PLANNING FOR KMML INDUSTRIAL AREA AND ITS AFFECTED REGIONS

THESIS REPORT

Submitted by

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in

Urban Planning

DEPARTMENT OF ARCHITECTURE

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DECLARATION

I hereby declare that the Project entitled **"PLANNING FOR KMML INDUSTRIAL AREA AND ITS AFFECTED REGIONS"** is a bonafide record of mine carried out under the supervision of **Prof. Anjana Murali,** Assistant Professor, Department of Architecture. I declare that the work reported herein does not form any part of any other project report or thesis based on which a degree or award was conferred on an earlier occasion to any other candidate. This study is done as a part of the fourth semester M. Plan (Urban Planning), Post Graduate Degree Course in the Department of Architecture, Thangal Kunju Musaliar College of Engineering, Kollam.

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Date:05.06.2023

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CERTIFICATE

This is to certify that the Thesis Report **"PLANNING FOR KMML INDUSTRIAL AREA AND ITS AFFECTED REGIONS"** submitted by **Ajmi Shajahan S** (TKM21MUP002) of MUP (2021-2023) Batch, in partial fulfilment of the requirements for the fourth-semester final examination in PL6401–Planning Thesis, under the **APJ Abdul Kalam Technological University** is a bonafide work carried out under our guidance and supervision.

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INTERNAL EXAMINER	**EXTERNAL EXAMINER**

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Ajmi Shajahan S

ABSTRACT

The study aims to understand and provide necessary planning solutions on the impacts of KMML, a public sector that plays a key role in the economic development of India. The research area is delineated based on secondary data such as those from the EIA NGT, IDDP and Disaster management reports as well as the degree of industrial impact from the pilot study. A comprehensive framework on planning for heavy industrial area was developed with its parameters and indicators analysed from various literature. This framework is later used in the study to analyse KMML industrial area and it's affected regions and to identify the major impacts of the industry in its surrounding built environment. Further validation was done with a primary survey with local community residing surrounding KMML industrial area to identify the opportunities and challenges.

The study finds that mining and processing of heavy and rare earth minerals of KMML is producing a tremendously negative impact on the land and environment in the area, the magnitude and intensity of which depends on the kind of chemicals and processes used, the efforts taken in the management of waste as well as on environmental fragility of the location. The project intends to develop advanced planning strategies to tackle the challenges in the study area put on by KMML to achieve positive economic benefits without endangering humanity.

The planning strategies suggested ensures integration of the environmental control measures into the process of planning industrial area. To build strategies, the mitigation measures are developed based on the best practices of well-planned industrial areas that have been thoughtfully built for a context like this. The solutions developed aim to preserve natural harmony and lessen the negative consequences of industry on humanity. The proposals are to intensify the water cleaning process, waste management, buffer zones, rehabilitation and resettlement, super specialty health care facilities and on other issues which have a direct bearing on the health and wellbeing of people in the area.

Keywords: Kerala minerals and metals limited, Acid fields, Industrial area planning

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ABBREVIATIONS

CPCB - Central Pollution control Board

EIA - Environment Impact Assessment

EMS- Environment Management System

GI - General Industrial

HI - Heavy Industrial

IASP - Industrial Area Structural Plan

IDDP- Integrated District Development Plan

KIC - Kwinana Industrial Council

LI- Light Industrial

LCA - Life Cycle Assessment

MoEF - Ministry of Environment and Forests

NGT-National Green Tribunal

PDCA -Plan Do Check Act

UNIDO -United Nations Industrial Development Organization

URDPFI - Urban and Regional Development Plans Formulation and Implementation Guidelines

KMML - The Kerala Minerals and Metals Limited

CHAPTER 1 INTRODUCTION

The Kerala Minerals and Metals Ltd. (KMML) is a Kerala Government firm that mines and processes beach sand minerals in the Chavara neighborhood in the Kollam District of Kerala. The KMML was established in 1972 by assuming control of M/s. FXP Minerals' mining and processing operations, which had been extracting beach sand since 1932. The study provides a complete description of the environmental status about the environmental elements, such as the air, noise, water, traffic, ecological, and socioeconomic elements surrounding the industry.

1.1 Background of the study

Mining and processing of heavy and rare earth minerals can produce a tremendously negative impact on the land and environment in the area, the magnitude and intensity of which depends on the kind of chemicals and processes used, the efforts taken in the management of waste as well as on environmental fragility of the location. Among the notable mining industries, KMML in Chavara is one of the noteworthy industries situated in Kerala. KMML spreads across two local grama panchayat Chavara and Panmana. (NIIST-CSIR, 2017)The pollutants released from this industry and accidental leakages of free Chlorine, degrading the environment, and posing a public health hazard. EIA is one of the most valuable, interdisciplinary objective decision making tools considering various alternate routes for development, process technologies and project site options. It is an anticipatory mechanism which establishes quantitative and qualitative values for parameters indicating the quality of environment and natural systems before and after the proposed activity. (NIIST-CSIR, 2017)

The aim of "planning of industrial areas" is to exhibit innovative planning and design for new or upgraded industrial districts. Resource efficiency integrated environmental monitoring, and management systems for eco-friendly planning techniques can all be used to achieve this. (Planning for sustainable Industrial areas in India, 2008)

Industrial estate

Industrial Estates are a cradle set up by the government for the growth of small-scale sectors. These are specific areas zoned for industrial activities in which infrastructure such as roads, power and other utility services are provided to facilitate the growth of industries and to minimize impacts on the environment. (KERALA SIDCO LTD, 2023)

Industrial Park

An Industrial Estate is an area of land set aside for industrial development. The concept of setting up of Industrial Park is to enable to concentrate dedicated infrastructure in a delimited area to reduce the per-business expense of that infrastructure, to enable to attract new business by providing an integrated infrastructure in one location, etc. (KERALA SIDCO LTD, 2023)

Industrial City

A zone or territory that contains a collection of independent industrial facilities that are all active at the same time is known as an industrial city. (KERALA SIDCO LTD, 2023)

Case of Madhya Pradesh

Industrial Area is around 64 Kms from Indore (Commercial Capital of Central India) with an area of 478 hectares. Out of the total 478 hectares of industrial land, the state has declared an Industrial Township of 206 hectares for SEFEAN's companies. (AKVN, 2021)

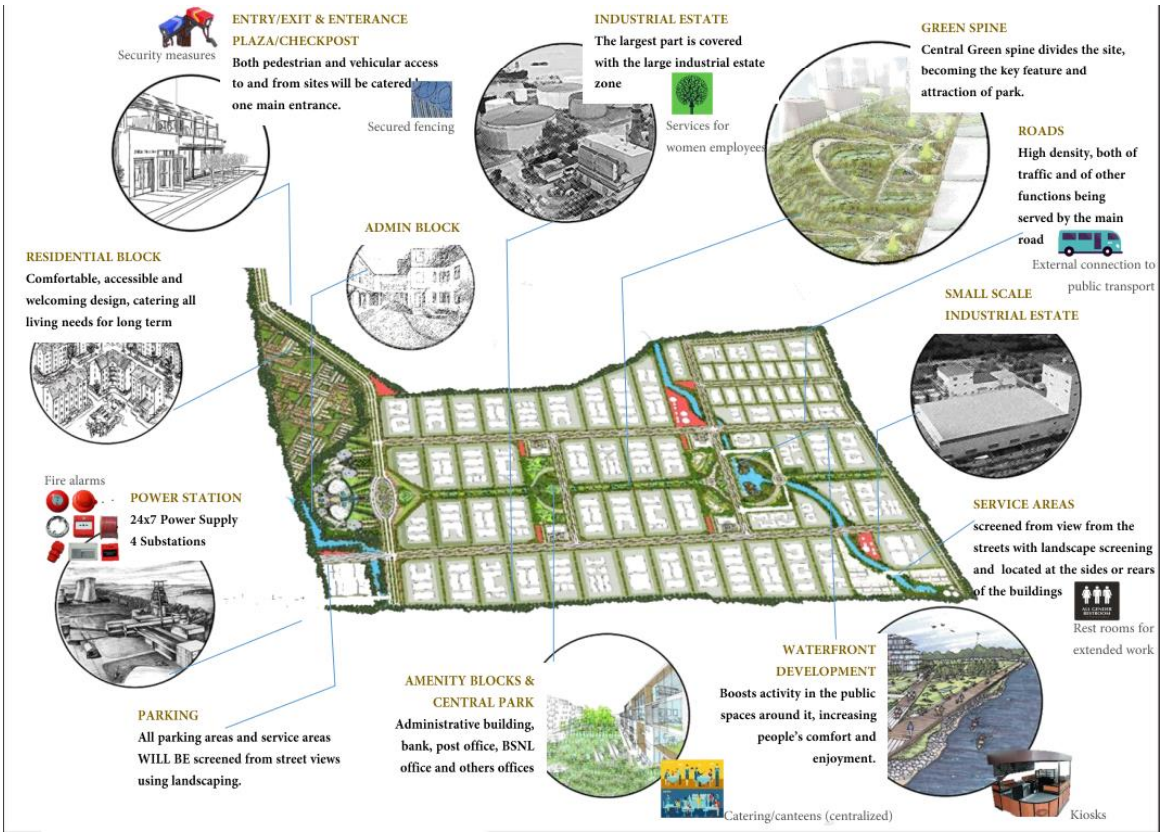


Figure 1.1: Smart Industrial Park of Dhar in Indore

Source: Smart Industrial Park,2021

An area is referred to as an "industrial region" if it has a significant concentration of industrial operations, and exports of manufactured goods from industrial trades and crafts are common. The land is in district Dhar near Pithampur, the most vibrant & biggest smart industrial park of Madhya Pradesh.

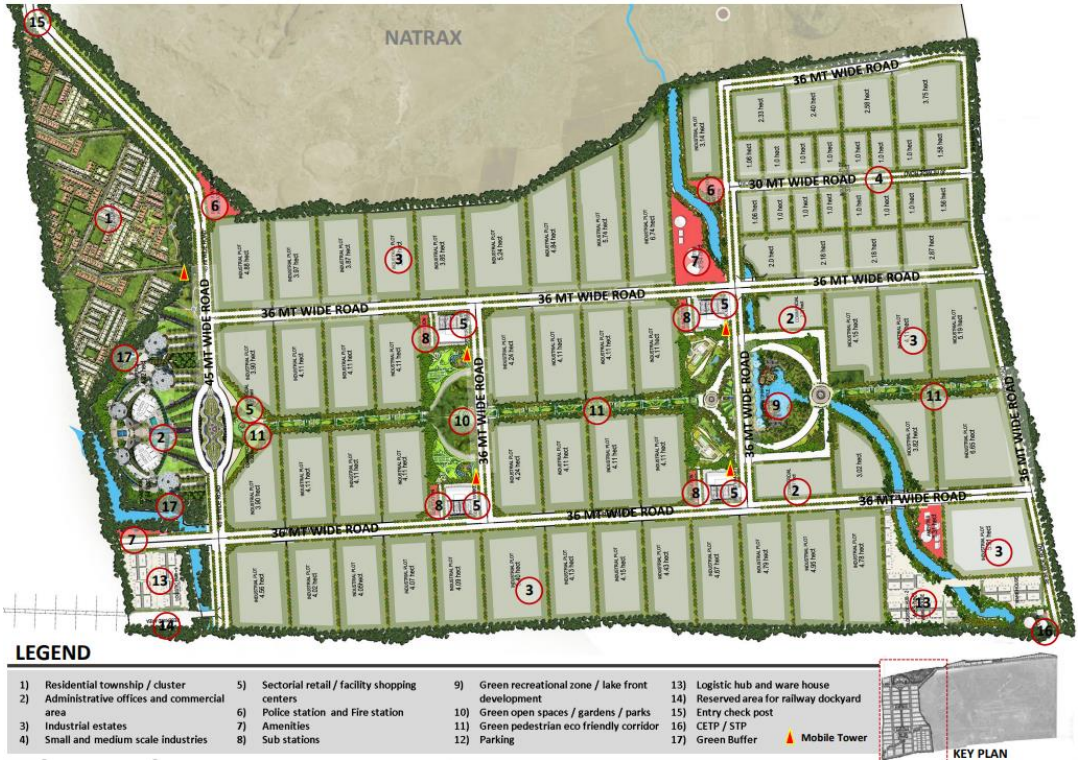


Figure 1.2: Site master plan of Smart Industrial Park of Dhar in Indore

Source: Smart Industrial Park,2021

1.1.1 Industrial Zoning

In sum, social factors can be used to create zones and define their roles, in contrast to the traditional method of zoning. This may be a direct reference to urban amenities like bus services, designated travel lanes, facilities for social and physical infrastructure, etc. (URDPFI, 2014) For zoning, there must be clearly specified green buffers of at least 500 meters between compatible and incompatible development due to health concerns and safety precautions.

Case study of Philadelphia

Philadelphia is the largest city in the Pennsylvania State of United States of America. Philadelphia population in 2022 is estimated 1.59 million. Philadelphia's land laws must be changed to protect and expand healthy industrial districts while converting formerly industrial land to other uses where it makes sense to guarantee the long-term viability of

urban industry. Philadelphia now has the chance to provide effective policy intervention for industrial land use thanks to efforts to revise the city's comprehensive plan and zoning code (Interface studio, 2012)**.** In the City of Philadelphia, there are over 17,800 acres of land that is allocated for industrial use, making up almost 21% of the total area of the city.

