within the range of the East African Lesser Flamingo which currently provides these parameters of isolation from mammalian predators. Documented evidence has suggested that a single episode of disturbance can cause the whole breeding colony to abandon the nest site
2) The presence of freshwater springs throughout the year. The juvenile birds, once in a crèche, move towards fresh water in large groups. If you look at the distribution of Lesser Flamingos at Natron, large concentrations gather at the river deltas and springs to wash their feathers.
3) The presence of suitable substrate for nest construction. This is extremely important, the 'preferred' breeding sites are in areas where this mud is available, in dry years the colonies can be more spread out and follow the cracks in the trona where suitable mud can be accessed (these are known as string formation

nests).

4) Suitable areas for the young when in a crèche to move, feed, and obtain freshwater as outlined above

5) Other than breeding, Lake Natron is a key feeding site for this species throughout the Year with numbers often exceeding 200,000 individuals (c. 8% of the global population). As mentioned, this species requires a network of sites to respond to changing environmental conditions.

7.5 WILDLIFE RESOURCES AND POTENTIAL

The wildlife of Tanzania is a unique natural heritage and resource that is of great importance both nationally and globally. Its importance lies both in the biological value of the species and habitats found in Tanzania, the economic value of the resource, and its potential to contribute to the sustainable development of Tanzania.

7.5.1 Biological Diversity

Tanzania has a rich and diverse spectrum of fauna and flora including a wide variety of endemic species and sub-species. The diversity and degree of endemism in Tanzania are clear for primates (20 species and 4 endemics), antelopes (34 species and 2 endemics), fish, reptiles (290 species and 75 endemics), amphibians (40 endemics), invertebrates and plants (around 11,000 species including many endemic). There are likely to be several species in Tanzania that are still unknown to science and await discovery. Besides the diversity and high degree of endemism, Tanzania possesses important populations of species that are threatened but widespread across Africa. These include the endangered wild dog, black rhinoceros, slender-snorted crocodile, and the vulnerable chimpanzee, cheetah, and African elephant. Furthermore, Tanzania also has large populations of wildebeest, zebra, giraffe, Cape buffalo, and many species of antelope which are similarly important in a continental context.

JOINT ORE RESERVE COMMITTEE INTERNATIONAL BRANCH

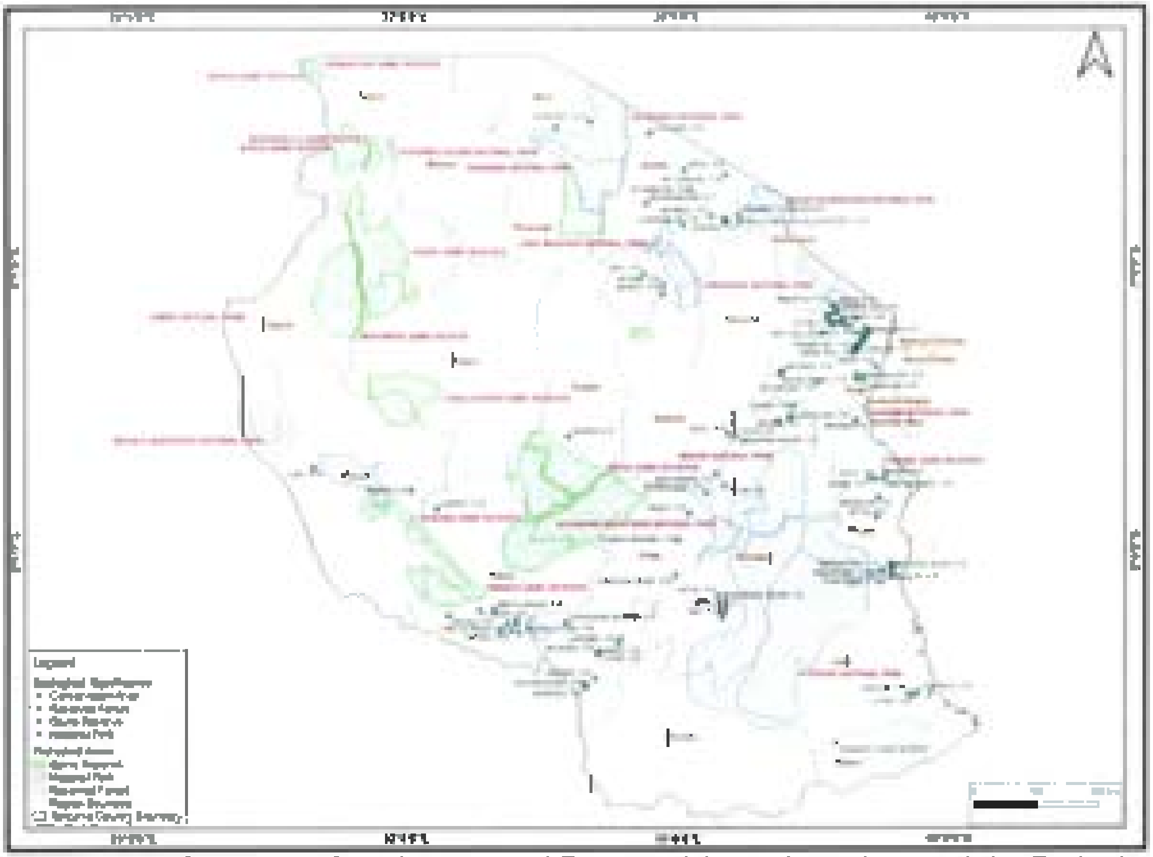

Figure 43: Ecological Significance and Protected Areas in and around the Project Area

7.5.2 Habitats

In terms of its habitats, the various grasslands and open woodlands of the Serengeti and Maasai Steppe in the northwest and northeast of Tanzania support some of the greatest concentrations of large mammals in the world. Important areas of wetlands, swamps, and floodplains are found throughout the country.

(Kilombero Valley, Wembere and Kagera Swamps, Usangu plains, etc.). A rich variety of lakes occur in Tanzania, including large parts of the Great Lakes (Victoria, Tanganyika, and Nyasa) which are important for endemic fish and invertebrates. Tanzania also possesses several soda lakes (Natron, Eyasi, Balangida, and Manyara) which are important for birds. A biologically diverse range of forests are found in –

Tanzania, including restricted lowland forests, and highly dispersed patches of coastal forest and montane forest. These forests, but most especially the Eastern Arc forests (Usambara, Ukaguru, Udzungwa, and Uluguru mountains) are important in terms of diversity and endemism. Unique montane grasslands also occur in some areas (Udzungwa mountains, Ufipa plateau, and Southern highlands) and are important with remarkable endemic flora. While the Itigi Thicket is a unique habitat in the center of the country, the south and west of Tanzania are largely dominated by miombo woodland containing some of the continent's significant populations of elephants and black rhinos.

7.5.3 Categories of Wildlife Areas

Tanzania's protected area (PA) network covers 28% of the total land area of which about 4% is 12 National Parks (NP), 1% is Ngorongoro Conservation Area (NCA), 15% is 31 Game Reserves (GRs) and 8% is 38 game-controlled areas (GCAs). Consequently, Tanzania has 19% of its surface area devoted to wildlife in PAs where no human settlement is allowed, (NPs and GRs) and 9% of its surface area to PAs where wildlife co-exists with humans.

The forestry sector has also followed conservation policies that greatly increase the coverage of PAs within Tanzania. A total of about 570 FRs cover around 15% of Tanzania's surface area, of which 3% overlap with PAs devoted to wildlife conservation. flora. While the Itigi Thicket is a unique habitat in the center of the country, the south and west of Tanzania are largely dominated by miombo woodland containing some of the continent's significant populations of elephants and black rhinos

Sl. No.	Ecological Significant Areas in and around Lake Natron including the Project Area	Distance from Lake Natron including the Project Area (in km)
1	Serengeti National Park	86.5
2	Lake Manyara National Park	90
3	Arusha National Park	108
4	Ngurdoto Crater National Park	128
5	Kilimanjaro National Park	135
6	Ngorongoro Conservation Area	85
7	Maswa Game Reserve	184
8	Mount Meru Forest Reserve	110
9	Mount Longido Forest Reserve	78
10	Gelai Forest Reserve	15
11	Kitumbeine Reserve Forest	47
12	Monduli Reserve Forest	99
13	Burko Reserve Forest	204
14	Lasiminguri Reserve Forest	100

Table 13: Distance of the Ecological Significant Areas from Lake Natron

7.5.4 Wildlife Utilization

The network of PAs devoted to wildlife conservation forms the basis of Tanzanian's wildlife utilization industry.

The forms of wildlife utilization currently practiced in Tanzania include:

a) **Game viewing.**

At present NCA and NPs of northern Tanzania are the main tourist destinations, while the southern NPs and GRs are under-utilized. Wildlife-based tourism and game viewing have great potential for earning considerable local and foreign currency and providing employment

b) **Tourist hunting**

Tourist hunting is an economically viable and sustainable use of wildlife that is consistent with the policy of high-quality, yet low-density tourism that can contribute significantly to the national economy. At present, tourist hunting is widely practiced across many remote areas of Tanzania in GR, GCA, Open Areas, and FRs.

c) **Resident hunting:**

It is the right of indigenous Tanzanians to have legal access to wildlife use. Different scales of fees for tourists and residents to hunt have been established through enabling legislation. Resident hunting licenses are issued for Open Areas and GCAs not allocated to tourist hunting.

d) **Ranching and farming:**

Ranching and farming of wildlife are not yet well-developed forms of wildlife use in Tanzania.

It is not the government's policy to engage itself in the direct utilization of wildlife resources in Tanzania.