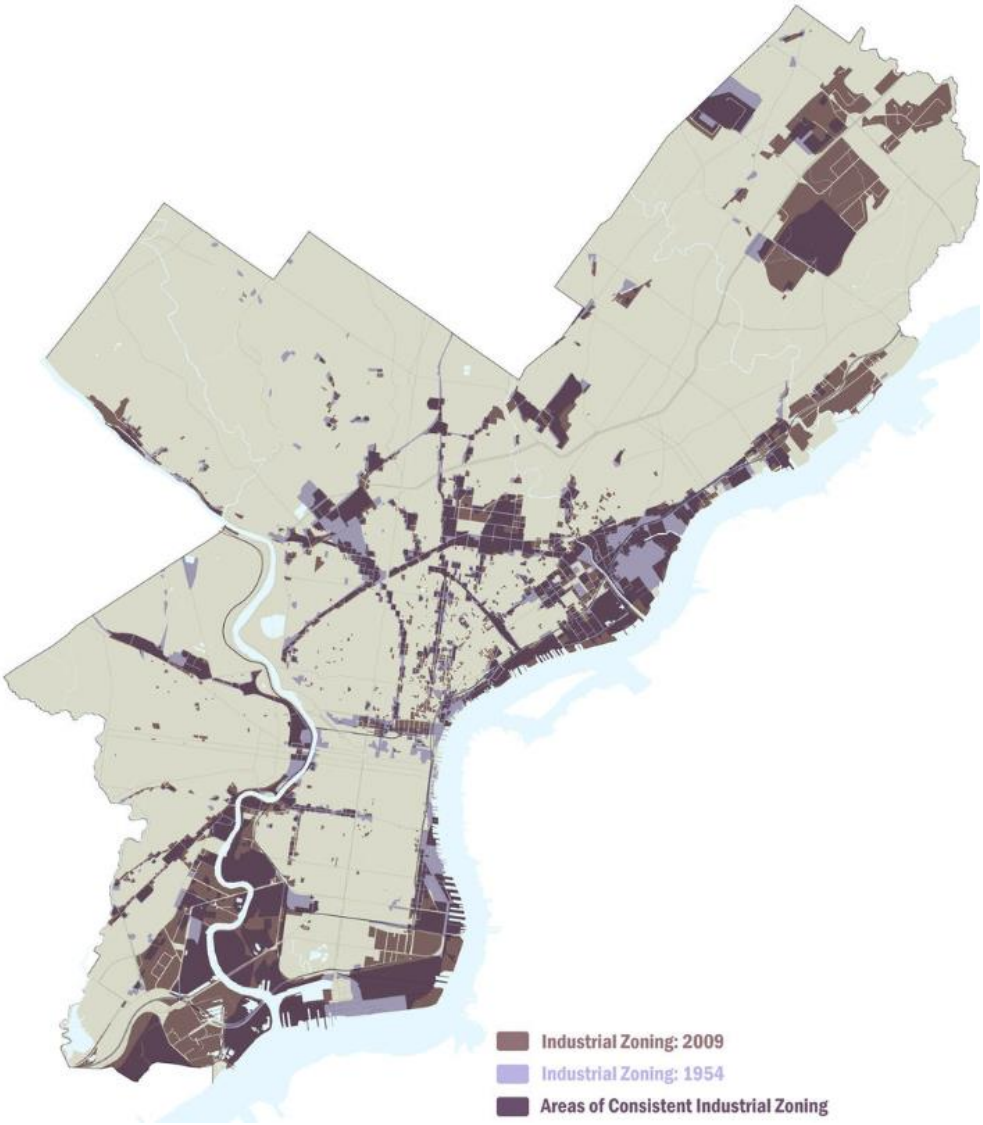


Figure 1.3: Industrial zoning of Philadelphia

Source: Interface studio, 2012

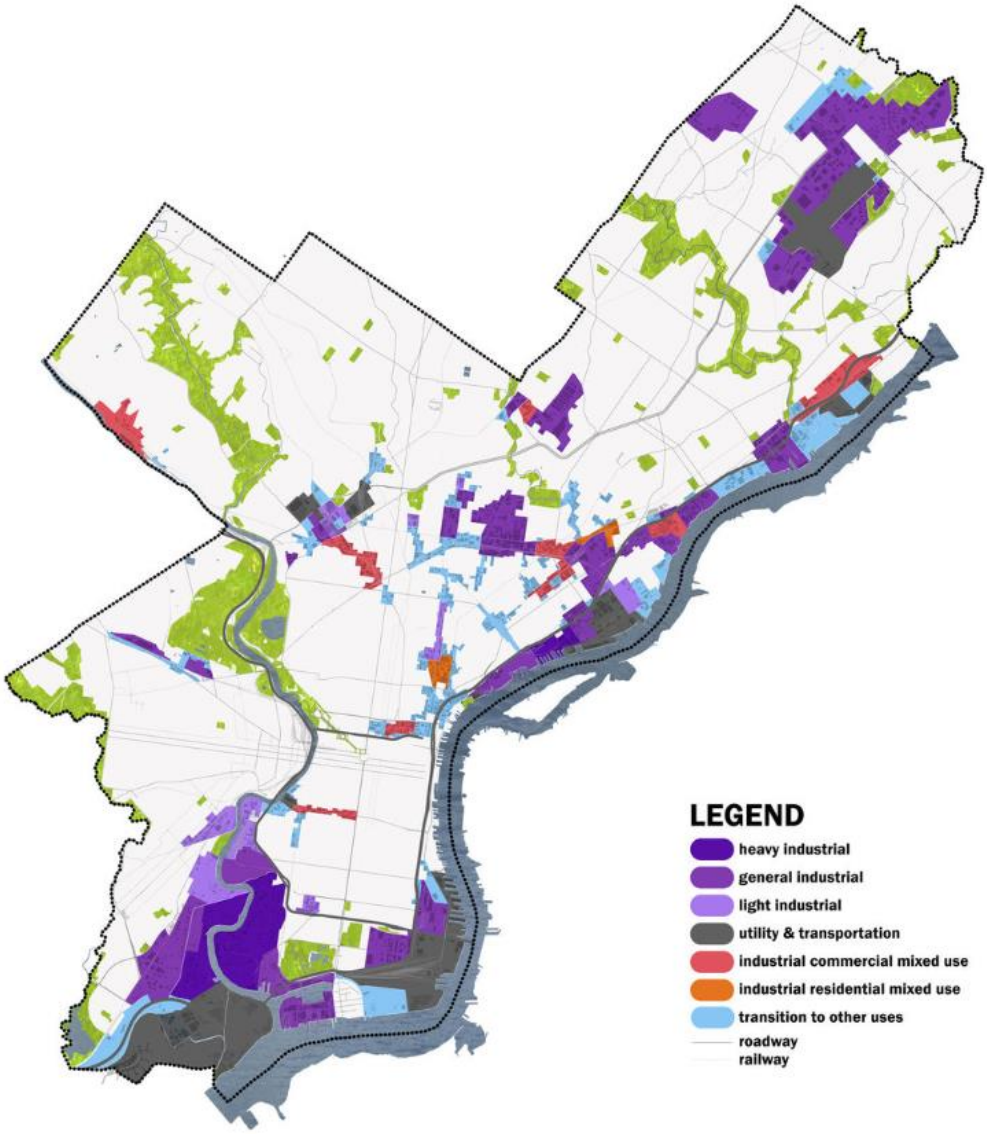


Figure 1.4: Classification of diverse types of industrial areas.

Source: Interface studio, 2012

Heavy Industry

Areas are not compatible with residential land uses and, as such, this zone incorporates areas well buffered or isolated from neighbourhoods and most commercial uses.

General Industry

The impact of the activities located here are less noxious than those found in heavy industrial areas, and many general industrial zones already abut residential neighbourhoods.

Light Industry

The light industrial classification is intended to accommodate modern business and technology parks, advanced manufacturing, and research and development facilities on high-value urban land in an attractive, low-impact environment.

Industrial-commercial use

This zone accommodates mixed-use corridors across the city consisting of commercially driven, locally serving light industrial and heavy commercial uses including food wholesaling, equipment fabrication and repair, and construction supply.

Industrial- residential use

This zone is intended to address the unique areas of Philadelphia that still bear the marks of the industrial revolution - multi-story factory buildings. workshops, and garages standing cheek-to-jowl with dense urban row housing.

Industrial policies

The Central Pollution Control Board (CPCB) have created an Environmental Pollution Index. On a scale of 0 to 100, CEPI values more than 70 have been classified as critically contaminated. The information relates to the Critically Polluted Industrial Clusters/Areas' Comprehensive Environmental Pollution Index (CEPI) scores. The index includes air, water, and land as some of the different environmental variables. (Central pollution control board, 2023) .The Rules specify the duties of various authorities, including the MoEF, the CPCB, state and local governments, SPCBs and Pollution Control Committees, the DGFT, the port authority, and the customs authority, while State Pollution Control Boards and Pollution Control Committees have been given broader responsibilities covering nearly

every facet of the generation, handling, and disposal of hazardous wastes. (Central pollution control board, 2023)

When particularly designing for an industrial area, it is recommended that service villages, hamlets, and rural settlements be given a buffer of 100 to 300 metres for the settlements' expansion from a health and safety standpoint. (URDPFI, 2014)

The State is working to create a responsible and cutting-edge industrial ecosystem with the new responsible agenda in place centred on the three pillars of environmental, social, and economic responsibility, which together create a responsible industry and a responsible society. (Kerala industrial and commercial policy draft , 2022)

Category	Description
RED	Industrial sectors with Pollution Index score 60 or above
ORANGE	Industrial sectors with Pollution Index score between 41 and 59
GREEN	Industrial sectors with Pollution Index score between 21 and 40
WHITE	Industrial sectors with Pollution Index score up to 20

Figure 1.5: Categories of industries based on pollution index score.

Source: Scroll.in ,2023

1.2 Need for the study.

Panmana village of the Chavara block panchayat in Kerala's Kollam district has been claimed by deadly chemicals which have spread in all its wards- Ponmana, Mekkad and Chittoor. The toxic effluents from the government-owned Kerala Minerals and Metals Limited (KMML) plant in Chavara have had a free run ever since the factory was set up in 1984, when it began dumping deadly waste into a patch of ground within its premises. (India Today, 2014). The iron-oxide sludge mixed with acid and heavy metals has been leaking from the old effluent ponds, where it had been accumulating for decades, causing cancer and skin diseases. The canals which once had crystal-clear water are now overflowing with foaming waste. Domestic wells and ponds have been run over by pale

effluents. The vegetation has been nearly wiped out. Panmana, once a green patch by the sea, is a picture of an industrial apocalypse.

The LSGI with highest number of cancer cases reported are the coastal local bodies of Chavara, Panmana in the Kollam district. Out of 18 Tones/day of Sulphur Dioxide (SO2) emission, major share is concentrated in Panmana Grama Panchayat (12.98 T/day). Out of 3.6 Tones/day of Carbon Monoxide (CO) emission, highest emission is in Panmana Grama Panchayat (0.836 T/day). The areas adjacent to Agro Allied Development Zone where urban activities are dominating over rural activities is delineated as Special Development Zone, Panmana comes under special development zone category 4 (IDDP , 2009). Based on the detailed study of each planning component of the study area to prepare an action plan for the study area.

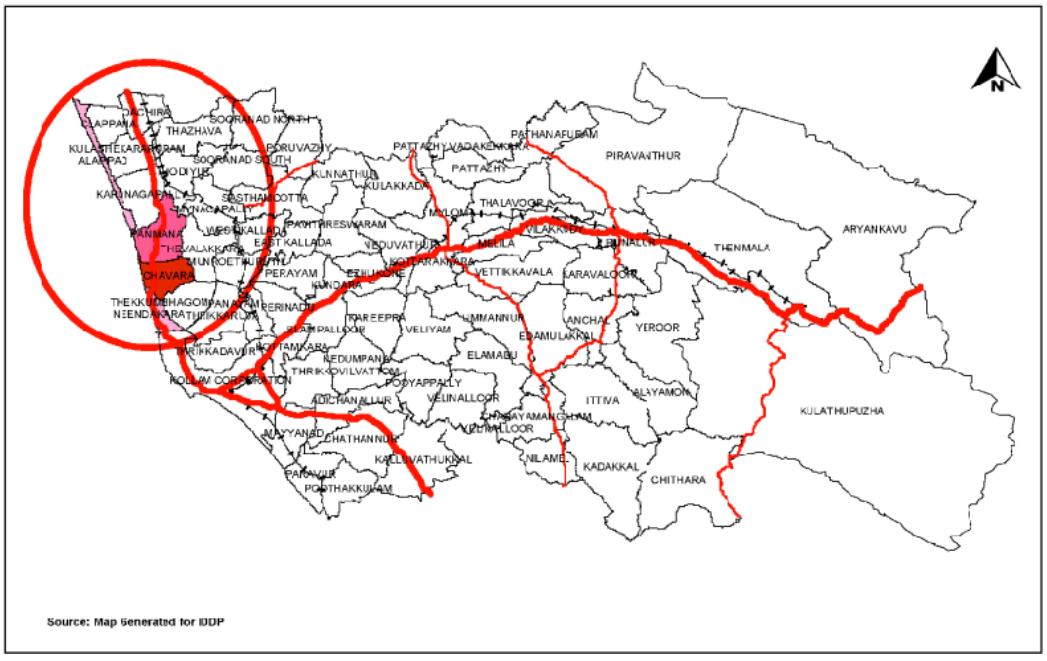


Figure 1.6: Distribution of cancer

Source: IDDP report ,2009

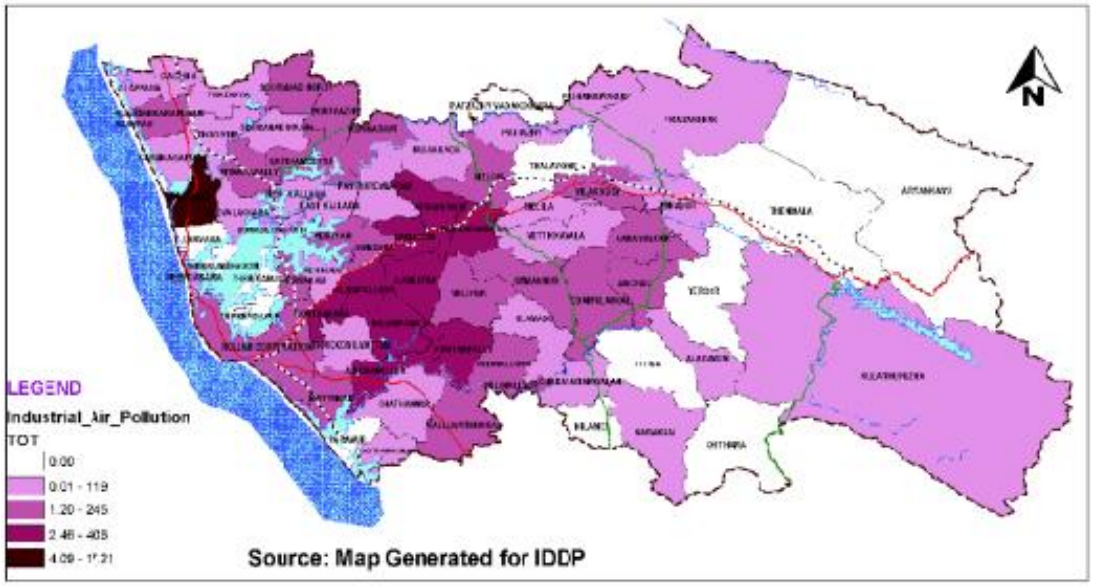


Figure 1.7: Distribution of total emission of major pollutants

Source: IDDP report,2009

It is not possible to wield the axe on a public-sector factory running in profit which contributes significantly to the state revenue besides providing employment. But we can take measures to see that it functions in a people-friendly manner. The landscape of Panmana bears the signature of a common enemy that afflicts people and plants alike.

1.3 Research question

1.What are the impacts of KMML in the surrounding built environment?

2.What are the planning strategies required for the regeneration of the study area?

1.4 Aim

To develop planning strategies for Kerala Minerals and Metals Limited (KMML) industrial area and its affected region.

1.5 Objectives

1.To study the concepts of industrial area planning and industrial policies

2.To study the impacts and determine the affected areas of the built environment in the KMML industrial region.

3.To evaluate and analyze the developed framework and determined parameters in the delineated region.

4.To analyze the issues and study various best practices for Industrial area planning

5.To develop planning strategies for Kerala Minerals and Metals Limited industrial area and its affected region

1.6 Methodology

The first stage of methodology includes background research and literature review on how to build an industrial region without having its effects negatively affect the nearby built environment. The research into the tools that can be used to evaluate the impacts of an industrial area and the strategies of planned industrial region like Ashdod Industrial Area is studied. A framework for evaluating the study area is developed. The second stage includes evaluating the study area's framework, the effects of industrial pollution there, and the delineation of the study areas based on the degree of the pollution. The study area's many planning components are studied and analysed primary and secondary data collection. The investigation of study area concerns and the selection of the best practices take place in the third stage. The development concept, mission, and vision are created in the final stage, and proposals for the KMML industrial area and its impacted regions.

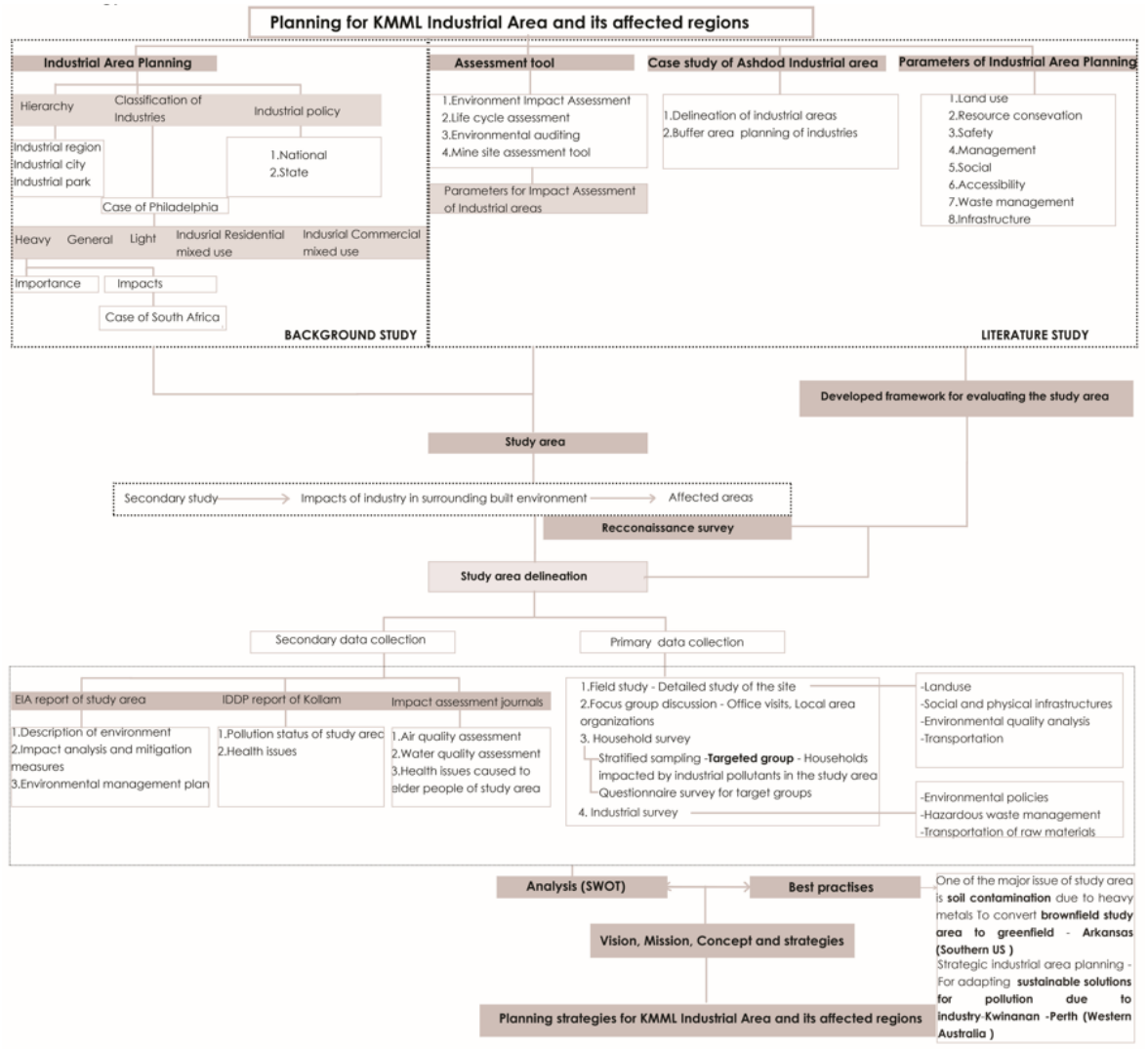


Figure 1.8 Methodology

Source: - Author generated, 2023

1.7 Scope

The aim of the action plan is to maintain ecological balance and check harmful effects due to the heavy mining industrial area. It ensures integration of the environmental control measures into the process of industrial area planning. The action Plan suggests measures to minimize adverse impacts. It also put forward reclamation plans for acid fields; replenishment plans for nature conservation and landscaping with a future vision for retrieval and conservation of all land components. The scope of study includes detailed

characterization of the Environmental status in respect of environmental components viz. air, noise, water, traffic, ecological and socio-economic components covering affected area with the industry boundary as its central nodal point.

Managing and continually improving processes, activities in view:

1.To control the impact on land, air and water and thus prevent pollution

2.To reduce health and safety risks

3.To optimize the use of resources

4.Strictly complying with the statutory and regulatory requirements

1.8 Limitations

Planning strategies formulated for the study based on validation of data collected from field study, offices, survey, and secondary data. It is difficult to do an in-depth investigation of each parameter, such as the quality of the water or the air, using sample data.

CHAPTER 2 LITERATURE REVIEW

This chapter explains the basic data studied to understand industrial area planning and the tools used for the assessment. The analysis of secondary studies related to the impacts of the KMML on the surrounding built environment.

2.1 Environment management tools

Environmental management tools are for the conservation of the environment for human existence. Harmony between man and environment is the essence of Environmental management. The main intention is to protect the environment in a sustainable way. The proper planning right from the start can go long way in preventing several environmental problems. (Krishnan, 2017).

Environmental management tools include:

1.Environmental Impact assessment
2.Environmental management system
3.Life cycle assessment
4.Environmental auditing

2.1.1 Environmental Impact Assessment

EIA is defined as "a planning tool used for the identification, evaluation and mitigation of potential impacts positive and negative of proposed plan / policy / program on physical/ biological /social/cultural / economic factors prior to decision making". (Krishnan, 2017).

EIA was first introduced in the United States (1969) in the form of United States National Environmental Policy Act (US NEPA). Later countries throughout the world made similar laws (EIA): Japan (1972), Canada (1973) New Zealand, Australia (1974) Brazil, France (1976) Thailand, Philippines (1978) Sri Lanka, Kuwait (1984) European Community (1985), Netherlands (1986) World Bank (1987) Italy, United Kingdom, Ireland (1988), Asian Development Bank (1990) India, Chile, Austria (1994), Iceland, Uganda (1995).

Evolution of EIA In India: In India, the concept of EIA was first initiated with the examination of environmental impacts associated with river valley projects in 1978-1979. (Krishnan, 2017).

The efforts to be made to lessen and avoid any potential negative environmental effects of the developmental activity are outlined in the EIA's mitigation processes. Finally, the various options chosen are ranked for selecting the best environmentally friendly and economically feasible one. The process of mitigation enhances the environmental and social benefits of the project under consideration. For each potential adverse impact, the plan for its mitigation at each stage of the project should be properly documented. (Krishnan, 2017).

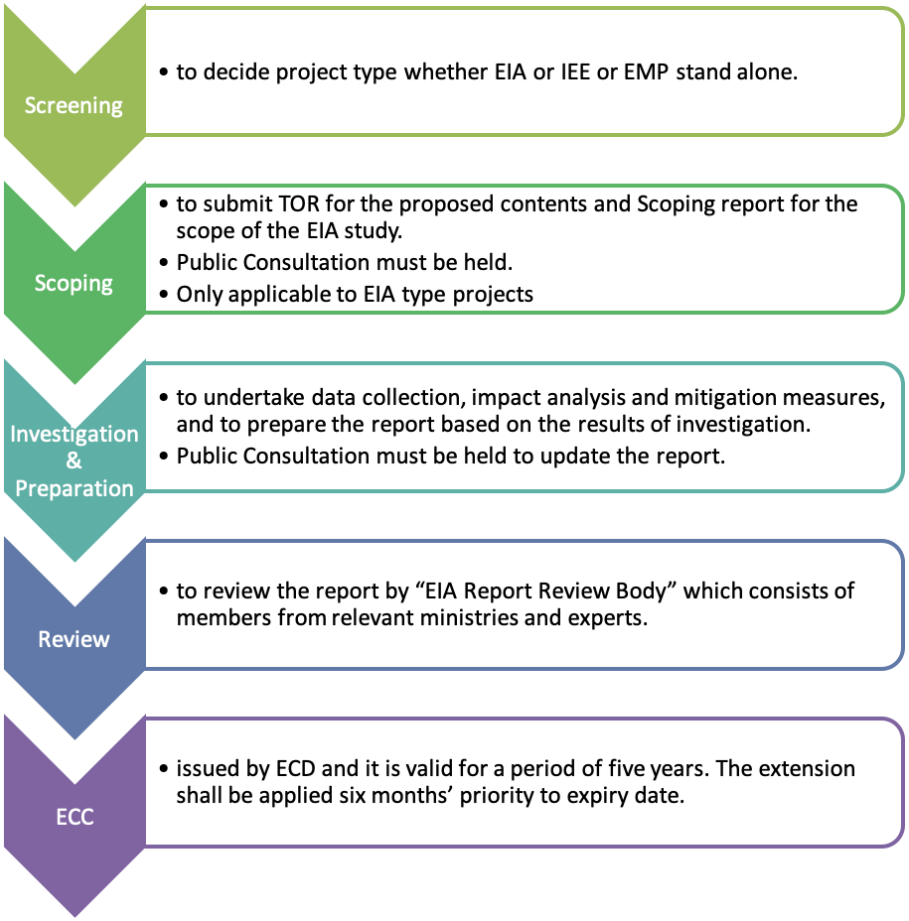


Figure 2.1: EIA process

Source: Drishti IAS,2022

2.1.2 Environment management system

Since the 1970s, when the Stockholm UN Conference in 1972 focused on developing policies and principles for the preservation of the environment, organizations have used environmental management systems (EMS). (Clements, 2020). A committee was established in 1993 with the goal of creating the 14000 series when it was deemed that a set of standards for environmental management would be necessary. The initial publication of ISO14001, however, didn't occur until 1996. 2015 saw the introduction of the standard's most current revision, ISO 14001:2015. To be accredited, an environmental management system must adhere to ISO 14001's specifications. It provides a step-by-step guide on how to create an effective environmental management system for a company or other organization. (ISO Standards, 2022). Plan-Do-Check-Act (PDCA) is the basic EMS framework (also called Deming-Shewhart Plan-Do-Check-Act Model). The PDCA cycle is a four stage, iterative management technique for identifying problems and later fixing them. If this cycle is followed, (ISO Standards, 2022)the system will continue to improve. (Krishnan, 2017).

Table 2.1: PDCA cycle

Source: Sustainable engineering 3rd edition 2017, Shibu Krishnan

Plan	**Planning & formulating basic environmental goals in accordance with the organization's environmental policy.**
Do	Implement the step-by-step actions which includes training and operational controls
Check	Checking and arriving at corrective measures
Act	Reviewing, includes periodic management reviews and actions to make needed changes which continuously improve performance of the environmental management system.

2.1.3 Life cycle assessment

It is an environmental management tool which helps to determine the environmental impact of a activity throughout the entire life. Life cycle assessment is also known as cradle-to-grave analysis. (Krishnan, 2017). LCA has developed from its beginnings in energy analysis in the 1960s and 1970s into a versatile methodology used to assess how various systems or goods will affect the environment and resources. (Marcella C. McManus, 2015). LCA follows three steps for assessing the impact:

Steps in LCA
1. **Selection of impact categories:** - This step involves the identification of environmental impact categories (such as Global warming, Stratospheric ozone depletion, Eutrophication, Toxicity etc.). LCIA mainly focuses on Human health, Ecological health, Resource depletion
2. **Classification of Impacts:** - Global, Regional (Acid rain) and Local impacts (Toxicity)
3. Impact characterization: - Impact characterization uses science-based conversion factors (known as characterization factors or equivalency factors) to convert and combine the individual Life Cycle Inventory results into a common equivalence unit to determine the overall harmful impact on the environment. (Krishnan, 2017).

Figure 2.2: Steps in LCA

Source: Krishnan ,2017

2.1.4 Environmental Auditing

Simply said, environmental auditing is a method used in environmental management to examine how certain actions influence the environment in contrast to established standards or criteria. Depending on the criteria employed and the audit's goal, there are many types of environmental audits. Today, businesses of all sizes recognize the importance of environmental concerns and that a variety of interested parties will be evaluating their environmental performance. (Introduction to Environmental Auditing and Management, 2022). Beginning in the early 1970s, a few industrial enterprises independently launched environmental auditing programmes as internal management tools to assist assess and examine the state of the business's operational units. These programmes marked the beginning of environmental auditing in the USA. (Introduction to Environmental Auditing and Management, 2022). An environmental audit can help management staff learn about a variety of environmental issues about

which they may not have previously been well-informed. This is particularly true in organizations with numerous locations or major manufacturing operations, where senior managers and directors are frequently dispersed throughout the organization, such as in the head office. Many of the locations with evident environmental concerns may not have been visited by managers, and even if they have, they may not have the necessary skills or training to recognize the presence of risks. Management can feel confident that any real or possible problems have been found by using environmental audits.

2.1.5 Mine site assessment tool

The MSAT has a survey-like format, with questions that can only be answered with a yes or no. The resource addresses 15 different subjects on a variety of economic, environmental, social, and governance (EESG) challenges that have an immediate impact on the lives and livelihoods of locals. Examples of the subjects covered are local hiring, regional purchasing, complaints, workplace health and safety, water quantity and quality, rehabilitation, and tailings management. MSAT is a versatile technology that enables the addition of additional topics to address specific problems faced by regional stakeholders. To increase knowledge of how mining operations must consider how their activities affect both men and women, the MSAT also incorporates gender throughout all its themes. (Mine assessment tool action, 2022).