The private sector is therefore encouraged to invest in the following:

i. Conducting hunting and photographic safaris.
ii. Investing in wildlife, ranching, and farming
iii. Wildlife and wildlife products.
iv. Developing tourism infrastructures in the framework of wildlife policy and respective protected areas management plans.

7.5.5 Wildlife Research and Monitoring

Considerable research on wildlife has been undertaken in Tanzania and has contributed greatly to the knowledge and publicity of wildlife in the country. The research so far undertaken has been varied in scope and includes taxonomic descriptions of species and their biogeography, behaviour, and ecology of single species, and studies of ecosystem processes. Several monitoring programs are in place for wildlife, mainly through aerial counts in and around PAs, and through monitoring individual populations during long-term research. The research undertaken to date has largely been directed towards aspirations of foreign researchers to publish results internationally, rather than to the needs of Tanzania. Furthermore, there is little involvement of Tanzanians in wildlife research, which is carried out mostly by foreigners permitted to study in the country. Moreover, wildlife authorities have continually been limited by financial resources and trained manpower to undertake all the applied or pure research that might be necessary or desirable.

7.5.6 Wildlife Policy

a) Challenges

The wildlife policy envisages to address the following national challenges:

- To conserve areas with great biological diversity which are representative of the major habitats of Tanzania.
- To continue to support and where necessary, enlarge the PA network as the core of conservation activities.
- To promote the involvement of local communities' participation in wildlife conservation in and outside the PA network.
- To increase foreign exchange earnings.
- To integrate wildlife conservation with rural development.
- To foster sustainable and legal use of wildlife resources.
- To ensure that wildlife conservation competes with other forms of land use.
- To enhance the recognition of the intrinsic value of wildlife to rural people
- To minimize human-wildlife conflicts wherever they occur.
- To regulate wildlife-related research to be of direct value to wildlife management.
- To build the capacity of the wildlife sector and foster professionalism; and

- To create an enabling environment for international cooperation in wildlife conservation.

b) Objectives

Wildlife is a natural resource of great biological, economic, environmental cleaning, climate ameliorating, water and soil conservation, and nutritional values that must be conserved. It can be used indefinitely if properly managed. Because of the dynamic and complex nature of the wildlife resources and the challenges ahead in conserving them, the Government policy for the wildlife sector will aim at involving a broader section of society in wildlife conservation, particularly the rural communities and the private sector. The role of the public sector will be to stimulate and guide the local communities and the private sector by administering, regulating, and promoting the management of wildlife resources, through the following objectives:

i. On Wildlife Protection

- To continue the establishment of PAs based on systems planning.
- To stress maintenance and development of a PA network to enhance biological diversity.
- To promote the conservation of wildlife and its habitats outside core areas (NPs, GRs & NCA) by establishing WMAs.
- To enhance the conservation of biological diversity by administering wetlands.
- To transfer the management of WMA to local communities thus taking care of corridors, migration routes, and buffer zones and ensuring that the local communities obtain substantial tangible benefits from wildlife conservation.
- To prevent illegal use of wildlife throughout the country by taking the appropriate surveillance, policing, and law enforcement.

ii. On Wildlife Utilization

- To promote the use of PAs to provide government revenue, employment, income, food, and other benefits to Tanzanians, especially the rural communities.
- To ensure that wildlife is appropriately valued to reduce its illegal offtake and encourage its sustainable use by rural communities.

- To create the opportunity for the Tanzanian people to become involved in the wildlife industry,
- To create an enabling environment that will ensure that legal and sustainable wildlife schemes directly benefit local communities,
- To create an enabling environment for the private sector to invest in different forms of wildlife utilization and conservation.

iii. On Management and Development of Pas

- To promote greater public awareness and understanding of wildlife issues
- To retain sufficient revenue from wildlife utilization in PAs for management and development purposes.
- To regulate development projects/activities in PAs.
- To promote research and monitoring activities which focus on providing answers to management issues,
- To undertake human resources development and institutional capacity building at all levels,
- To revamp professional ethics and standards.

iv. On International Co-operation

- To encourage, where necessary, possible, and appropriate, the involvement of donors and other conservation agencies to support Tanzania in conserving her wildlife resources, both for national, regional, and international benefits,
- To enable Tanzania to participate in relevant international treaties and conventions, and promote policies within the framework of such treaties and conventions as are consistent with Tanzania's position on the conservation of wildlife, and
- Co-operate with neighboring countries in the conservation of transboundary ecosystems.

7.5.7 Wildlife Management Areas (WMAs)

WMAs are Wildlife Management Areas WMAs are one of the community conservation programs set outside protected areas (NPs, GRs, GCAs) within village lands and used by communities for conservation, and benefit sharing Strategically established within corridors and migratory routes WWF started implementing WMAs in Tanzania in 2002; currently implementing 6 WMAs and advising 10 Consultations with all villagers' sensitization meetings to get support setting aside area for WMA on village land. Participatory land use planning, GMP development and approval process Formation of CBO and registration Application for Authorized association status Application user rights Functioning WMA – business venture.

7.5.8 Wildlife Systems in and around the Lake

The Lake has permanent and migratory wildlife populations. The permanent species are either those adapted to arid systems reptiles, rodents rodentivoures (foxes and jackal), insectivoures, and generalists (mongoose, Gerinuk), or dependent on available fresh water. There are permanent populations of primates along the river systems and near settlements. There are also permanent larger ungulate populations in the well-watered Galei forests.

Apart from the Wosi Wosi area, these permanent populations appear to be under threat from intensive land use practices (TAWIRI & FZS, 2002). On the west side of the lake, there is a displacement of wildlife due to the expansion of arable agriculture, irrigation, and settlement. To the southeast (Magadi) there is competition for dry-season grazing and systematic attempts to exclude wildlife from the dry-season range. On Gelai there is considerable settlement, arable agriculture, and pastoral activities.

During the dry season, there are relatively large populations of migratory and nomadic ungulates using the fresh water and semi-sodic springs and associated wetlands for dry season grazing. During the wet season, ungulates move onto the open grasslands to the southeast and southwest.

Literature suggests two migratory corridors between the Lake and other wildlife systems:

i. A link between the Ngorongoro Conservation Area and Natron along the open grass plains
ii. A link between Lake Manyara National Park (Mto wa Mbu GCA) and the Lake

Natron GCA (Game Controlled Area) along the approximate alignment of the existing Mto wa Mbu to Engare Sero road.

7.2 POTENTIAL IMPACTS ON BIODIVERSITY, PARTICULARLY THE FLAMINGO POPULATION

The ESIA baseline work has found that there is indeed change occurring, both near the Lake and in the catchments of the rivers feeding Lake Natron. This change will accelerate exponentially the accessibility of roads and logistics as well.

There have been many concerns expressed due to the location of the proposed project in a wetland of international concern, the Lake Natron Ramsar Site. The importance of the Lake to certain bird populations and the transboundary importance of the lesser flamingo population which, although breeding at Lake Natron, moves about and Feed in most of the Rift Valley Lakes has been identified as an important trans frontier concern and thus potentially affects countries in addition to Tanzania.

Birds, particularly internationally threatened species that are large and well known, will have large-scale international support if the wider public feels there is any threat to them from the project. This makes decision-making move from being based on environmental and economic criteria to that of the political arena.

7.2.1 Summary of Impact Rankings on Administrative and Planning Impacts

No.	Component	Specific Activity and Aspects	Impact	Rank
P/C 1	Changes in groundwater quality/quantity	Water abstraction for plant and housing	Depletion of fresh groundwater	
		Seepage of effluent into groundwater	Groundwater pollution and loss of aquifer	

		Solid waste management	Leachate from solid water reaching groundwater or seeping into the Lake	
P/C 2	Changes in crop and grazing areas (productive land)	Establishment of plant, housing, and access corridors	Loss of grazing land	
			Loss of critical dry season grazing along SE shores of Lake Natron	
P/C 3	Changes in pollution discharges	Operation of plant	Emissions and discharges that will negatively impact on the Lake	
P/C 4	Changes to Lake water quality	Encroachment of used water within the lake after usage at the soda ash site	The impact will not be significant at the preliminary stage.	
		Use of fresh water in the soda ash abstraction process. Use of surface water flows that enter the Lake	Lake water composition changed due to soda ash abstraction and the increase of fresh water from the process	
		Removal of soda ash from the Lake	Lake chemical composition significantly changed due to Soda Ash	

			abstraction	
P/C 5	Change in sound levels	Operation of the plant, steam, and power plants will create noise	High noise levels will reduce the wilderness value of the Lake environment and disturbance to biota	
P/C 6	Change in air quality	Air quality	No significant pollution as any sort of impact at the preliminary stage of work, but later it may be impactful and require precautions, control, and measures.	