The MSAT can be used to do any of the following, depending on local conditions and requirements: Raise awareness of the fundamentals of responsible mining; engage a mine operator in conversation about the fundamentals of responsible mining; agree on an agenda for issues that need to be addressed; Build leadership skills in meaningful engagement and constructive communication; Identify gaps in a mining operation's responsible mining; Measure improvement over time; Provide information to assist collaborative decision-making and monitoring; organize a treasure hunt.

2.1.5 a Tanzania

Context	Mining areas in the Geita region, especially those with small mining operations, are facing various socio-economic and human rights challenges such as water scarcity, deforestation and contamination of water resources
Objectives	Build capacity and confidence of local stakeholders. Establish a dialogue between communities and operators to better understand and address expectations and grievances.
Challenges	There are issues of child labour, and limited participation of women in mining activities. Despite the existence of a national action plan to reduce the use of mercury in gold mining, these areas still use mercury.
Outcomes	Following initial introduction meetings and capacity building of local leaders ('agents of change') to act as facilitators, several multi-stakeholder forums were held in two mining areas (7 villages in total). In both cases, the initiative was positively welcomed by local mining associations and cooperatives, as well as local authorities. Common expectations were formulated and approved. Mining companies have committed to improve their practices, including through the formalisation of grievance mechanisms, regular discussions on air and water quality, and better rehabilitation actions. Regarding gender issues, women workers contributed a lot to raising awareness on the issues they face such as wage inequality, gender-based violence, and forms of corruption based on sexual extorsion.
Facilitator	Population and Development Initiative (PDI) – national NGO providing capacity building to local communities and expertise on climate change, responsible mining, agro-forestry, water and sanitation, human rights and governance.
Outlook	These MSAT initiatives have been taken very seriously by all the stakeholders engaged. PDI recently won a grant to further engage on the MSAT and monitor progress. PDI also started to facilitate a similar approach in the Kigoma region.

Source: (Responsible mine foundation ,2021-22)

2.2 Parameters for heavy Industrial area

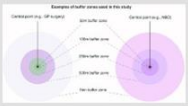
Parameters	Measures	
1.Land use	When specifically planning for an Industrial area; service villages, hamlets and rural settlements to be provided with a buffer of 100-300 meters for the expansion of the settlements, for health & safeguard point of view	 *Figure : Buffer zones* *Source :URDPFI guidelines*
2. Resource conservation	Sustainable resource management nurtures biodiversity value	 *Figure : Biodiversity conservation* *Source :UN environment programme, 2022*
3. Safety	Centre for Safety, Security and Environment – serves as emergency response centre (fire, chemical hazard, incidents), monitors eco-relevant data.	 *Figure : Public safety protection* *Source :dreamstime.com*
4. Management	Management and service concept for operation of Industrial area	 *Figure : Industrial management using smart technologies* *Source :Google images*
5. Social	Many industrial parks are located near residential areas, which makes it especially critical to address environmental concerns, such as air pollution, water pollution, waste generation, etc. To understand the relevant concerns, it is very important to involve local communities in EIP projects	 *Figure : Social indicators of industrial management* *Source :Google images*
6.Accessibility	Access to air, road, rail, and sees	 *Figure : Utilities and transportation* *Source :Google images*
7. Waste management	Collection, storage, transport, treatment, and disposal & recycling (landfill, incineration.)	
8. Infrastructure	Infrastructure planning and amenities available and managing the area to enhance health and safety of the residents to support economic development as well as to enhance the quality of living, environment, and for area specific	

Figure 2.3: Parameters of heavy industrial area

Source: Based on the reference of literature study

2.3 Importance of heavy industrial area

The top 40 mining corporations in the world, which make up the great majority of the sector, generated about 656 billion dollars in revenue in 2020. In the mining sector, the net profit margin dropped from 25% in 2010 to 11% in 2020.China is emerging as the world's leading producer of minerals, particularly the highly sought-after rare earths, of which China produced about 58 percent of the world's supply in 2020. Furthermore, China is the world's top producer of gold from mines.

The mining sector’s contribution to the GDP is 2.3-2.5 % at present. Mineral production in India grew at a compound annual growth rate (CAGR) of 5.72% between 2013-14 and 2017-18. The contribution of mining and quarrying sector to Gross State Value Added (GSVA) of Kerala at constant prices is estimated at ₹2,622.9 crore in 2018-19. Heavy industry has a major negative influence on the environment because of the nature of its products and manufacturing methods. It contributes to around 22% of the world's greenhouse gas emissions and has additional issues like chemical leaks, oil spills, and excessive water use. Heavy industry's need for the construction of enormous facilities can also result in the eviction of different animal species and even people. (Heavy Industry, 2022)

Ilmenite, Rutile, Leucoxene, Monazite, Zircon, and Sillimanite are among the minerals found in Kerala's Heavy Mineral Sand deposits. In the coastal areas between Neendakara and Kayamkulam, the State is home to one of the top mineral sand resources in the entire globe. After the primary site, this deposit is also known as the Chavara deposit and spans a total of 22 km in length, with widths of roughly 8 km in the north and 6 km in the south. To extract ilmenite to produce TiO2, the 225 m wide Chavara barrier beach is separated into 8 blocks designated I to VIII. The blocks are split between Kerala Minerals and Metals Ltd. (KMML), an enterprise of the State Government, and Indian Rare Earths Ltd. (IRE), a business venture of the Government of India under the Department of Atomic Energy. (Department of mining and geology, 2023)

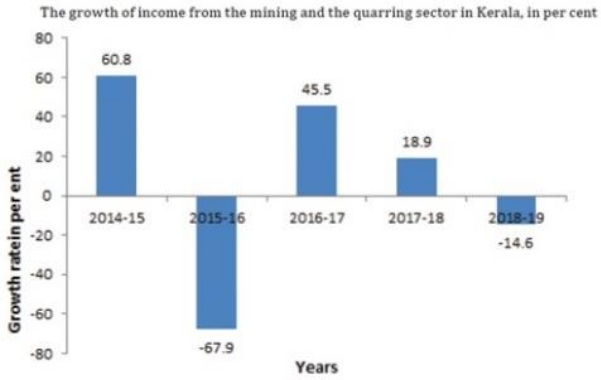


Figure 2.4: The growth of income from the mining sector in Kerala

Source: Directorate of economic statistics,2019

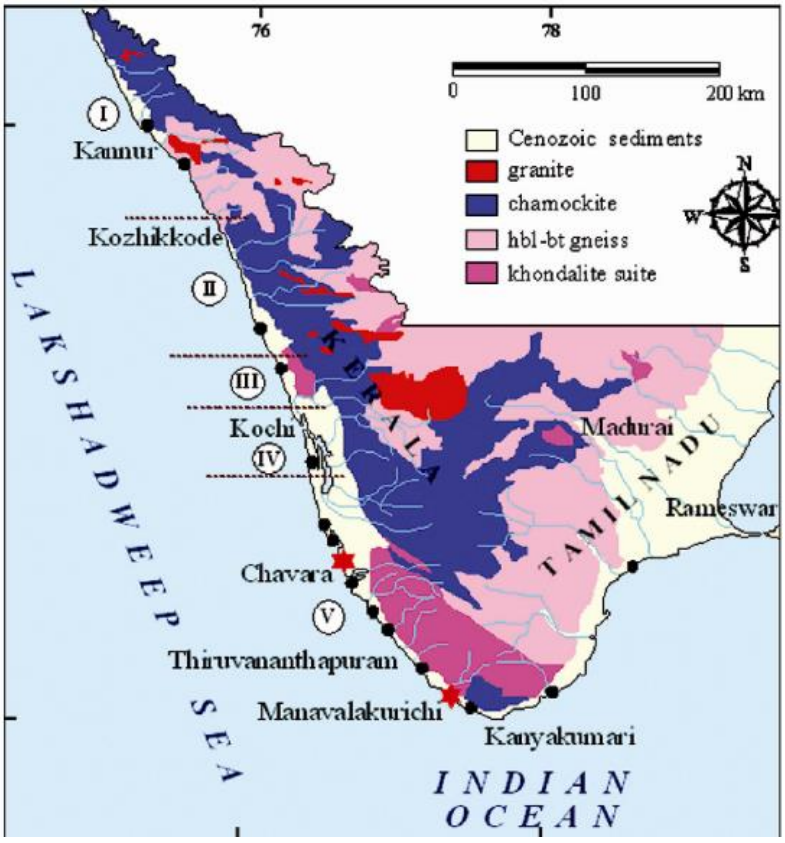


Figure 2.5: Map showing the major mineral deposit of Kerala.

Source: Relationship between heavy mineral placer deposits and hinterland rocks of southern Kerala: A new approach for source-to-sink link from the chemistry of garnets,Researchgate,2010

2.4 Impacts of heavy mining industrial area

Almost 30% of the known mineral reserves are found in Africa, with Southern Africa hosting 20% of the world's cobalt reserves, 36% of the world's gold resources, and 50% of the platinum group metals deposits (SA). The SA region's increased heavy metal output has had detrimental effects on both human and environmental health. Due to the faster entry and deposition of heavy metals, mining waste from artisanal and industrial mining has recently had a substantial negative impact on the ecological integrity of aquatic ecosystems in SA. (O.Ouma, 2021)

CHAPTER 3 CASE STUDIES

The chapter analyses two scenarios that demonstrate how mining and its processing unit affect the environment, as well as a proposed industrial district in Ashdod that was zoned as an industrial region to lessen the impact.

3.1 Case of Threats to Southern African Lotic System Biodiversity from Metal Mining and Processing

The loss of species and habitats due to many anthropogenic factors, including the impacts of climate change, pose a greater danger to Africa's freshwater biodiversity than ever before. The most significant anthropogenic risks in South Africa's mining river basins include flow modification, habitat degradation/destruction, and water pollution (including metal ions/metalloids and acid mine drainage) (abstraction, diversion, and effluent discharges). The number, source, kind, and character of mining-related toxins that reach aquatic systems determine how serious these concerns are. For instance, toxic metals like Pb, Zn, and Hg, metalloids like As and CN, and other substances like acids are released more quickly because of hydraulic and hard rock mining via runoff or leaching disrupting stream ecosystems physically and chemically and aggravating the loss of biodiversity. Additionally, the abstraction of large amounts of water is required for the extraction of minerals like diamonds and gold, which are frequently mined in water-scarce environments. This causes aquatic ecosystems to experience increased water stress and shrinking habitats, which are already made worse by episodic stream drought and climate change events. (O.Ouma, 2021)

Physical and chemical approaches have been used for a very long time in SA to monitor and control the pollution of its water systems. An integrated strategy that incorporates inorganic and biomonitoring techniques is gradually becoming more rational from a practical and scientific standpoint. Biological techniques are becoming more and more common because of their dependability, sensitivity, affordability, simplicity of use, and ease of interpretation. Based on the effective South Africa SASS-5 approach, rapid

bioassessment schemes (RBS) have been created for SA leverage. Due to the disaggregated methods used in bioassessments, monitoring aquatic ecosystems still faces difficulties.

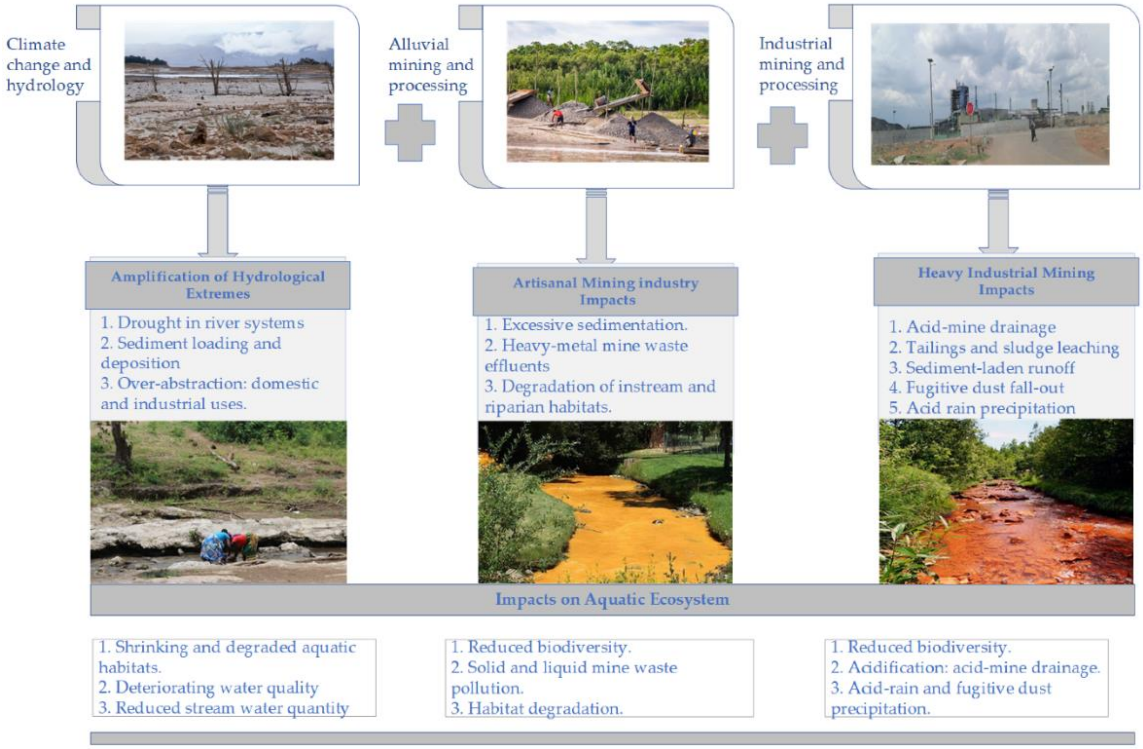


Figure 3.1: Chart showing the impacts of heavy mining industry in South Africa

Source: (O.Ouma, 2021)

Even though heavy metals (HM) are a substantial source of water pollution in South Africa, these indicators are not included in the RBS, which is a serious omission. Also, the existing approaches, particularly taxonomic resolutions for biodiversity assessments, need to be integrated and standardised. Long-term gains in RBS development would come from the use of environmental molecular monitoring tools (eDNA/eRNA) in barcoding and referencing biotic and metric index advances. The mini-SASS biomonitoring, reporting, and knowledge exchange platform for South Africa's River systems is a classic example of how citizen science is a viable and inclusive approach for collective responsibility and accountability by riparian communities and stakeholders in sustainable river basin management (O.Ouma, 2021).

3.2 Case study of Ashdod Industrial area planning

Ashdod is a port city with 218,000 people living in it and a total area of 46.13 square kilometres. Ashdod is a planned city. The northern industrial portions of the city are clearly separated from the southern residential districts (south). With many polluting factories situated close to residential areas, pollution does, nevertheless, travel into the urban regions. The following outlines the spatial arrangement of Ashdod's industrial areas, their existing programmes and broad guidelines, and environmental problems. (Developing a Framework for Ashdod's Industrial Areas, 2017)

Figure 3.2: Industrial Quarters of Ashdod industrial area planning

Source: Strategic plan for Ashdod Industrial area,2017

The residential parts of Ashdod are segmented into quarters (Alef, Bet, Gimel, etc.). There are four things these quarters have in common: Clearly defined boundaries are provided by the following factors: nearby streets; a core that is either an amenity or an open space; an internal secondary circulation network; and a certain architectural style and identity. This plan suggests bringing the industrial zones under this spatial organization. (Developing a Framework for Ashdod's Industrial Areas, 2017)

Figure 3.3: Stich the dual city of Ashdod industrial area planning.

Source: Strategic plan for Ashdod Industrial area,2017

Ashdod is split into two sections: the city center and the residential neighborhoods in the south and the industrial sectors in the north. This plan calls for making improvements along

the city's two main north-south axis, Sderot Herzl and Sderot Beni Brit, to link these separate areas. Higher density mixed-use developments or landscape spaces could be considered interventions. This plan also involves using these main axes to organize environmental laws and policies, creating a gradient of permitted noise levels, pollutants, and other dangers from south to north. (Developing a Framework for Ashdod's Industrial Areas, 2017)

Figure 3.4: A city- industry ring of Ashdod industrial area planning.

Source: Strategic plan for Ashdod Industrial area,2017

This method to constructing Ashdod takes advantage of the diversity of industry on Ashdod's periphery as well as the ring of parks, gardens, and natural areas that surround

Ashdod while also acknowledging that Ashdod's population center is in the central and southern regions of the city. It recommends the creation of a dynamic transition zone, or "city industry ring," where specific industrial uses can coexist with other commercial uses and the surrounding environment. The ring might be divided conceptually into segments focused on the sea and tourism, light industry and workshops, agriculture and logistics, and research and sophisticated manufacturing. This ring would link the city's dispersed areas. (Developing a Framework for Ashdod's Industrial Areas, 2017)

3.2.1 Strategies of Ashdod Industrial area

1.See the city as a single organism to better integrate it with its industrial districts. By doing this, the city's industrial districts will be developed alongside the rest of the city. In terms of livability, urban manufacturing has a visceral character that is vital to sense of place and civic pride in towns with an industrial history. To make a city more livable, one must be connected to its production centers and draw on its positive, innovative energy. The Fourth Industrial Revolution offers a chance to priorities urban quality of life and human empowerment to create a future that benefits all residents.

2. Restructure industrial districts' spatial and physical layout. This vision divides Ashdod's industrial regions into four quarters based on the layout of the quarters: the Port quarter, the Manufacturing quarter, the Mixed quarter, and the Campus quarter. The development of the industrial quarters paid attention to the same factors as the residential sections of Ashdod: Physical planning and boundaries are followed by a defined core, which could be an amenity or an open space, a secondary internal circulation network, and a specific architectural character.

3. Create a detailed development strategy for each region. While specific rules should be created for each quarter, all of the quarters should have policies relating to three major themes: (1) Collaborative structures, (2) Environmental concerns, and (3) Public Amenities and Education.

4. Create an integrated management structure to assist the industrial areas. The leadership of a visioning process, physical planning, policymaking, and the implementation of ideas

and initiatives pertaining to industry would fall within the purview of this group, which should comprise both planners and policy makers. This group's mission is to make sure that current industrial sites are divided, given new names, and reorganized in a way that will make it easier to formulate a precise plan that will guarantee the best possible economic and physical planning.

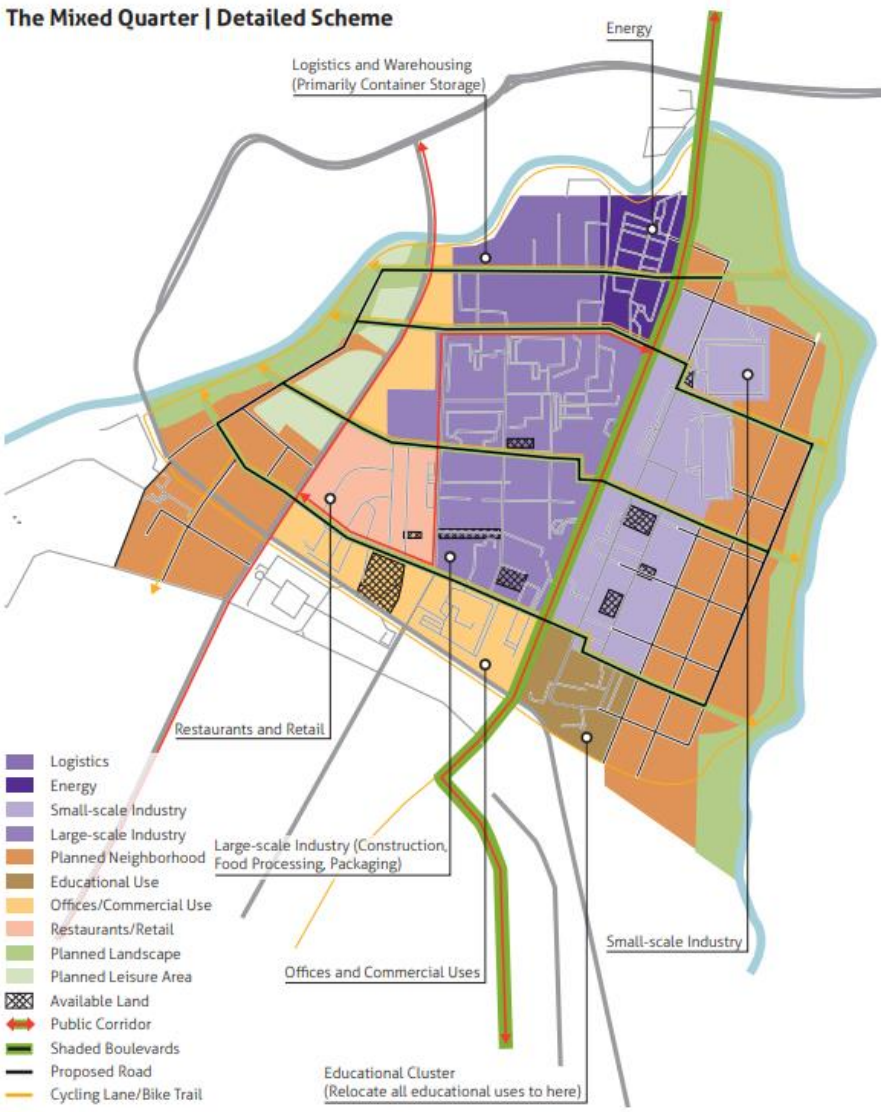


Figure 3.5: A mixed quarter detailed scheme of Ashdod.

Source: Strategic plan for Ashdod Industrial area,2017

CHAPTER 4 DEVELOPED FRAMEWORK FOR HEAVY INDUSTRIAL AREA

The chapter details the parameters to be focused on while planning a heavy industrial area based on the study of various literatures related to industrial area planning. These parameters are validated in the study area.

4.1 Developed framework for heavy industrial area

Industrial planning has gained national attention to address the difficulties that are predicted and achieve sustainable growth in industrial regions. Considering the significance of industries to the city's economy, it is essential to have a thorough grasp of their needs to meet them. Along with facilitating access to the industries, it's critical to comprehend the ancillary activities or land uses necessary to facilitating the industrial workers and the commuter population to the industrial area, as well as the proper zoning norms to be developed to ensure better environment in the industrial neighborhood.

Based on the literature examined, the planning criteria for industrial areas are developed in this study. The case studies selected based on the obtained criteria are used to guide the remedial procedures for the effects of heavy industries on the surrounding region. Using these corrective actions, a framework for heavy industries is developed. After studying the impact assessment tools, it is determined that EIA is the most useful one for evaluating the study area. The research derives the planning elements to be concentrated in the study area based on the secondary and primary examination of the site. The outcome of the research and the validation of the site using the developed framework is the framework suitable for heavy industry. This helps to give better planning interventions in the heavy industry affected areas. KMML and the surrounding area need a sustainable industrial planning for lowering the consequences, according to the secondary study and pilot survey. The Panmana Panchayat can utilize the tools for industrial planning from the literature evaluation for its reclamation. The derived indicators for the study area based on the secondary study are used to develop the framework for the study area based on these findings.

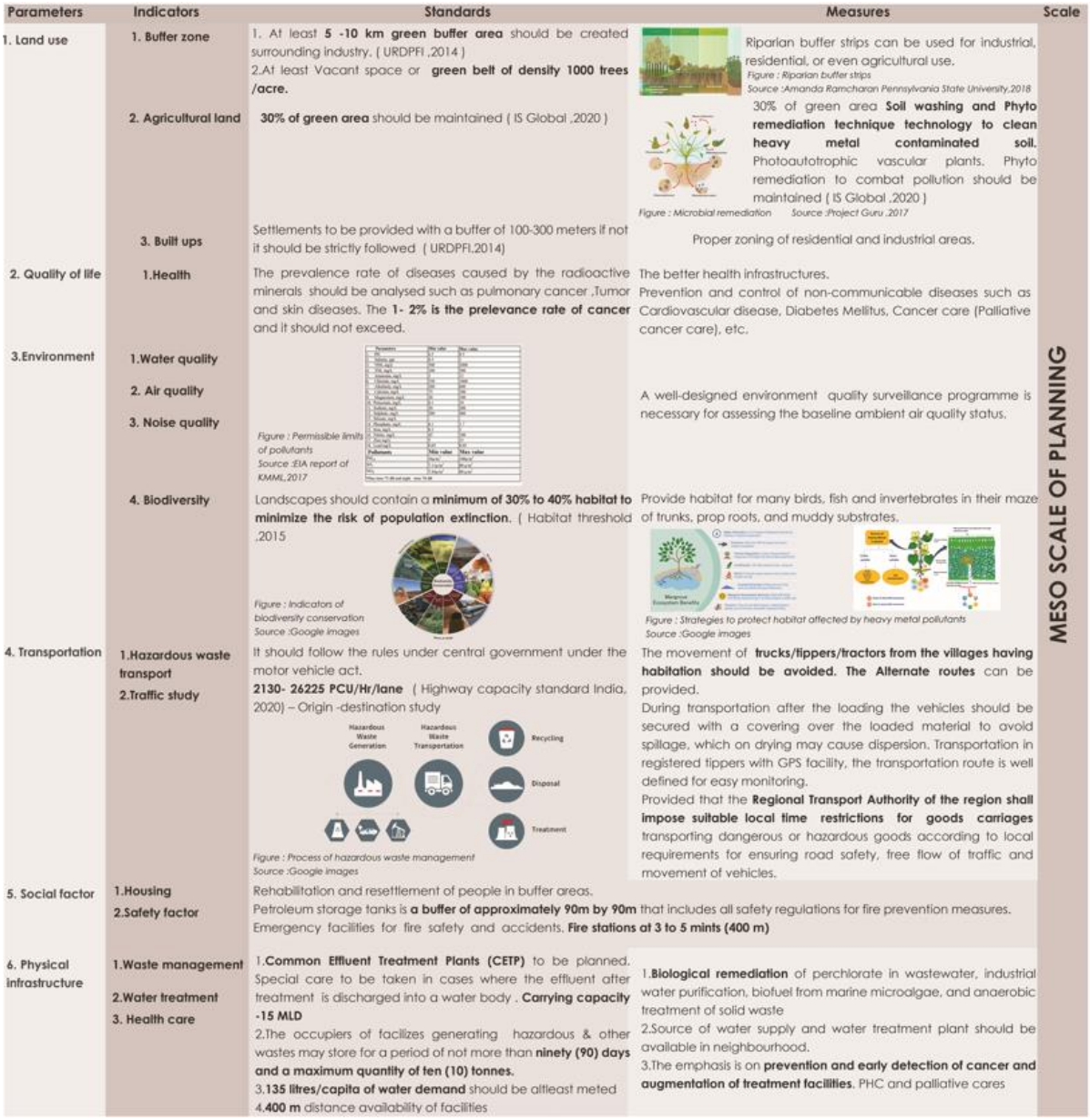


Figure 4.1: Developed framework for heavy industrial area.

Source: Author generated based on literature study ,2023

CHAPTER 5 INTRODUCTION TO STUDY AREA AND ITS DELINEATION

The study area is identified and delineated based on the secondary and reconnaissance survey of the study area. On the defined area, a more in-depth study is undertaken.

5.1 Introduction

Chavara and Panmana are independent Local self-government bodies of Kollam district. It is 17.9 km from Kollam.The Kerala Minerals and Metals Ltd (KMML) company has a 285-acre area and is located at Chavara near to NH-47. The research area, which includes the vicinity of the KMML Industrial Zone, is situated in Sankaramangalam, Chavara Taluk, 32 kilometres southwest of Kollam Central Railway Station and 5 kilometres from Neendakara Port. Chavara and Panmana panchayats are included in the Chavara taluk.

5.1.1 Administrative profile of study area

The study area is in the Chavara block of the Karungapally taluk.

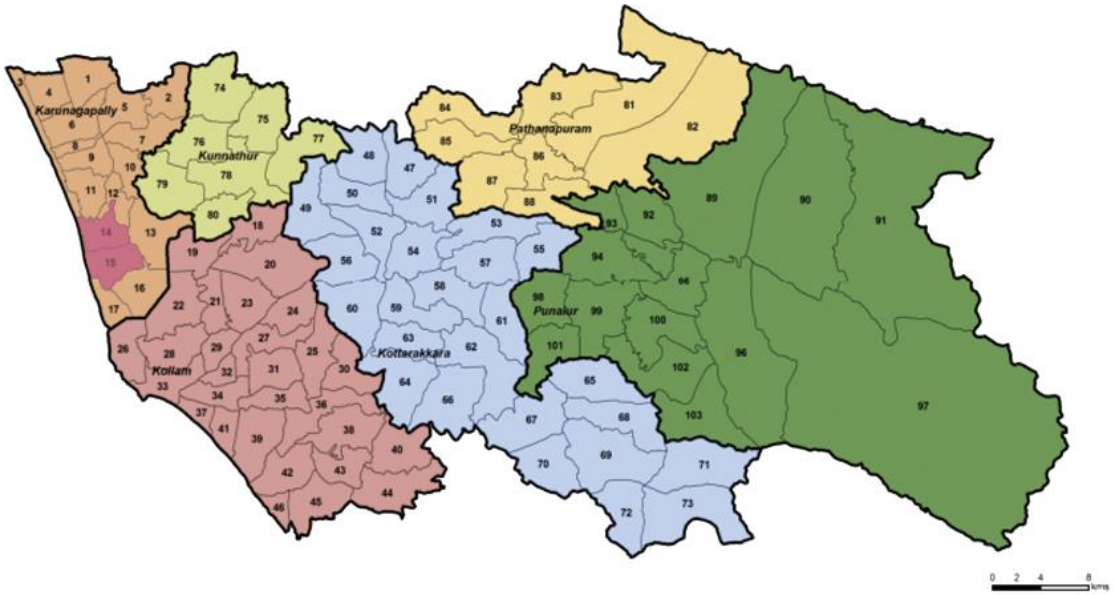


Figure 5.1 Map showing the administrative profile of study area.