Table 14: Summary of Changes to the Physical/Chemical Environment

7.2.2 Summary of Changes to the Biological/Ecological Environment

No.	Component	Specific Activity and Aspects	Impact	Rank
B/E 1	Changes to fish populations	Change in water composition due to removal of soda ash or changes of freshwater inflows	Threat to the viability of endemic fish populations	
B/E 2	Changes in biodiversity	Change in water composition due to removal of soda ash or changes of freshwater inflows	Potential threat to endemic species of fish. Threat to lesser flamingo populations	
B/E 3	Changes in disease	Domestic waste attracts pests. Abandoned borrow pits providing	Introduction of animal pests and pathogens	

	vector populations	mosquito breeding sites. Increase in the introduction of vectors through human and vehicle movement		
B/E 4	Changes in aquatic biota	Abstraction of surface water	Loss of freshwater habitats in the Lake due to dry season abstraction	
B/E 5	Changes to wetlands	Abstraction of fresh water from west shore rivers entering the Lake	Loss of freshwater wetlands.	
B/E 6	Changes to areas of natural habitat (including protected areas)	Abstraction of fresh water from rivers entering the Lake	The lake surface and the wetlands provide feeding, shelter, and nesting sites for several water birds, reptiles, and amphibians that are important to the Lake ecosystem. Any changes that would dry out the wetlands would adversely impact this important ecosystem	
B/E 7	Changes to the Ramsar ecological character criteria	The Influence of conservation status of wildlife and habitats. Suggestions to strengthen the legal basis for protecting the area by banning hunting in the Ramsar site		

Table 15:Summary of Changes to the Biological/Ecological Environment

7.2.3 Summary of Social and Cultural Impacts

No.	Component	Specific Activity and Aspects	Impact	Rank
S/C 1	Changes involving loss of housing	Establishment of a tar access road	No losses identified	
S/C 2	Changes involving loss of commercial/ public buildings	Establishment of major and supporting infrastructure	No losses identified	
S/C 3	Changes involving loss of cultural and archaeological heritage	Many hominins remains have been identified in the Humbo formation to the west of the Lake. It is thought that this formation also occurs to the east of the Lake. The Lake is one of the most important archaeological sites in East Africa.	In the preceding stage, there is no record of any negative influence on the preserved cultural and archaeological heritage in the Project Area.	
S/C 4	Changes to livelihoods		Possible increase in wage labor opportunities	
		Land occupancy	There is no requirement for any land occupancy from private or government land beyond the license area at the current stage of activity.	
S/C 5	Changes to patterns of	development of the access road	Improved access (development and	

	mobility and settlement		associated road access) must result in an influx of people into the area including the advantage of the existing communities	
S/C 6	Changes involving the resettlement of people		No resettlement identified	
S/C 7	Changes to social stability/cohesion	The traditional use of grazing, local soda ash extraction, watering of livestock, settlement, and fuelwood.	The mentioned activities will not deteriorate or be negatively impacted at the current stage of the soda ash project.	
		Uncontrolled immigration and settlement	Not significant	
S/C 8	Changes involving loss of access to natural resources	The sale of soda ash is an income-generating activity, particularly for women, and is a part of the household income	Potential loss of right of access and use of soda ash by traditional users	
S/C 9	Changes in health and disease status	Immigrant contract workers and the limited knowledge of HIV/AIDS and COVID status at the project site	Safety measures have to be taken care	

		Good road links	Improved access to healthcare facilities	
S/C 10	Changes in access to social services	Good road links	Improved access to social services	

Table 16: Summary of Social and Cultural Impacts

7.2.4 Summary of Economic Impacts

Table 24: Summary of Economic Impacts

No.	Component	Specific Activity and Aspects	Impact	Rank
E/1	Changes in crop/livestock-generated incomes	Loss of grazing and disturbance/disruption of grazing systems in the dry season refuge	Not significant	
E/2	Changes in local wage labour incomes/opportunities		Short-term employment opportunities.	
E/3	Changes in trade/commercial incomes/opportunities		Not significant	
E/4	Cost of resettlement for land loss (to project)		None	
E/5	Cost of compensation for physical structures (to project)		None	
E/6	Changes in tourism economy (potential)	Improved road access for tourism and other economic activities due to the project	Increase in tourism and change in type of tourism client due to project	

Table 17: Summary of Economic Impacts

7.3 MITIGATION MEASURES TO MINIMIZE ENVIRONMENTAL AND SOCIAL IMPACTS

The proposed soda ash extraction project at Lake Natron in Tanzania presents significant environmental and social challenges due to the lake's unique ecosystem, which is critical for the breeding of the lesser flamingo and other wildlife. To mitigate these impacts effectively, a comprehensive set of measures must be implemented. This essay outlines potential mitigation strategies aimed at minimizing the environmental and social effects of the soda ash extraction plant.

7.3.1 Environmental Mitigation Measures

7.3.1.1 Environmental Impact Assessment (EIA)

Before commencing the project, a thorough Environmental Impact Assessment (EIA) should be conducted. This assessment will identify potential environmental risks associated with the extraction process, including impacts on biodiversity, water quality, and air quality. The EIA should involve stakeholders, including local communities and conservation organizations, to ensure that their concerns and insights are incorporated into the project planning

7.3.1.2 Habitat Protection

Given that Lake Natron is a critical breeding ground for the lesser flamingo, measures must be taken to protect their habitat. This includes:

- **Buffer Zones**: Establishing buffer zones around sensitive ecological areas to prevent disturbances from construction and operational activities. These zones should limit access and development to safeguard wildlife habitats.
- **Monitoring Programs**: Implementing ongoing monitoring programs to track the health of the ecosystem, particularly the bird populations and water quality. This data will help in making informed decisions and adjustments to operations as needed

7.3.1.3 Water Management

The extraction process will require significant water resources, which could impact the lake's hydrology. To mitigate this:

- **Sustainable Water Use**: Develop a water management plan that prioritizes the sustainable use of water resources. This includes recycling and reusing water in the extraction process to minimize withdrawals from the lake.
- **Water Quality Monitoring**: Regularly monitor water quality to prevent contamination from extraction activities. This includes testing for pollutants and ensuring that any wastewater is treated before being discharged.

7.3.1.4 Air Quality Control

Construction and operational activities can lead to air pollution, impacting both the environment and local communities. Mitigation measures should include:

- **Dust Suppression**: Implementing dust control measures during construction, such as water spraying or the use of dust suppressants, to minimize airborne particulate matter.
- **Emission Controls**: Installing emission control systems on machinery and vehicles to reduce exhaust emissions. Regular maintenance of equipment can also help minimize air pollution.

7.3.1.5 Waste Management

The project will generate waste, both during construction and operation. Effective waste management strategies should include:

- **Waste Reduction Plans**: Developing plans to minimize waste generation through efficient resource use and recycling initiatives.
- **Proper Disposal**: Ensuring that all waste is disposed of responsibly, with hazardous materials treated according to environmental regulations to prevent contamination of land and water resources.

7.3.2 Social Mitigation Measures

7.3.2.1 Community Engagement

Engaging local communities is crucial for addressing social impacts and fostering positive relationships. This can be achieved through:

- **Stakeholder Consultation**: Conducting regular consultations with community members to inform them about project developments, address concerns, and incorporate their feedback into decision-making processes.
- **Community Benefits Agreements**: Establishing agreements that outline the benefits the local community will receive from the project, such as job creation, infrastructure improvements, and support for local businesses.

7.3.2.2 Employment and Training Programs

The project has the potential to create jobs for local residents. To maximize these benefits:

- **Local Hiring Initiatives**: Prioritize hiring local workers for construction and operational roles to boost the local economy.
- **Training and Capacity Building**: Provide training programs to equip local residents with the skills needed for employment in the soda ash industry. This can enhance employability and support long-term economic development.

7.3.2.3 Cultural Heritage Protection

The area surrounding Lake Natron may hold cultural significance for local communities. To mitigate impacts on cultural heritage:

- **Cultural Impact Assessments**: Conduct assessments to identify and protect sites of cultural importance. This includes engaging with local leaders and cultural organizations to ensure that their heritage is respected and preserved.
- **Awareness Programs**: Implement programs to raise awareness among project staff about the cultural significance of the area, fostering respect and understanding.

Mitigating the environmental and social impacts of the soda ash extraction project at Lake Natron requires a multifaceted approach that incorporates comprehensive planning, community engagement, and ongoing monitoring. By implementing effective mitigation measures, the project can minimize its ecological footprint while providing economic benefits to local communities. Ensuring that environmental and social considerations are prioritized will be essential for the project's long-term success and sustainability, ultimately contributing to the preservation of Lake Natron's unique ecosystem and the well-being of its surrounding communities.

7.4 REGULATORY REQUIREMENTS AND COMPLIANCE

The Environmental and Social Impact Assessment (ESIA) for the soda ash extraction project at Lake Natron is a critical process designed to evaluate the potential environmental and social impacts of the proposed activities. This assessment ensures compliance with national and international regulations, safeguarding the unique ecosystem of Lake Natron while addressing the concerns of local communities. This note outlines the regulatory requirements and compliance aspects included in the ESIA process for the soda ash project.

7.4.1 Regulatory Framework

National Environmental Management Council (NEMC)

In Tanzania, the National Environmental Management Council (NEMC) is the primary regulatory body responsible for overseeing environmental assessments. The ESIA process is governed by the Environmental Management Act (EMA) No. 20 of 2004 and the National Environmental Impact and Auditing Regulations of 2005. These regulations establish the legal framework for conducting ESIAs and outline the procedures that must be followed.

Screening Process

The ESIA process begins with a screening phase, where NEMC assesses whether the proposed project requires a full ESIA or a preliminary environmental assessment. This screening is based on:

- **Project Characteristics**: NEMC evaluates the nature, scale, and potential impacts of the project to determine its significance.
- **Sensitive Areas**: Projects located in or near environmentally sensitive areas, such as wetlands, national parks, or critical habitats, are subject to more stringent scrutiny.
- **Stakeholder Engagement**: NEMC distributes project briefs to relevant stakeholders, including government ministries and local authorities, for

feedback within a specified period. This engagement is crucial for identifying potential concerns early in the process.

Full Environmental and Social Impact Assessment

If a full ESIA is deemed necessary, the following components are typically included:

Scoping

The scoping phase identifies the key environmental and social issues that need to be addressed in the assessment. This involves consultations with stakeholders, including local communities, to ensure that their concerns are incorporated into the assessment process.

Baseline Studies

Baseline studies are conducted to gather data on the existing environmental and social conditions of Lake Natron and its surroundings. This includes:

- **Ecological Surveys**: Assessing the flora and fauna in the area, particularly the lesser flamingo populations and other wildlife that depend on the lake.
- **Water Quality Analysis**: Evaluating the current state of water quality in Lake Natron to establish a reference point for assessing potential impacts.
- **Social Impact Assessment**: Understanding the demographics, livelihoods, and cultural significance of the local communities affected by the project.

Impact Assessment

The core of the ESIA involves evaluating the potential impacts of the soda ash extraction project on the environment and local communities. This includes:

- **Environmental Impacts**: Analyzing how the extraction process may affect water quality, biodiversity, and habitat integrity.
- **Social Impacts**: Assessing potential effects on local livelihoods, cultural heritage, and community health. This includes evaluating the potential for job creation versus potential disruptions to traditional ways of life.

Mitigation Measures

The ESIA must outline specific mitigation measures to address identified impacts. These measures could include:

- **Habitat Protection**: Establishing buffer zones to protect critical habitats and implementing monitoring programs for wildlife.
- **Water Management**: Developing strategies for sustainable water use and ensuring that extraction does not negatively impact local water resources.
- **Community Engagement**: Implementing programs to engage local communities in decision-making and ensuring that they benefit from the project.

7.4.2 Compliance and Monitoring

Regulatory Compliance

The ESIA must demonstrate compliance with relevant national and international environmental regulations. This includes adherence to the guidelines set forth by NEMC and any other applicable laws, such as the Ramsar Convention on Wetlands, given Lake Natron's designation as a Ramsar site.

Monitoring and Reporting

Post-approval, the project will be subject to ongoing monitoring to ensure compliance with the mitigation measures outlined in the ESIA. NEMC requires regular reporting on environmental and social performance, allowing for adaptive management if unforeseen impacts arise.

The regulatory requirements and compliance aspects of the ESIA for the soda ash extraction project at Lake Natron are vital for ensuring that the project is conducted responsibly and sustainably. By adhering to the established legal framework and engaging with stakeholders throughout the process, the project can minimize its environmental and social impacts while contributing to the economic development of the region. The ESIA serves as a critical tool for balancing development needs with the preservation of Lake Natron's unique ecosystem and the well-being of local communities.

8. FINANCIAL ANALYSIS

This section describes the operating and capital expenditure program TMTL has outlined in support of its strategic plan.The prime objective is to be focused on cost and productivity programs that will result in substantial savings in both CAPEX and OPEX.

CAPEX is defined as Capital expenditure which is an expense a project or business incurs to create a benefit in the future including physical assets such as buildings. equipment. machinery, and vehicles.OPEX covers the short term which is an expense required for the day-to-day functioning of a project or business including employees. salaries, rent, utilities. and property taxes.

Cost improvement ideas can arise out of a programme facilitated by a consultant yielding continuous savings.Lean Six Sigma and other continuous improvement programs will be invigorated. Lean Six Sigma is a team-focused managerial approach that seeks to improve performance by eliminating resource waste and defects. It combines Six Sigma methods and tools with the lean manufacturing/lean enterprise philosophy.

A Modernised Caustic plant will be yielded to increased volumes and efficiencies in the Lake Natron at the current soda ash project site.The inception of a carbon capture and usage plant at a combined heat and power (CHP) plant will reduce carbon emissions.The boiler plant will be optimized at the soda ash project site in Lake Natron based on lower energy consumption and carbon emissions.

Power plant and Soda Ash (Carbonating Towers) Industrial Internet of Things (IIoT) projects will be implemented at the ongoing soda ash project site in Lake Natron.As per to suitability and specific terms and conditions, automation projects will be undertaken for efficiency, quality, and cost benefits for soda ash production.Recovery of Soda Ash from waste streams will be expanded from time to time with proper investigation and guidance.Furthermore, new technologies will be invested in to move towards lowering environmental footprint and increasing circularity timely.

Technologies across manufacturing, Research and Development, human resources, supply chain, sales, and distribution functions will be deployed to drive automation and efficiency.Digital interventions will be encouraged for better access to production information. upgrading and reporting dashboards, production management, and supply chain forecasting. A diversified vendor base and explored opportunities for backward integration to secure raw material supplies will be pivoted.Supply chain efficiency and increased customer service levels will be encouraged by stepping up the usage of container rake movement. The supply chain network will be configured and re-configured timely at the soda ash project site in Lake Natron.

PROJECT ASSUMPTIONS		
Description	**Unit**	**Value**
Budget Calendar	Month	Jan to Dec
Effective Working Days in a Month	days	25
Effective Working Days in a Year	days	300
Plant Running / Day	hr/day	20
Targeted Annual Production	MT	1500000
Targeted Finished Soda Ash Production	MT	480000
Recovery of Sodium Carbonate from Soda Brine (in Excavation)	%	80
Finished Product (Soda Ash) recovery	%	40
Dredger capacity	ton/hr.	250-300
Shift per Day	no's	3
Shift Timing	Time	06:00AM to 02:00PM, 02:00PM to 10:00PM, 10:00PM to 06:00AM
Effective Working Hours in a Shift	hr.	6
Stripping Ratio	%	0.25
Diesel Cost	US$/ltr.	1.2

Table 18: Project Assumption

SUMMARY OF CAPEX & OPEX ESTIMATION

CAPEX	
DEPARTMENT	**AMOUNT (USD)**
MINING	$16090,000
PROCESSING PLANTS	$65138,131
ELECTRICAL	$2254.000
ENGINEERING	$7712.000
SECURITY	$370.000
ADMIN	$1110.000
INFORMATION & TECHNOLOGY	$265.000
HSE	$80.000
TOTAL	**$93019,131**
OPEX FOR 12 MONTHS	
DEPARTMENT	**AMOUNT (USD)**
MINING	$2880,000
ELECTRIC POWER & DIESEL	$930,191
PROCESSING PLANTS	$586,243
ENGINEERING	$600,000
SECURITY	$345,000
ADMIN	$467,128
IT SERVICES	$63,000
LOGISTICS	$150,000
CSR	$40,000
CONSULTANT'S, ADVISOR'S	$100,000
HSE	$194,000
HUMAN RESORSES	$3701.400
TOTAL	**$10056,962**

8.3 REVENUE PROJECTIONS BASED ON MARKET ANALYSIS

The revenue projections for the soda ash project at Lake Natron are based on comprehensive market analysis, which indicates a growing demand for soda ash driven by various industries, particularly glass manufacturing and detergents. This section outlines the projected revenue figures, growth rates, and market dynamics influencing the soda ash market

8.3.1 Current Market Overview

- **Market Size (2022)**: The global soda ash market was valued at approximately **USD 19.95 billion** in 2022.

- **Projected Market Size (2032)**: It is expected to reach **USD 32.30 billion** by 2032, representing a compound annual growth rate (CAGR) of **4.9%** during the forecast period from 2023 to 2032.

8.3.2 Key Market Drivers

1. **Demand from the Glass Industry**: The glass manufacturing sector is the largest consumer of soda ash, accounting for nearly **50%** of the total demand. The growth in construction and automotive industries is expected to further boost this demand.
2. **Detergents and Soaps**: The rising production of synthetic detergents and soaps, particularly in emerging markets, is another significant driver. Soda ash is essential in the formulation of many cleaning products.
3. **Chemical Manufacturing**: Soda ash is widely used in the production of various chemicals, which is projected to grow as industrial applications expand.

Year	Projected Revenue (USD Billion)	Growth Rate (%)
2022	19.95	-
2023	20.95	5
2024	21.95	5
2025	23.05	5
2026	24.15	5
2027	25.35	5
2028	26.7	5.3
2029	28.1	5.3
2030	29.6	5.3
2031	31	4.7
2032	32.3	4.2

Table 19: Projected Revenue of global Soda ash Market

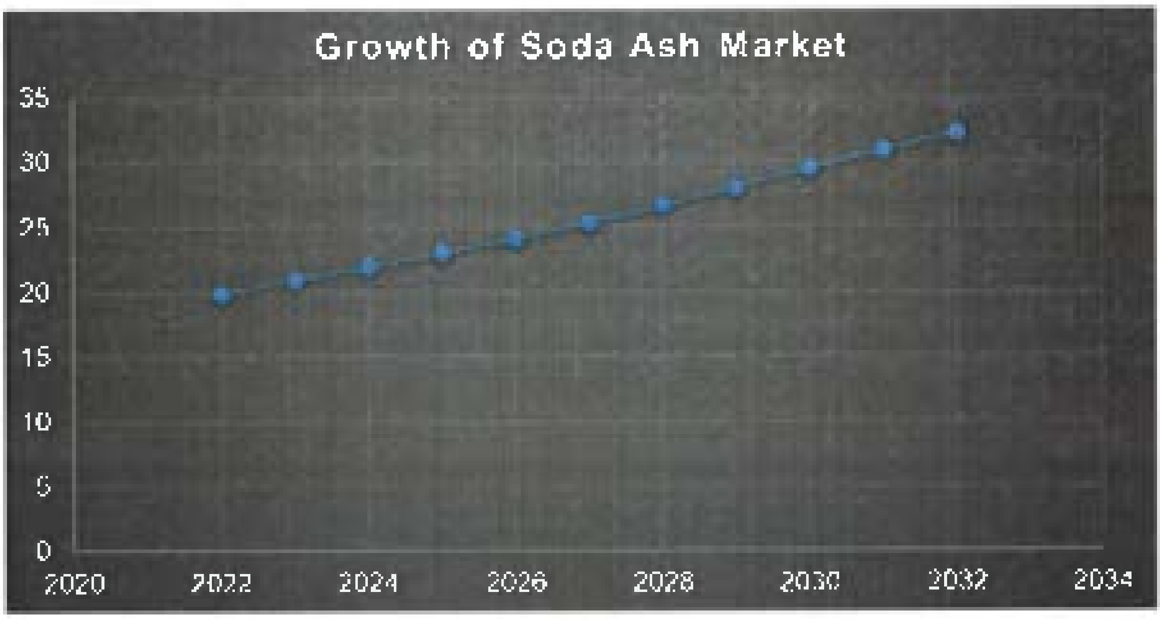

Figure 44: Future Forecast on Global Soda ash Project

8.3.3 Market Segmentation

The soda ash market can be segmented into various categories that influence revenue generation:

- **By Application**:
  - Glass Manufacturing: Largest segment
  - Detergents and Soaps
  - Chemicals
  - Others (e.g., metallurgy, water treatment)
- **By Region**:
  - North America: Significant contributor due to natural soda ash production.
  - Asia-Pacific: Fastest-growing region, driven by increasing industrial activities in countries like China and India.
  - Europe: Stable market with a focus on sustainable production practices.