Source: India Map ,2011

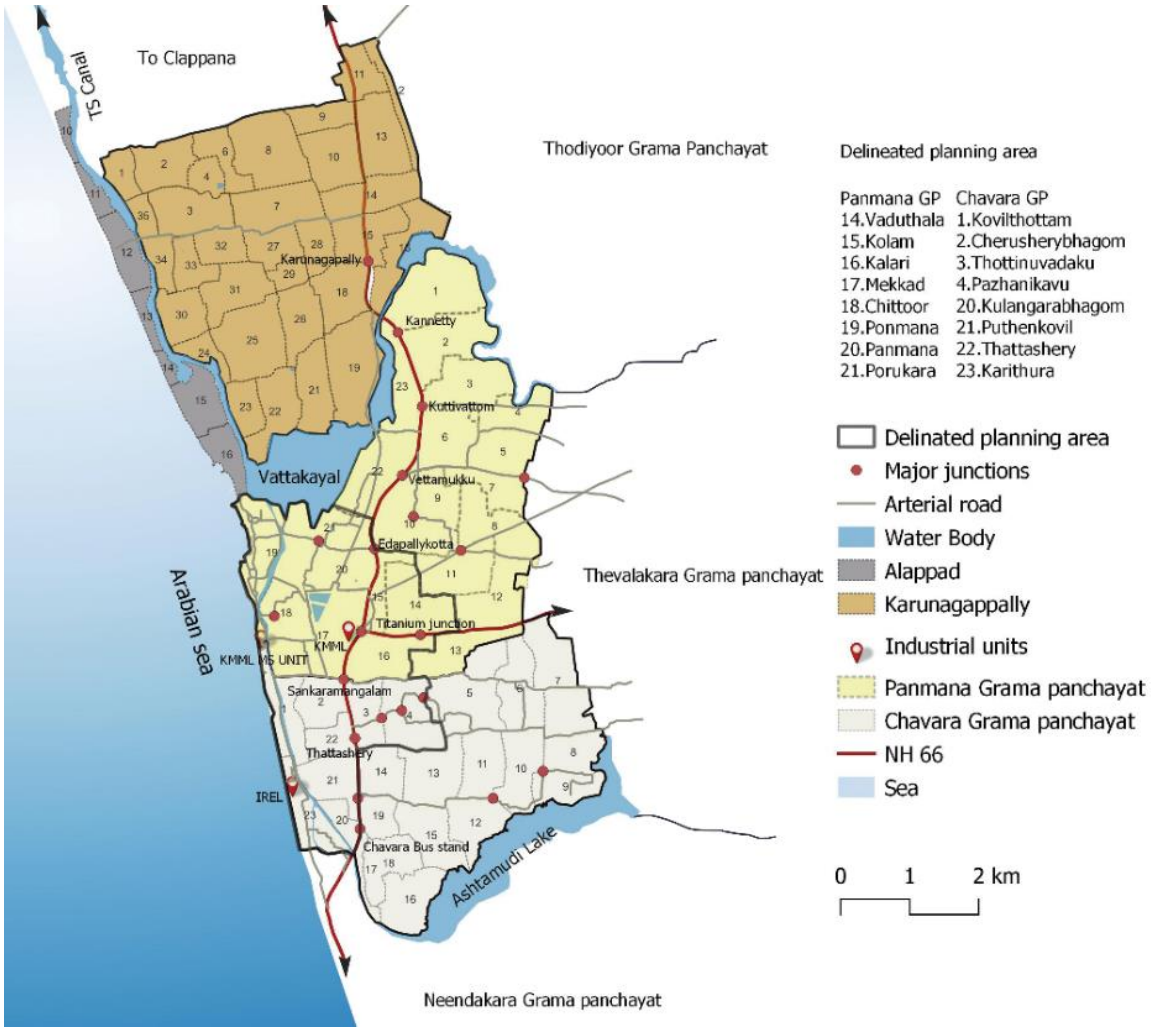


Figure 5.2: Base map of study area.

Source: Author generated using Qgis ,2023

5.1.2 Regional profile

Sand from the village's beaches is rich in rare-earth elements, particularly titanium. Kerala Minerals and Metals Limited (KMML) and Indian Rare Earths Limited are the two main rare-earth mining and processing businesses in Chavara's public sector. (IRE). German chemist Mr. Herr Shomberg made the discovery of the deposits at the southernmost sections of Kerala's coastline way back in 1909. Since then, these resources have been investigated and mined for heavy minerals by several organizations. The Neendakara-

Kayamkulam coastline section in Kerala's Kollam district is home to the Chavara heavy minerals deposit, which stretches for roughly 22.5 km of barrier beach.

5.1.3 Development history

Chavara had a prominent place in the economic growth of the country. The one of the major industries made India 7th in the world is in Chavara. Industrial development shifted the traditional occupation of study area.

5.1.4 Delineated study area profile

The 16 wards from Chavara and Panmana surrounding the industrial area are delineated for studying the impacts of KMML industrial area to the local community.

Table 5.1: Showing the demographic detail of delineated study area.

Source: District census handbook, 2011

	Chavara Grama panchayat	**Panmana Grama panchayat**
Block	Chavara	Chavara
Area	402.279 hectares	579.58 hectares
No: of wards	8	8
Population (SEC)-Above 18	12157	13330
Male population	5842	6460
Female population	6315	6870
Children population (1-18)	2416	2074
Total population	**14573**	**15404**
Population density	3622	15409

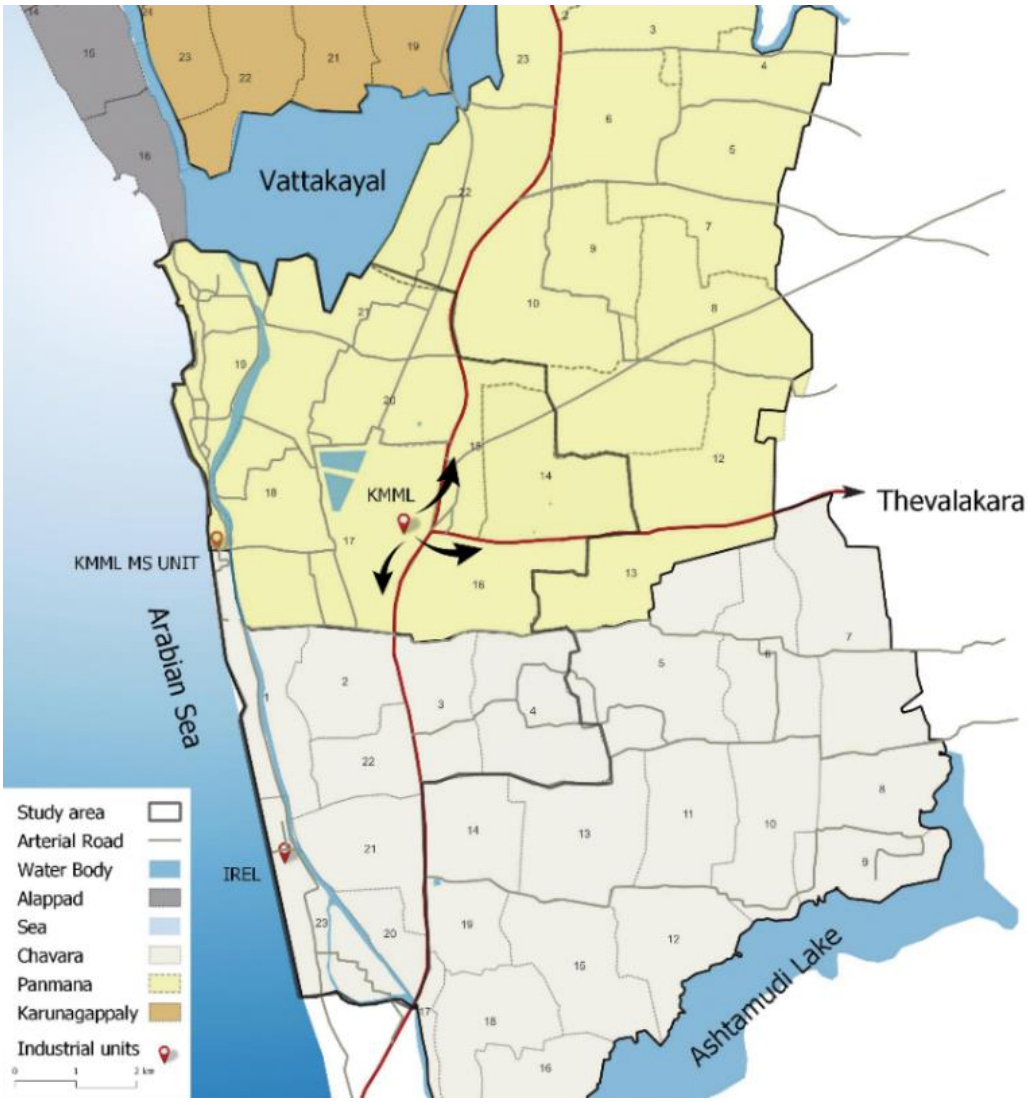


Figure 5.3 Map showing the delineated study area.

Source: Author generated using Qgis 2023

5.1.5 Process of Industries

1. Indian Rare Earth Limited (IREL)

Engaged in mining and separation of Atomic Minerals from the beach sand and provide to KMML and other industries Black sand. The Chavara mines, which span 23 km along the coast between Neendakara and Kayamkulam, contain up to 40% heavy minerals. The deposits are particularly rich in ilmenite, rutile, zircon, and silimanite, and the weathered

type of ilmenite is special since it contains 60% TiO2.2,35,900 tpa of ilmenite and related minerals including rutile, zircon, and sillimanite can be produced at the plant. The zircon opacifier factory features a capability to make Zirflor in sizes (-300 and -200). (IREL, 2019)

Figure 5.4. IREL Chavara

Source: Primary survey, March 2023

2.The Kerala Minerals and Metals Limited

KMML is a titanium dioxide manufacturing company since 1972 in Kerala. It is under the red category industry in Kerala. The many grades produced by KMML under the trade name KEMOX have a ready market that demands more. With the inauguration of the Titanium Sponge Plant, KMML is now used in aerospace and defense applications. The TSP is a cooperative initiative between KMML, the Defense Metallurgical Research Laboratory, and the Vikram Sarabhai Space Center (VSSC). (DMRL). The VSSC provided total funding for the TSP project for Rs.143 crore. With the launch of TSP, India surpassed China to become the seventh nation in the world to have the technology to produce titanium sponge, the primary component of titanium metal. (KMML, 2022)

Figure 5.5. The Kerala Minerals and Metals Limited

Source: Primary survey, March 2023

3.Mineral Separation Plant

The Mineral Separation Unit (MS Unit) is where Ilmenite, Rutile, Leucoxene, Monazite, Sillimanite, etc. are separated from the beach sand after the mineral-rich sands from the captive beaches are collected. The MS Unit separates minerals from sand using gravity, magnetism, and high-tension electrostatic processes.

Figure 5.6 Mineral Separation Unit

Source: Primary survey, March 2023

5.1.6 Impacts of Kerala Minerals and metals limited in its surroundings.

A tall stick sways in the wind in an empty field. It is a dead coconut tree, with a terrible indication of violent death in the form of its missing hairy head. This infant's infected leg has inflamed skin that resembles the dying tree's bark. Red effluent-filled patches of the ground resemble diseased tissues. The environment bears the mark of a common foe that affects both people and plants. (The Acid Fields of Panmana: Toxic effluents from a mineral plant are killing people and nature in a Kerala village, 2014)

5.2 Study area delineation

5.2.1 Impact of Industrial area

The area affected by the acid effluents from industry is categorized as highly polluted areas. The areas polluted by water pollution, air pollution and diseases are categorized as medium polluted. The areas have less impact on water, air, and environment due to industry is categorized as low. 16 wards are most affected.

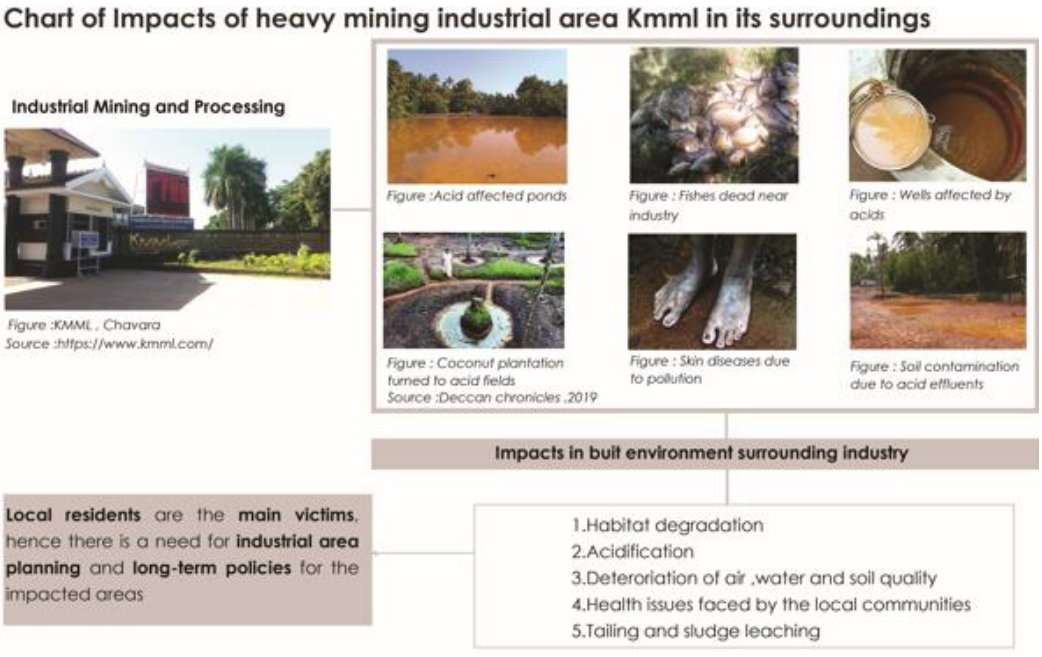


Figure 5.7: Chart of impacts of study area.