The soda ash project at Lake Natron is well-positioned to capitalize on the growing global demand for soda ash, particularly in the glass and detergent industries. With a projected revenue growth from **USD 19.95 billion** in 2022 to **USD 32.30 billion** by 2032, the project is expected to generate substantial economic benefits. By leveraging the unique resources of Lake Natron and adhering to sustainable practices, the project can contribute significantly to Tanzania's economy while meeting the increasing global demand for soda ash.

8.4 PROFITABILITY ANALYSIS, INCLUDING NET PRESENT VALUE (NPV), INTERNAL RATE OF RETURN (IRR), AND PAYBACK PERIOD

PARTICULARS	OPENING	YEAR -01	YEAR -02	YEAR -03	YEAR -04	YEAR -05	YEAR -06	YEAR -07	YEAR -08	YEAR -09	YEAR -10
REVENUE FROM OPERATION	165000000	171600000	178464000	185602560	193026662	200747728	208777637	217128742	225813892	234846448	244240306
CAPEX	93019131	83717218	75345496	67810946	61029851	54926866	49434179	44490761	40041685	36037517	37433765
DEPRICIATION	9301913	8371722	7534550	6781095	6102985	5492687	4943418	4449076	4004169	3603752	3243377
OPEX	10056962	10660380	11300003	11978003	12696683	13458484	14265993	15121953	16029270	16991026	18010488
MANPOWER	308450	339795	373225	410548	451603	496763	546439	601083	661191	727310	800041
TOTAL EXPENDITURE	10365412	10999675	11673228	12388551	13148286	13955247	14812432	15723036	16690461	17718336	18810529
PROFITABILTY ANALYSIS	154634588	160600325	166790772	173214009	179878376	186792481	193965205	201405706	209123431	217178112	225429777
WORKING CAPITAL	154326138	160261030	166417547	172803461	179426773	186295718	193418766	200804623	208462740	216400802	224629736
CHANGES IN WORKING CAPITAL	-5934892	-6156517	-6385914	-6623312	-6868945	-7123048	-7385857	-7657617	-7938562	-8228934	224629736
CASH FLOW	-241718827	85254829	98979876	112184158	124951510	137358302	149474444	161364071	173085915	184694347	196239389

IRR (Internal Rate of Return)	45%
NPV AT 10% DISC (Net Present Value)	$816136,531.84
PAYBACK PERIOD (Year)	2

Note: The currency indicated in USD.

Table 20: Profitability analysis, including net present value (NPV), internal rate of return (IRR)

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8.5 SENSITIVITY ANALYSIS TO ASSESS RISKS AND UNCERTAINITIES

8.4.1 Key Variables and Parameters

The following key variables will be analyzed for their impact on the project's financial outcomes:

1. Brine Composition:

Variations in the concentration of sodium carbonate and impurities in the brine can significantly affect the extraction efficiency and costs.

2. Production Costs:

This includes labor, raw materials, energy, and maintenance costs, which can fluctuate due to market conditions.

3. Market Price of Soda Ash:

The selling price of soda ash is subject to market demand and competition, impacting revenue.

4. Regulatory Costs:

Compliance with environmental regulations can lead to additional costs, which may vary based on local policies.

5. Operational Efficiency:

Changes in the efficiency of the extraction process can influence overall production costs and output levels.

8.4.2 Methodology

1. Quantification of Uncertainties:

Each input variable will be assigned a range of possible values based on historical data and expert estimates.

2. Modeling Outputs:

The financial model will calculate key outputs, including NPV, IRR, and payback period, based on varying input combinations.

3. Design of Experiments:

A Monte Carlo simulation will be employed to run multiple scenarios, allowing for a comprehensive understanding of how changes in inputs affect outputs.

4. Sensitivity Measures:

The analysis will focus on sensitivity indices to rank the importance of each variable based on its influence on financial outcomes.

8.4.3 Risk Assessment

The sensitivity analysis will help identify which variables pose the greatest risk to the project's financial health. For instance:

High Sensitivity to Production Costs:

If production costs show high sensitivity, any increase could significantly reduce profitability, necessitating cost-control measures.

Market Price Volatility:

If the market price of soda ash is highly sensitive, fluctuations could impact revenue, suggesting the need for pricing strategies or market diversification.

The sensitivity analysis for the soda ash extraction project at Lake Natron will provide valuable insights into potential risks and uncertainties. By identifying key variables that influence financial outcomes, stakeholders can make informed decisions, implement risk mitigation strategies, and enhance the project's overall financial viability. This proactive approach will ultimately support the successful establishment and operation of the soda ash

9. RISK ANALYSIS AND MANAGEMENT

9.1 IDENTIFICATION OF KEY PROJECT RISKS (TECHNICAL, ENVIRONMENTAL, FINANCIAL, MARKET)

Risk analysis and management in a soda ash project at Lake Natron involves identifying and assessing various risks associated with the project's technical, environmental, financial, and market dimensions. Each of these categories presents distinct challenges that must be addressed to ensure the project's success and sustainability.

9.1.1 TECHNICAL RISKS

Technical risks in the soda ash project primarily relate to the extraction and processing methods employed. The proposed methods, such as dredging and draining sections of the lake, may face challenges in efficiency and environmental impact. There is also the risk of technological failures that could disrupt operations or lead to increased costs. Additionally, the project's reliance on significant energy resources (11.5 MW of power and 21 metric tons/hour of raw materials) poses logistical and operational risks, especially if energy supply becomes unstable or insufficient.

9.1.2 ENVIRONMENTAL RISKS

Environmental risks are particularly critical given Lake Natron's status as a Ramsar site, which is vital for biodiversity, particularly for the lesser flamingo population. The construction of a soda ash plant could lead to habitat destruction, increased pollution, and disturbances to local wildlife. The potential for cross-border environmental impacts, as the lake is shared with Kenya, raises concerns about biodiversity loss and the sustainability of local ecosystems. Environmental assessments have highlighted the need for comprehensive studies to evaluate the socio-economic and ecological implications of the project, emphasizing that the impact on local tourism and natural resources could be detrimental.

9.1.3 FINANCIAL RISKS

Financial risks include the high capital investment required for the project, estimated at approximately USD 729 million. The project's financial viability is contingent on stable soda ash prices and the ability to manage operational costs effectively. Fluctuations in market demand or price volatility could jeopardize returns on investment. Furthermore, the project's financial sustainability may be threatened by potential legal challenges or opposition from environmental groups, which could lead to delays or increased costs.

9.1.4 MARKET RISKS

Market risks involve the demand for soda ash in both local and international markets. Changes in global market dynamics, such as shifts in consumer preferences or competition from alternative sources, could impact the project's profitability. The reliance on tourism as a significant economic driver in the region also poses risks; if the environmental integrity of Lake Natron is compromised, it could deter tourists and adversely affect local economies dependent on tourism revenue.

In summary, effective risk analysis and management for the soda ash project at Lake Natron require a comprehensive understanding of these technical, environmental, financial, and market risks. Addressing these challenges through strategic planning and stakeholder engagement will be crucial for the project's success and its alignment with sustainable development goals.

9.2 RISK MITIGATION STRATEGIES

Effective risk mitigation strategies for a soda ash project at Lake Natron encompass a comprehensive approach to address technical, environmental, financial, and market risks. Here are significant notes on potential strategies for each category:

9.2.1 TECHNICAL RISK MITIGATION

1. **Robust Engineering Design**: Implement advanced engineering practices and technologies to enhance the reliability and efficiency of extraction and processing methods. This includes regular maintenance and upgrades to equipment to minimize operational failures.

2. **Training and Safety Protocols**: Conduct thorough training programs for personnel on safety and operational procedures. Establish clear protocols for handling hazardous materials and emergency situations to reduce the likelihood of accidents.

3. **Quality Control Measures**: Implement stringent quality control processes throughout the production cycle to ensure that the final product meets industry standards and reduces the risk of product recalls or failures.

9.2.2 ENVIRONMENTAL RISK MITIGATION

1. **Environmental Impact Assessments (EIA)**: Conduct comprehensive EIAs to identify potential environmental impacts before project initiation. This should include assessments of biodiversity, water quality, and local ecosystems.

2. **Pollution Prevention Strategies**: Adopt a preventive approach to environmental management, focusing on waste minimization, recycling, and the use of cleaner production technologies. Implement best available technologies (BAT) to reduce emissions and waste generation.

3. **Biodiversity Conservation Programs**: Develop and implement programs aimed at protecting local wildlife, particularly the lesser flamingo population. This could involve habitat restoration and monitoring efforts to ensure minimal disruption to local ecosystems.

9.2.3 FINANCIAL RISK MITIGATION

1. **Diversified Funding Sources**: Seek multiple funding avenues, including public-private partnerships, grants, and loans, to spread financial risk and ensure adequate capital for project development and operation.

2. **Comprehensive Financial Planning**: Develop detailed financial models that account for potential fluctuations in soda ash prices and operational costs. This should include contingency plans to manage unexpected financial challenges.

3. **Insurance and Risk Transfer**: Utilize insurance products to transfer certain financial risks, such as operational interruptions or environmental liabilities, to third parties.

9.2.4 MARKET RISK MITIGATION

1. **Market Research and Analysis**: Conduct ongoing market research to understand demand trends for soda ash and identify potential new markets. This will help in adapting production strategies to meet changing market conditions.

2. **Strategic Partnerships**: Form strategic alliances with key stakeholders in the supply chain, including suppliers and distributors, to enhance market access and stability.

3. **Product Diversification**: Explore opportunities for product diversification to reduce reliance on soda ash alone. This could include developing related products or services that can leverage existing capabilities and market presence.

By implementing these risk mitigation strategies, the soda ash project at Lake Natron can enhance its resilience against various risks while promoting sustainable development and environmental conservation.

9.3 CONTIGENCY PLANNING

Contingency planning is a crucial aspect of risk analysis and management for the soda ash project at Lake Natron. It involves developing alternative strategies and backup plans to mitigate the impact of potential risks and ensure the project's success. Here are some key elements of contingency planning for the project:

9.3.1 TECHNICAL RISKS

- Develop backup plans for alternative extraction and processing methods in case the proposed dredging and draining methods prove inefficient or environmentally damaging.
- Secure contingency plans for reliable energy supply to mitigate the risk of disruptions or shortages.
- Establish clear protocols for handling hazardous materials and emergency situations to reduce the likelihood of accidents and minimize their impact.

9.3.2 ENVIRONMENTAL RISKS

- Conduct comprehensive Environmental Impact Assessments (EIAs) to identify potential environmental risks and develop mitigation strategies before project initiation.
- Implement contingency plans for habitat restoration and wildlife monitoring to ensure minimal disruption to local ecosystems.
- Establish cross-border cooperation and contingency plans to address potential transboundary environmental impacts.

9.3.3 FINANCIAL RISKS

- Secure multiple funding sources, including public-private partnerships and insurance products, to spread financial risk and ensure adequate capital for project development and operation.
- Develop detailed financial models that account for potential fluctuations in soda ash prices and operational costs, including contingency plans to manage unexpected financial challenges.

9.3.4 MARKET RISKS

- Conduct ongoing market research to identify potential new markets and adapt production strategies to meet changing market conditions.
- Explore opportunities for product diversification to reduce reliance on soda ash alone and develop related products or services that can leverage existing capabilities and market presence.
- Establish strategic alliances with key stakeholders in the supply chain to enhance market access and stability.

By incorporating these contingency planning strategies into the risk analysis and management framework, the soda ash project at Lake Natron can enhance its resilience against various risks while promoting sustainable development and environmental conservation.

Phases	Description	Activities
Business impact analysis	• Evaluate potential impacts affecting business negatively • Conduct business impact analysis	• Data breaches • Inventory damages
Recover strategies	• Recognize and list resources needed for recovery • Develop and evaluate recovery strategies	• Cost-oriented strategies • Revenue oriented strategies
Plan development	• Develop relocation & reconditioning plan to [illegible] • Gain senior management and approval of plan	• Director • Vice-president • CEO
Testing & exercises	• Examine and evaluate plan effectiveness • Update plan based on examination results	

Table 21: Business Contingency Strategies

10. LEGAL AND REGULATORY FRAMEWORK

10.1 OVERVIEW OF APPLICABLE LAWS AND REGULATIONS

The soda ash project at Lake Natron in Tanzania is subject to various laws and regulations that govern environmental protection, resource management, and industrial operations. Here are the key laws applicable to the project:

10.1.1 ENVIRONMENTAL LAWS

1. **Environmental Management Act (EMA) 2004**: This act provides a framework for environmental management, requiring Environmental Impact Assessments (EIAs) for projects that may significantly affect the environment. The soda ash project must comply with this regulation to assess its potential impacts on Lake Natron's ecosystem.

2. **Wildlife Conservation Act 2009**: Given that Lake Natron is a critical breeding ground for the lesser flamingo, this law is crucial. It aims to protect wildlife and their habitats, mandating that any project in sensitive areas must ensure the conservation of biodiversity.

3. **Ramsar Convention on Wetlands**: As Lake Natron is a designated Ramsar site, the project must adhere to international obligations under this convention, which focuses on the conservation and sustainable use of wetlands.

10.1.2 MINING AND RESOURCE LAWS

4. **Mining Act 2010**: This act regulates the exploration and exploitation of mineral resources in Tanzania. The soda ash project must obtain the necessary licenses and permits for mining operations, ensuring compliance with safety and environmental standards.

5. **Water Resources Management Act 2009**: This legislation governs the management and use of water resources in Tanzania. The soda ash project will need to secure water use permits, considering the significant water requirements for both industrial processes and domestic use.

10.1.3 LAND USE AND COMPENSATION LAWS

6. **Land Act 1999**: This act outlines land ownership and use rights in Tanzania. The project will need to navigate land acquisition processes, including compensating residents displaced by the project, as mandated by this law.

7. **Village Land Act 1999**: This law governs land use in rural areas, ensuring that local communities have a say in land use decisions affecting their livelihoods. The soda ash project must engage with local communities and adhere to the provisions of this act.

10.1.4 INDUSTRIAL REGULATIONS

8. **Factories Act 2003**: This act regulates the establishment and operation of factories in Tanzania, ensuring compliance with health and safety standards. The soda ash plant must meet these requirements to operate legally.

9. **Occupational Health and Safety Act 2003**: This law mandates the protection of workers' health and safety in industrial operations. The project must implement safety measures to protect workers involved in soda ash production.

The soda ash project at Lake Natron must navigate a complex legal landscape that includes environmental protection, resource management, land use, and industrial regulations. Compliance with these laws is essential not only for legal operation but also for promoting sustainable development and minimizing adverse environmental impacts.

10.2 LICENSING AND PERMITTING REQUIREMENTS

To obtain approval from the Tanzanian government for the soda ash project at Lake Natron, several licensing and permitting requirements must be fulfilled. These requirements ensure compliance with national laws and regulations, particularly regarding environmental protection, resource management, and industrial operations. Below are the key licensing and permitting steps involved:

10.2.1 ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

- **Requirement**: Conduct a comprehensive EIA as mandated by the Environmental Management Act (EMA) of 2004. This assessment evaluates the potential environmental impacts of the project, particularly given Lake Natron's status as a Ramsar site.

- **Process:** The EIA involves several stages, including screening, scoping, public consultation, and appraisal. Stakeholder engagement is crucial to address concerns from local communities and environmental groups.
- **Approval:** The EIA report must be submitted to the National Environment Management Council (NEMC) for review and approval before any project activities can commence.

10.2.2 MINING LICENSE

- **Requirement:** Obtain a mining license under the Mining Act of 2010. This license is essential for the extraction of soda ash from the lake.
- **Process:** The application must include details about the proposed mining methods, environmental management plans, and compliance with safety regulations.
- **Approval:** The Ministry of Minerals reviews the application, and approval is contingent upon meeting all regulatory requirements.

10.2.3 WATER USE PERMIT

- **Requirement:** Secure a water use permit in accordance with the Water Resources Management Act of 2009. The project will require significant water resources for processing soda ash.
- **Process:** The application must demonstrate how water will be sourced, used, and managed, ensuring minimal impact on local water resources.
- **Approval:** The permit is issued by the relevant water authority after assessing the potential impacts on water quality and availability.

10.2.4 LAND USE AND COMPENSATION

- **Requirement:** Comply with the Land Act of 1999 and the Village Land Act of 1999 for land acquisition and compensation of affected residents.

- **Process:** Conduct a valuation of assets and ensure fair compensation for residents displaced by the project. This includes engaging with local communities to address their concerns and needs.
- **Approval:** The Ministry of Lands, Housing, and Human Settlements Development oversees the land acquisition process and compensation agreements.

10.2.5 INDUSTRIAL LICENSES

- **Requirement:** Obtain necessary industrial licenses under the Factories Act of 2003 and the Occupational Health and Safety Act of 2003.
- **Process:** Submit applications that demonstrate compliance with health, safety, and operational standards for the soda ash processing plant.
- **Approval:** The Ministry of Industry and Trade evaluates the applications and issues the required licenses.

10.2.6 COMPLIANCE WITH ADDITIONAL REGULATIONS

- **Wildlife Conservation Act:** Given the ecological significance of Lake Natron, compliance with the Wildlife Conservation Act of 2009 is necessary to protect local wildlife.
- **Ramsar Convention Obligations:** As a Ramsar site, the project must adhere to international obligations related to the conservation and sustainable use of wetlands.

The licensing and permitting process for the soda ash project at Lake Natron is extensive and requires careful planning and compliance with various laws and regulations. Engaging with stakeholders, conducting thorough assessments, and ensuring transparency throughout the process are critical for obtaining the necessary approvals and fostering community support for the project.

10.3 COMPLIANCE WITH NATIONAL AND INTERNATIONAL STANDARDS

The soda ash project at Lake Natron in Tanzania must comply with a complex set of legal and regulatory frameworks at both the national and international levels. These frameworks are designed to ensure the project's adherence to environmental protection standards, resource management regulations, and sustainable development principles. Here are the key legal and regulatory requirements the project must fulfill:

10.3.1 NATIONAL LAWS AND REGULATIONS

1. **Environmental Management Act (EMA) 2004**: This act mandates the conduct of Environmental Impact Assessments (EIAs) for projects that may significantly impact the environment. The soda ash project must comply with this regulation by undertaking a comprehensive EIA to assess its potential effects on Lake Natron's ecosystem.