Source: Generated using the impacts reported in articles,2023

From the factory's establishment in 1984, when it started discharging lethal waste into a patch of ground on its premises, the government-owned Kerala Minerals and Metals Ltd (KMML) plant in Chavara has been able to discharge its toxic effluents into the environment at will. That tiny hazardous area has now grown to include the whole community. The iron-oxide sludge mixed with acid and heavy metals has been escaping from the ancient effluent ponds, where it had been building for decades, causing cancer and skin problems. (India Today, 2014)

1.To identify critically polluted industrial clusters/areas from the point of view of pollution and taking concerted action and for being centrally monitored at the national level to improve the status of environmental components, for example, air and water quality data, public complaints, ecological damage, and visual environmental conditions.

2.To facilitate the definition of critically polluted industrial clusters/areas based on the environmental parameter index and prioritization of an economically feasible solution through the formulation of an adequate plan for environmental sustainability (Criteria for comprehensive industrial assessment, 2009)

5.2.2 Environmental Impact assessment Report for Mining lease of KMML

The proposed mining and mineral separation of heavy mineral sand has led to KMML appointing CSIR-NIIST, Thiruvananthapuram, to evaluate the environmental aspects and their potential associated impacts as well as to develop an environmental monitoring programme to prevent, control, minimize, or eliminate the negative environmental impacts anticipated from the proposed mining and mineral separation. In Panmana Panchayath five wards were taken for the study- Chittoor, Mekkad, Kalari, Ponmana and Panmana wards which are free from mining but fall within the neighborhoods and indirectly affected by mining. In Chavara panchayat the Kovilthottam is affected due to mining of Indian Rare Earth (IRE – Mineral separation unit) and Thottinuvadaku is indirectly polluted due to the KMML industrial area. (NIIST, EIA study for renewal of mining lease of KMML , 2017)

As per the EIA report the income from the traditional job of fishing is diminished. It is fact that the mining has invited a lot of health issues among the people especially in the

spreading up of allergic disorder, kidney and lung diseases which are attributable to rampant mosquito problem, poor air and water quality. Allergies and skin ailments are on the increase among the people. Another important sensitive issue of the locality is resettlement. The existing families in the mining area are still not willing to vacate the present place of settlement. If the Company feels resettlement is essential, then it must ensure that the R&R package is reasonable and meets with the demand of the project affected people.

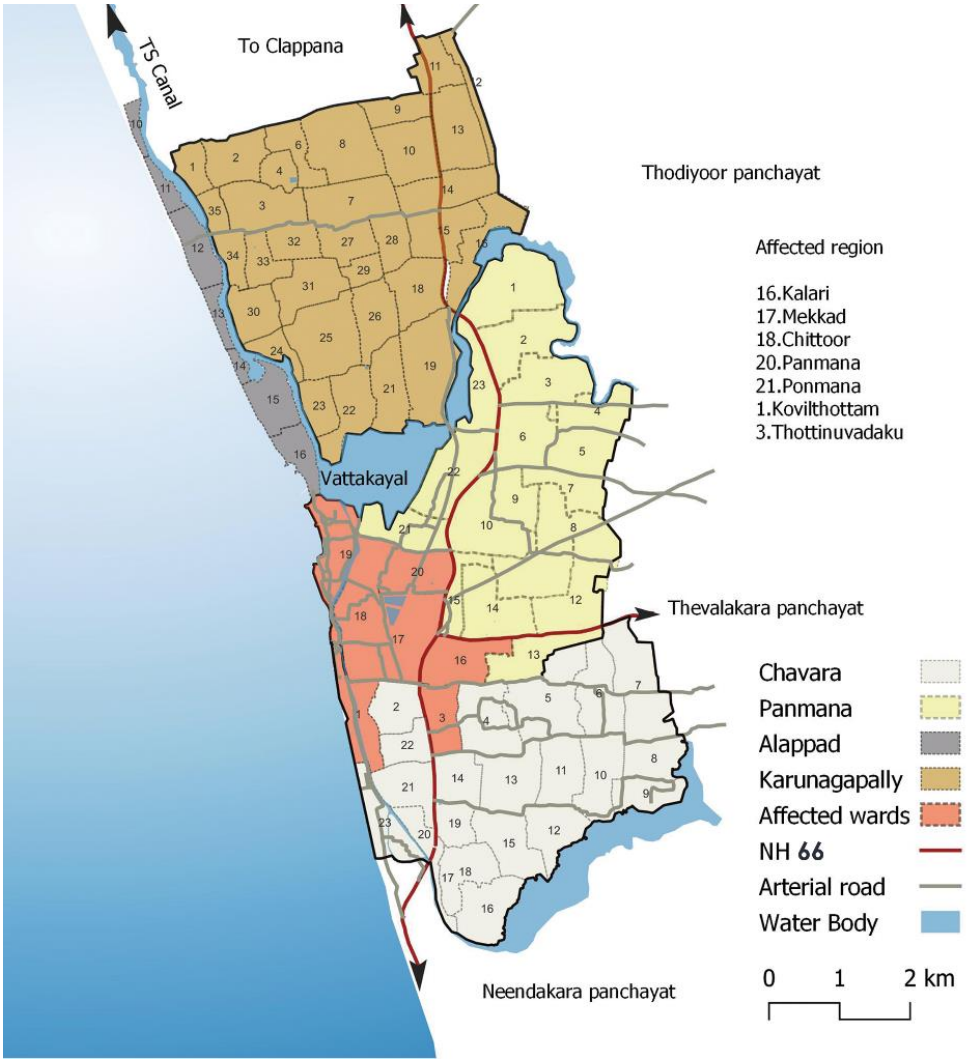


Figure 5.8: Chart of impacts of study area.

Source: Author generated using Qgis 2023

5.2.3 Integrated district development Plan of Kollam District

An extensive long-term plan for the district's development is the Integrated District Development Plan, Kollam. The District Planning Committee of Kollam has become the first DPC in the nation to own an IDDP that was created in accordance with the Constitution by creating the IDDP. This ground-breaking project has evolved into a model for community-based spatial platform planning. The proposed approach is easily transferable to other parts of the nation and has proven to be theoretically sound and practically valid to produce district and local plans in accordance with the 73rd and 74th Constitutional Amendments. (Integrated district development plan Vol 1, 2009)

5.2.3.a Health pattern

The LSGIs with highest number of cancer cases reported are the coastal local bodies of Chavara, Panmana, Neendakara and Alappad Grama Panchayats of the district.

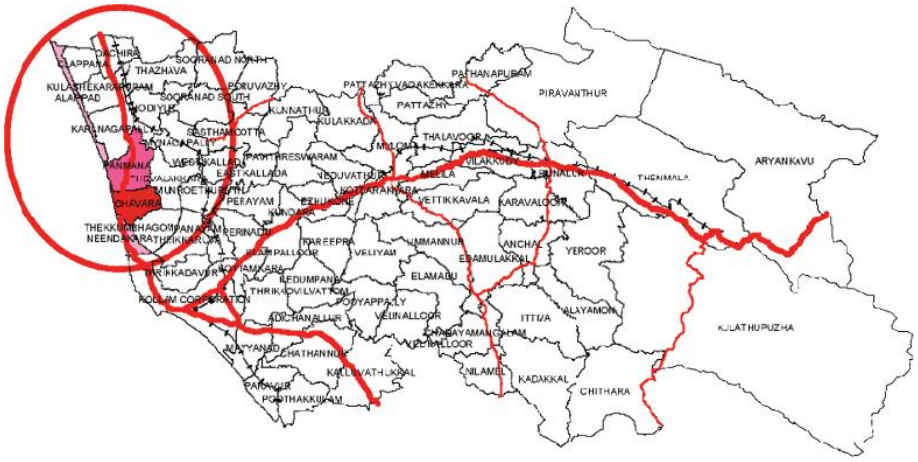


Figure 5.9: Map showing the distribution of cancer cases in Kollam.

Source: IDDP report ,2009

5.2.3.b Water supply

Backlog of water supply has been analyzed as back logs in source, distribution, treatment, and storage. The severity index has been arrived by taking the product of the values of backlog in source, treatment, storage, distribution, and quality of water.

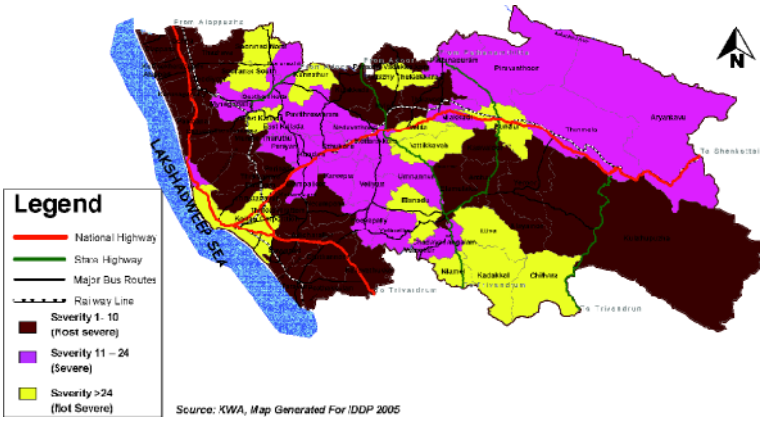


Figure 5.10: Map showing the backlogs of water supply in Kollam.

Source: IDDP report ,2009

5.2.3.c Pollution

Out of 18 Tonnes/day of Sulphur Dioxide (SO2) emission, major share is concentrated in Panmana Grama Panchayat (12.98 T/day). Panchayat (0.154 T/day). Out of 1.01Tonnes/day of Cl emission, major share is from Panmana LSGI (0.836 T/day) followed by Kollam Corporation (.008 T/day). Out of 99.11 Tonnes/day of total emission of major pollutants namely Particulate matter, oxides of nitrogen, Sulphur dioxide, Carbon monoxide and chlorine and its compounds, the total share is highest in Panmana Grama Panchayat (17.21 T/day). (IDDP , 2009)

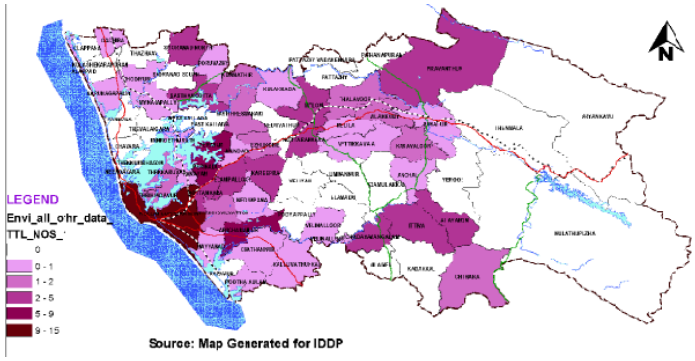


Figure 5.11: Map showing the LSGs with high air pollution in Kollam.

Source: IDDP report ,2009

Out of 18 Tones/day of Sulphur Dioxide (SO2) emission, major share is concentrated in Panmana Grama Panchayat (12.98 T/day). Panchayat (0.154 T/day). Out of 1.01Tonnes/day of Cl emission, the major share is from Panmana LSGI (0.836 T/day) followed by Kollam Corporation (.008 T/day). Out of 99.11 Tones/day of total emission of major pollutants namely Particulate matter, oxides of nitrogen, Sulphur dioxide, Carbon monoxide and chlorine and its compounds, the total share is highest in Panmana Grama Panchayat (17.21 T/day). (IDDP , 2009)

5.2.4 Disaster Management Plan Kollam 2015

The chemical Hazard Prone Area in Karunagapally Taluk is 179.275 ha i.e., KMML industrial area and mining companies in Panmana Grama Panchayat. (Disaster management Plan , 2015)

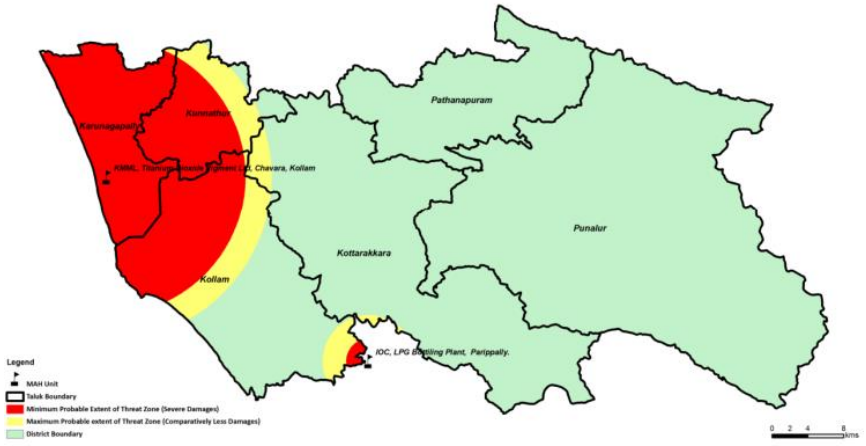


Figure 5.12: Map showing the chemical susceptibility map of Kollam.

Source: Disaster management plan,2015

5.2.5 National Green Tribunal

7 wards namely Chittoor, Mekkad, Kalari,Kolam, Panmana, Ponmana and Porrukara of Panmana Grama Panchayat and Kovilthotam , Thottinuvadaku of Chavara Grama Panchayat at the western and northern sides of the unit. The Hon'ble National Green Tribunal (NGT) Principal Bench, New Delhi based on a letter petition received from Sri. Padmakumar regarding pollution caused by M/s. Kerala Minerals and Metals Limited

(KMML), situated in Chavara, Kollam District, Kerala. The Hon'ble NGT had constituted Joint Committee for study of site. The fishing communities impacted by IREL's black sand mining include Cherusherybhagom, Thattashery, Karithura, Puthenkovil, and Kulangarabhagom in the Chavara Grama Panchayat.

When specifically planning for an Industrial area; service villages, hamlets, and rural settlements to be provided with a buffer of 100-300 meters for the expansion of the settlements, for health & safeguard point of view. The wards at an extent of 1 km from the industrial area and based on a pilot study of site and focus group discussion the planning area is delineated for the further site study.