2. **Wildlife Conservation Act 2009**: Given that Lake Natron is a critical breeding ground for the lesser flamingo, this law is crucial. It aims to protect wildlife and their habitats, requiring the project to ensure the conservation of biodiversity in the area.

3. **Mining Act 2010**: This act regulates the exploration and exploitation of mineral resources in Tanzania. The soda ash project must obtain the necessary licenses and permits for mining operations, ensuring compliance with safety and environmental standards

4. **Water Resources Management Act 2009**: This legislation governs the management and use of water resources in Tanzania. The project will need to secure water use permits, considering the significant water requirements for industrial processes and domestic use.

5. **Land Act 1999 and Village Land Act 1999**: These acts outline land ownership and use rights in Tanzania. The project will need to navigate land acquisition processes, including compensating residents displaced by the project, as mandated by these laws.

6. **Factories Act 2003 and Occupational Health and Safety Act 2003**: These acts regulate the establishment and operation of factories in Tanzania, ensuring compliance with health and safety standards. The soda ash plant must meet these requirements to operate legally.

10.3.2 INTERNATIONAL AGREEMENTS AND STANDARDS

1. **Ramsar Convention on Wetlands.** As Lake Natron is a designated Ramsar site, the project must adhere to international obligations under this convention, which focuses on the conservation and sustainable use of wetlands.

2. **Environmental and Social Impact Assessment (ESIA)**: The project must conduct an ESIA to identify and mitigate potential environmental and social risks, in line with international best practices and standards.

3. **Strategic Environmental Assessment (SEA)**: The Development Partners Group (DPG) has suggested that a Strategic Environmental Assessment should be undertaken for the overall extraction of soda ash in Tanzania to ensure a comprehensive evaluation of the project's impacts.

4. **Stakeholder Engagement**: The project must engage with local communities, environmental groups, and other stakeholders throughout the planning and implementation phases to address concerns and ensure transparency.

5. **Precautionary Principle**: The Permanent Secretary in the Ministry of Natural Resources and Tourism has emphasized the need to apply the precautionary principle, which favours acting according to an assumption of worst-case scenarios to protect the environment and local communities.

Compliance with these legal and regulatory frameworks is essential for the soda ash project to proceed while minimizing environmental and social risks. The project must navigate a complex landscape of national laws, international agreements, and stakeholder expectations to ensure its long-term sustainability and acceptance.

11. PROJECT IMPLEMENTATION PLAN

The project implementation plan for the proposed soda ash plant at Lake Natron outlines a structured approach to ensure successful execution while addressing environmental, social, and economic considerations. This plan encompasses various phases, from initial planning to operational commencement, and includes stakeholder engagement, infrastructure development, and compliance with regulatory frameworks. Below is a detailed overview of the key components of the implementation plan.

Project Initiation and Planning

Feasibility Study and ESIA Clearance

- **Objective**: Confirm the viability of the project through comprehensive feasibility studies and obtain Environmental and Social Impact Assessment (ESIA) clearance.
- **Actions**: Conduct detailed assessments of technical, economic, environmental, and social factors, ensuring alignment with national and international standards.

Stakeholder Engagement

- **Objective**: Establish open communication with local communities, government authorities, and environmental organizations.
- **Actions**: Organize public consultations, workshops, and informational sessions to gather feedback and address concerns regarding the project's impact on the environment and local livelihoods.

Regulatory Compliance and Licensing

Obtain Necessary Permits

- **Objective**: Secure all required licenses and permits before project commencement.
- **Actions**:
    - Apply for mining licenses under the Mining Act.
    - Obtain water use permits in accordance with the Water Resources Management Act.

- Ensure compliance with the Environmental Management Act for ongoing environmental monitoring.

Infrastructure Development

Site Preparation

- **Objective**: Prepare the site for construction activities.
- **Actions**:
  - Conduct land clearing and grading.
  - Establish access roads and transportation infrastructure to facilitate the movement of materials and personnel.

Construction of Plant Facilities

- **Objective**: Build the soda ash extraction and processing plant.
- **Actions**:
  - Construct evaporation ponds for brine concentration.
  - Install crystallization and calcination units.
  - Develop storage facilities for raw materials and finished products.

Resource Management

Water Supply and Management

- **Objective**: Ensure a sustainable water supply for plant operations and local communities.
- **Actions**:
  - Develop a water sourcing strategy, including potential groundwater extraction and recycling systems.
  - Implement water conservation measures to minimize environmental impact.

Energy Supply

- **Objective**: Secure reliable energy sources for plant operations.

- **Actions**:
    - Assess energy requirements (approximately 11.5 MW) and explore options for renewable energy integration.
    - Coordinate with local energy providers to ensure adequate supply.

Environmental Management

Implement Environmental Management Plan (EMP)

- **Objective**: Mitigate environmental impacts throughout the project lifecycle.
- **Actions**:
    - Monitor air and water quality regularly.
    - Establish biodiversity protection measures, particularly for local wildlife habitats.
    - Develop waste management protocols to handle by-products and emissions.

Community Development Initiatives

Local Economic Development

- **Objective**: Enhance the socio-economic conditions of local communities.
- **Actions**:
    - Create job opportunities during construction and operation phases.
    - Invest in community infrastructure, such as schools and health facilities, to support local development.

Training and Capacity Building

- **Objective**: Equip local residents with skills relevant to the soda ash industry.
- **Actions**:
    - Develop training programs for local workers in areas such as plant operations, maintenance, and environmental management.

Operational Phase

Commencement of Operations

- **Objective:** Begin production of soda ash following successful construction and testing.
- **Actions:**
    - Conduct pre-operational checks and staff training.
    - Start the extraction and processing of soda ash, ensuring compliance with operational standards.

Continuous Monitoring and Evaluation

- **Objective:** Ensure ongoing compliance with environmental and operational standards.
- **Actions:**
    - Implement a monitoring framework to track environmental impacts and production efficiency.
    - Conduct regular audits and assessments to identify areas for improvement.

Review and Adaptation

Periodic Review

- **Objective:** Evaluate project performance and adapt strategies as needed.
- **Actions:**
    - Conduct annual reviews of environmental and social impacts.
    - Adjust operational practices based on feedback from stakeholders and monitoring results.

The project implementation plan for the soda ash plant at Lake Natron is designed to ensure a systematic approach to development while addressing environmental, social, and economic factors. By emphasizing stakeholder engagement, regulatory compliance, and sustainable practices, the plan aims to foster a successful project that benefits local communities and contributes to Tanzania's economic growth. Continuous monitoring and adaptation will be essential to maintain alignment with sustainability goals and community needs throughout the project lifecycle

11.1 PROJECT TIMELINE AND MILESTONES

11.2 PROCUREMENT STRATEGY

11.3 CONSTRUCTION AND COMMISSIONING PLAN

11.4 PROJECT MANAGEMENT AND GOVERANANCE STRUCTURE

The project management and governance structure for the natural soda ash extraction project at Lake Natron should be designed to ensure effective decision-making, stakeholder engagement, and adherence to regulatory requirements. Here's a detailed overview of the key components:

11.4.1 Project Management Team

Project Manager: Responsible for overall project coordination, planning, and execution. Serves as the primary point of contact for stakeholders.

Technical Manager: Oversees the design, engineering, and implementation of the extraction and processing facilities. Ensures adherence to technical specifications and best practices.

Environmental Manager: Responsible for developing and implementing the Environmental Management Plan (EMP). Monitors environmental impacts and ensures compliance with regulations.

Community Liaison Officer: Facilitates communication and engagement with local communities. Addresses concerns and ensures that community development initiatives are aligned with their needs.

11.4.2 Steering Committee

Composition: Representatives from the Tanzanian government (e.g., Ministry of Minerals, Ministry of Natural Resources and Tourism), project partners, and independent experts.

Responsibilities: Provide strategic guidance, review progress, and make key decisions regarding the project. Ensure alignment with national development goals and environmental policies

11.4.3 Technical Advisory Panel

Composition Experts in fields such as hydrology, ecology, and mining engineering

Responsibilities: Provide technical advice and recommendations to the project management team. Review studies and assessments to ensure scientific rigor and best practices.

11.4.4 Stakeholder Engagement Forum

Composition: Representatives from local communities, environmental organizations, and other interested parties.

Responsibilities: Facilitate regular dialogue and consultation with stakeholders. Provide a platform for addressing concerns and incorporating feedback into project planning and implementation.

11.4.5 Regulatory Compliance

Compliance Officer: Ensures that the project adheres to all relevant laws and regulations, including the Mining Act, Environmental Management Act, and Water Resources Management Act

Reporting: Submits regular compliance reports to government authorities, such as the National Environment Management Council (NEMC) and the Ministry of Minerals.

11.4.6 Monitoring and Evaluation

Monitoring Framework: Establishes key performance indicators and a system for tracking progress and impacts.

Independent Audits: Commissions regular independent audits to assess environmental and social performance, identify areas for improvement, and ensure transparency.

11.4.7 Grievance Redresses Mechanism

Grievance Officer: Responsible for receiving, investigating, and resolving complaints from stakeholders related to the project's impacts or operations.

Grievance Redressal Committee: Includes representatives from the project management team. local authorities, and community members. Ensures fair and timely resolution of grievances.

By implementing this project management and governance structure, the natural soda ash extraction project at Lake Natron can foster effective decision-making, stakeholder engagement, and adherence to regulatory requirements. Regular monitoring, evaluation, and adaptation will be crucial to ensure the project's long-term sustainability and alignment with the interests of local communities and the environment

12. CONCLUSIONS AND RECOMMENDATIONS

12.1 SUMMARY OF THE FEASIBILITY STUDY FINDINGS

The feasibility study findings for the soda ash project at Lake Natron highlight its significant potential to contribute to Tanzania's economic growth, job creation, and industrialization while minimizing impacts on biodiversity. Here's a detailed summary of these findings:

12.1.1 ECONOMIC GROWTH AND GDP CONTRIBUTION

The soda ash project is poised to play a vital role in boosting Tanzania's GDP by leveraging the country's rich natural resources. Lake Natron is one of the few natural sources of soda ash globally, making it an economically strategic asset. The project is expected to generate substantial revenue through the extraction and processing of soda ash, which is a critical raw material used in various industries, including glass manufacturing, detergents, and chemicals. The initial capacity of the plant is projected to reach up to 500,000 tons per year, with potential for future expansion. This output can significantly contribute to national exports, enhancing foreign exchange earnings and overall economic stability.

12.1.2 JOB CREATION

The development of the soda ash project is anticipated to create numerous job opportunities in the region. The construction and operation of the extraction and processing plant will require a diverse workforce, from skilled labour in technical roles to unskilled labour for various support functions. Moreover, the project is likely to stimulate local economies by attracting ancillary businesses and services, further increasing employment opportunities. This influx of jobs can lead to improved living standards for local communities, reducing poverty levels and enhancing economic resilience.

12.1.3 IMPROVEMENT IN LIFESTYLE AND INDUSTRIALIZATION

The soda ash project is expected to foster industrialization in the Lake Natron region, which is currently underdeveloped. By establishing a processing plant and associated infrastructure, the project will catalyze further industrial activities, encouraging investment in related sectors and promoting technological advancements. As industries develop, and local communities will gain access to better services, infrastructure, and markets, leading to an overall improvement in lifestyle. Enhanced economic activity can also lead to better educational and healthcare facilities, contributing to the quality of life for residents.

12.1.4 MINIMAL IMPACT ON BIODIVERSITY

One of the critical aspects of the feasibility study is the emphasis on using the monohydrate extraction process for soda ash. This method is considered less invasive and more sustainable compared to traditional crust mining techniques. By focusing on solar evaporation of sub-soil brine, the project aims to minimize environmental degradation and preserve the unique biodiversity of Lake Natron, which is home to various wildlife species, including the lesser flamingo. The feasibility study recommends implementing robust environmental management practices to monitor and mitigate any adverse effects on the ecosystem. This includes conducting regular environmental assessments and engaging with local communities to ensure that conservation efforts are prioritized alongside economic development.

In summary, the feasibility study for the soda ash project at Lake Natron underscores its potential to significantly impact Tanzania's economic landscape. By contributing to GDP growth, creating job opportunities, fostering industrialization, and adopting sustainable extraction methods, the project presents a balanced approach to economic development that aligns with national goals and environmental stewardship. The careful implementation of the monohydrate extraction process will be crucial in ensuring that the project's benefits are realized while safeguarding the region's rich biodiversity.

12.2 FINAL RECOMMENDATIONS FOR PROJECT APPROVAL OR FURTHER STUDY

The final recommendations regarding the soda ash project at Lake Natron, following extensive feasibility studies and environmental assessments, have significant implications for its approval or the necessity for further study. Here's a detailed overview of these recommendations:

JOINT ORE RESERVE COMMITTEE (JORC) INTERNATIONAL BRANCH

12.2.1 CONDUCT A NEW ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

If the soda ash facility is to be reconsidered, a new EIA should be conducted that encompasses a detailed feasibility study covering the full scope of the project's environmental, social, and economic impacts. This assessment must include

- **Biodiversity Impact**: A thorough evaluation of how the project may affect the lesser flamingo population and other wildlife in the Lake Natron area, which is recognized as a critical breeding site.
- **Water Resource Management**: Analysis of how the project will impact local freshwater resources, which are vital for both human and ecological communities
- **Community Engagement**: Involvement of local communities in the assessment process to ensure their concerns are addressed and to foster transparency.

12.2.2 DEVELOPMENT OF A RAMSAR SITE MANAGEMENT PLAN

The government should prioritize the development of a management plan for the Lake Natron Ramsar site. This plan should outline objectives for conservation and sustainable use of the site, ensuring that any industrial activities do not compromise its ecological integrity.

12.2.3 STRATEGIC ENVIRONMENTAL ASSESSMENT (SEA)

A Strategic Environmental Assessment should be conducted for any economic development policies and plans that could affect Lake Natron. This assessment will help identify potential cumulative impacts of multiple projects in the region and guide sustainable development practices.

12.2.4 PRECAUTIONARY APPROACH

While further studies are being conducted, a precautionary approach should be adopted in all decision-making processes. This means that if there is any uncertainty regarding the environmental impacts of the project, the government should err on the side of caution and prioritize environmental protection.

12.2.5 LEGAL PROTECTION FOR LAKE NATRON

Investigate options for establishing legal protection and regulatory regimes for Lake Natron, including potential designations that can safeguard the area against harmful development. This could involve stricter regulations on land use and resource extraction in the vicinity of the Ramsar site.

12.2.6 COMMUNITY-BASED DEVELOPMENT ALTERNATIVES

Encourage the exploration of alternative development models that empower local communities through sustainable practices, such as eco-tourism and natural resource management. This approach can provide economic benefits while preserving the ecological and cultural significance of Lake Natron.

The recommendations emphasize the need for a cautious and comprehensive approach to the soda ash project at Lake Natron. By prioritizing environmental assessments, community involvement, and sustainable development practices, the Tanzanian government can ensure that any future decisions regarding the project align with national and international standards for biodiversity conservation and sustainable resource management. The focus on a new EIA and the development of a Ramsar management plan will be crucial in balancing economic interests with the protection of one of East Africa's most vital ecosystems.

12.3 NEXT STEPS FOR PROJECT DEVLOPMENT

The further procedural development regarding soda ash project on Lake Natron deals with compliance with regulatory frame works, stake holder engagement and sustainable practices.

12.3.1 PROJECT APPROVAL AND STAKEHOLDER ENGAGEMENT

- **Formal Approval**: After receiving ESIA clearance, the project must secure formal approval from relevant government authorities, including the Ministry of Minerals and the National Environment Management Council (NEMC). This approval is contingent upon demonstrating adherence to environmental regulations and community concerns.

- **Stakeholder Consultation**: Engage with local communities, environmental groups, and other stakeholders to discuss project plans, address concerns, and incorporate feedback into project design. This may involve organizing public forums and workshops to ensure transparency and build trust.

12.3.2 DETAILED PROJECT PLANNING

- **Project Design and Engineering**: Develop detailed engineering designs for the soda ash extraction and processing facilities. This includes selecting the appropriate technology for solar evaporation of sub-soil brine and calcination, which was identified as the most efficient method during the feasibility study.

- **Resource Assessment**. Conduct a thorough assessment of the natural resources required for the project, including water, energy, and raw materials (e.g., limestone and coal). This assessment should ensure sustainable sourcing to minimize environmental impacts.

12.3.3 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

- **Development of EMP**: Create an Environmental Management Plan that outlines strategies for mitigating potential environmental impacts identified in the ESIA. This plan should address issues such as habitat preservation, water quality management, and waste disposal.

- **Monitoring and Reporting**: Establish a monitoring framework to track environmental performance throughout the project lifecycle. Regular reporting to government authorities and stakeholders is essential to ensure compliance with environmental standards.

12.3.4 LICENSING AND PERMITTING

- **Obtain Necessary Licenses**: Secure all required licenses and permits, including mining licenses under the Mining Act, water use permits under the Water Resources Management Act, and industrial operation licenses under the Factories Act. Each application must demonstrate adherence to relevant regulations.

- **Land Acquisition and Compensation**: Navigate the land acquisition process in accordance with the Land Act and Village Land Act. This includes compensating affected communities and ensuring that land use rights are respected.

12.3.5 INFRASTRUCTURE DEVELOPMENT

- **Construction of Facilities**: Begin construction of the soda ash extraction and processing plant, ensuring that all activities comply with health and safety regulations. This phase should also include the development of supporting infrastructure, such as roads and utilities.

- **Energy Supply Management**: Establish reliable energy sources for the plant, considering the projected demand of 11.5 MW for operations. This may involve partnerships with local energy providers or investments in renewable energy solutions.

12.3.6 COMMUNITY DEVELOPMENT INITIATIVES

- **Local Economic Development**: Implement community development initiatives that support local economies, such as training programs for local workers, investment in community infrastructure, and support for local businesses.

- **Sustainable Practices**. Promote sustainable practices among local communities to minimize reliance on unsustainable resource extraction, such as illegal charcoal production, which can lead to environmental degradation

12.3.7 OPERATIONAL PHASE

- **Commencement of Operations**: Once all facilities are constructed and operational readiness is confirmed, commence soda ash production. This phase should include rigorous adherence to the EMP and continuous monitoring of environmental impacts.

- **Ongoing Stakeholder Engagement**: Maintain open lines of communication with stakeholders throughout the operational phase, providing updates on production, environmental performance, and community initiatives.

12.3.8 REVIEW AND ADAPTATION

- **Periodic Review**: Conduct periodic reviews of the project's environmental and social impacts, adjusting practices as necessary to enhance sustainability and address any emerging concerns.

- **Feedback Mechanism**: Establish a feedback mechanism for stakeholders to voice concerns or suggestions, ensuring that the project remains responsive to community needs and environmental considerations.

The procedural description for the soda ash development project at Lake Natron emphasizes a structured approach to implementation following the feasibility study and ESIA clearance. By prioritizing stakeholder engagement, environmental management, and sustainable practices, the project can contribute positively to the local economy while safeguarding the unique ecological characteristics of Lake Natron.