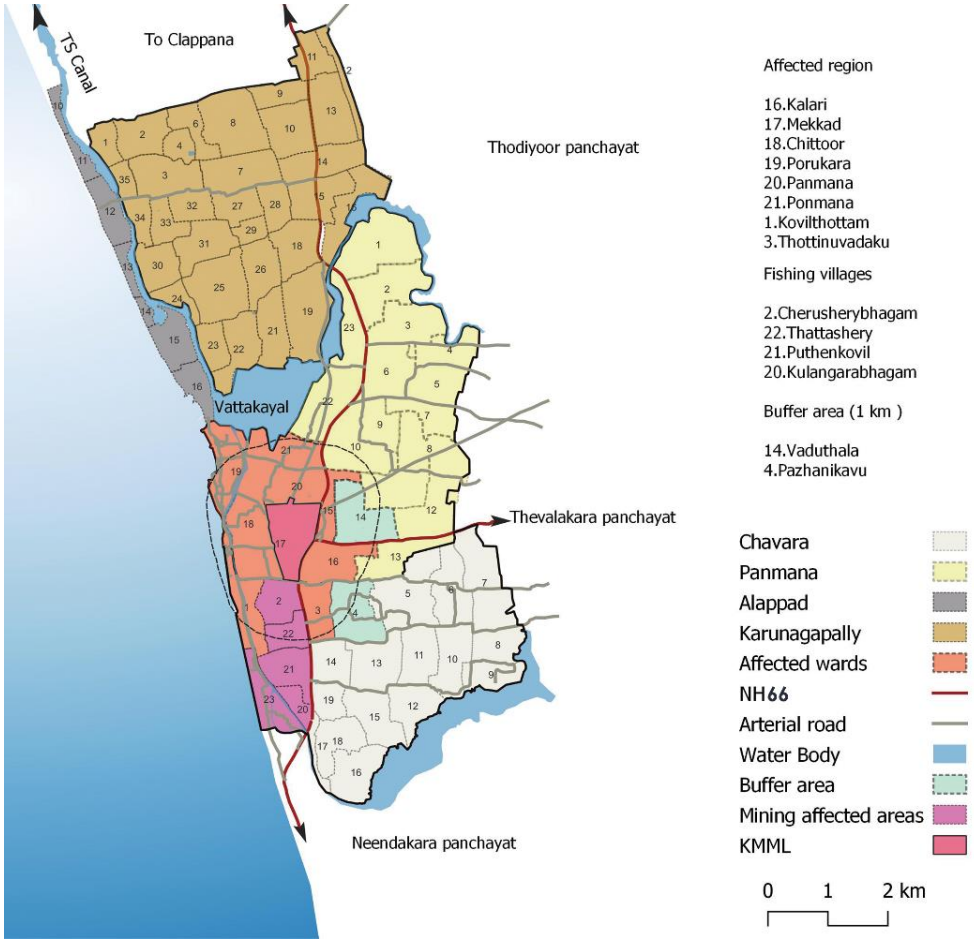


Figure 5.13: Map showing the delineated study area.

Source: Author generated using Qgis , 2023

5.3 Primary survey methodology

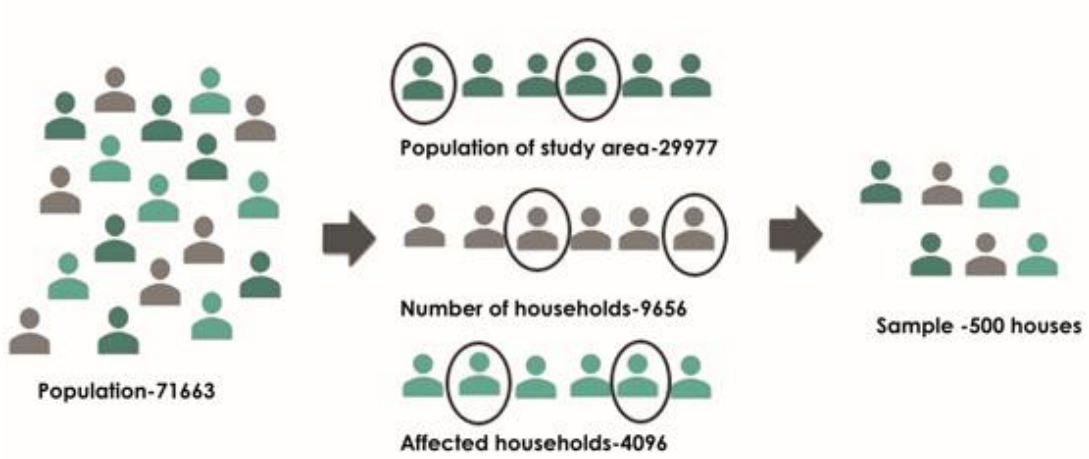
1.Need of primary survey

Secondary data indicates the need for planning in the industrial area. The main study is to assess the effect of industry on the public and what are the key concerns of the public in the area and develop plans based on the requirements of people through primary survey. The source of information of research, discussion with local panchayats, affected people, officials of state government relevant offices, literature survey and field studies. Primary and secondary data on air, noise, water, soil, traffic, land use, ecology and socio economics were collected and analyzed for study.

2.Type of survey

Stratified sampling

The planning in bottom to top approach holistically delves into the intangible aspects of human settlements used in spatial planning. The planning strategies for the affected population due to KMML industry is the targeted sample data. The stratified sampling is used because the target is to identify the issues of heavy industry KMML, and how it affects the community surrounding region. The affected households are 4096, 12 % of the affected household 500 sample study is conducted in the 16 wards nearer to industrial area.



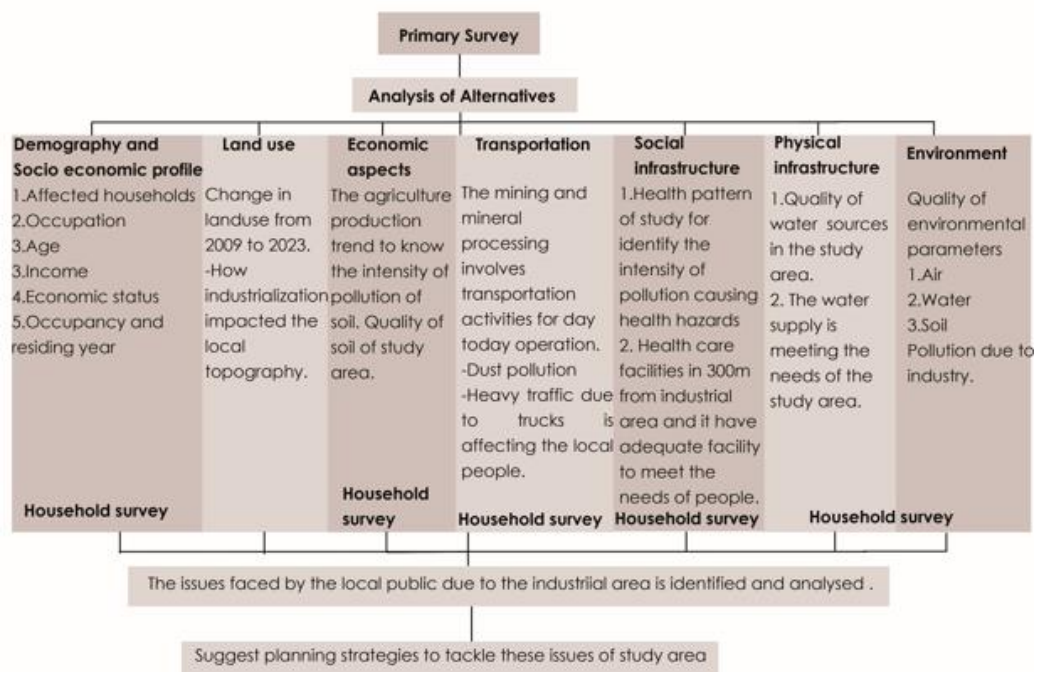


Figure 5.14: Primary survey methodology

Source: Author generated. March 2023

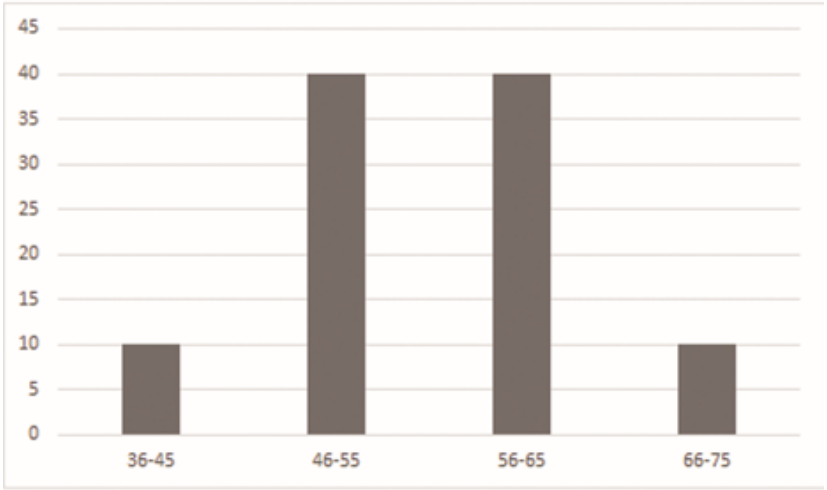


Figure 5.15: Chart showing the respondents.

Source: Primary survey, March 2023

The age of the population is of paramount relevance since it affects the accuracy and completeness of the necessary information. Age also affects maturity, which gives knowledge and analytical skills needed to comprehend the numerous problems at hand. All the respondents that were chosen for the interview were family heads. The chart below shows that the age groups of 36–45 and 66–75 years were followed by 46–65 years for the majority (40%) of the respondents.

The survey was conducted with the prime intention of assessing the effect of mining among the people residing at the site as well as the people inhabited surrounding industrial area, Data for the empirical study was collected mainly through interview schedule. The schedule elicited information on areas such as socio-economic and demographic backgrounds of projected affected families in the and data on mining and transportation of sand to the separation plant of KMML, problems faced and perceived by the projected affected families; socio-economic impact and other driving forces involved in the area. Wherever possible the responses were pre-coded to facilitate easy tabulation and analysis. Most of the questions in the schedule were closed questions.

CHAPTER 6 SITE STUDY

This chapter explains the detailed study of the Socio-economic profile and demography, land use, Economic, Transportation, social and physical infrastructure, Environmental aspects, and their associated impacts that would arise due to the heavy mineral processing industrial area KMML in delineated study area.

6.1 Socio-economic profile

6.1.1 Economic status

It is seen that majority (66%) of the inhabitants belonged to the category of APL followed by Below poverty class (34%). This shows that their condition of their survival.

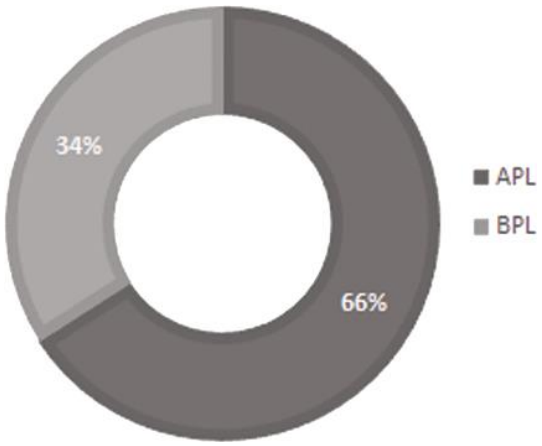


Figure 6.1: Chart showing the economic status of study area.

Source: Primary survey, March 2023

6.1.2 Occupancy

Data was gathered and questions were given to determine whether families rent or own their homes. It is evident that 100% of respondents said their family were housed in their own structure.

Nature of ownership

90 percent of the respondents reported that the nature of ownership is inherited followed by purchased (10%). This shows that almost all of them have availed the land as inherited. Their families have been living here for years. Traditionally, they are living there and engaged in their own occupation (70%). And they are socially and culturally accustomed to this area. The sentimental attachment of the people of this soil necessarily compels them to stay there. So, care and caution may be taken while evacuating them from this area.

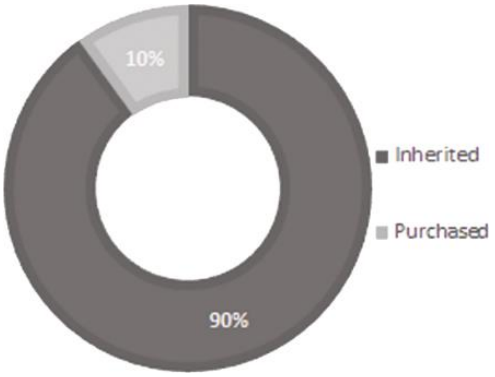


Figure 6.2: Chart showing the nature of ownership.

Source: Primary survey, March 2023

The majority (70%) of the occupants in the present area live for 20-25 years, followed by 10% of people residing for 15-20 years and 20 % people residing for 10-15 years.

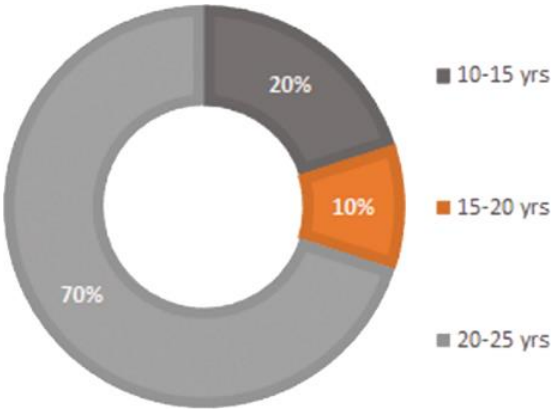


Figure 6.3: Chart showing the duration of occupancy.

Source: Primary survey, March 2023

6.1.3 Housing

Most (80%) of the houses have concrete roof followed by tiled roof (10%) and asbestos 10%.

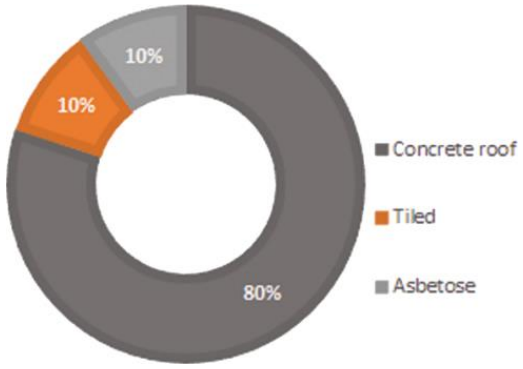


Figure 6.4: Chart showing the type of housing.

Source: Primary survey, March 2023

6.1.3.a Market value

It is essential to understand the market price of the land in the area to decide the actual compensation to be provided to the landowner by KMML. From the opinion of the respondents, it is seen that the majority (50%) reported that their land value is about Rs. 100,000-1,25,000/- per cent followed by Rs. 50,000/- (30%) and Rs.50,001-75,000/- (20%). KMML needs to keep this figure in view while offering R&R package.

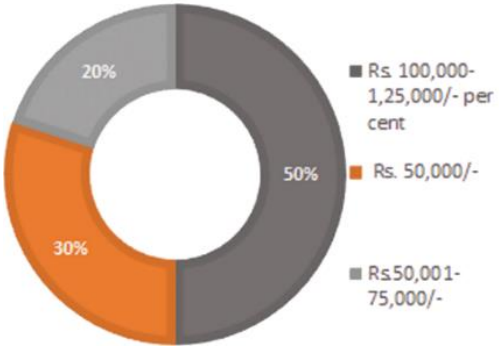


Figure 6.5: Chart showing the market value of land.

Source: Primary survey, March 2023

6.1.3.b Density and frequency of dwellings

The analysis of the data showed that the majority (60%) of the individuals informed that the density and frequency of the dwellings are dense followed by spares (40%).

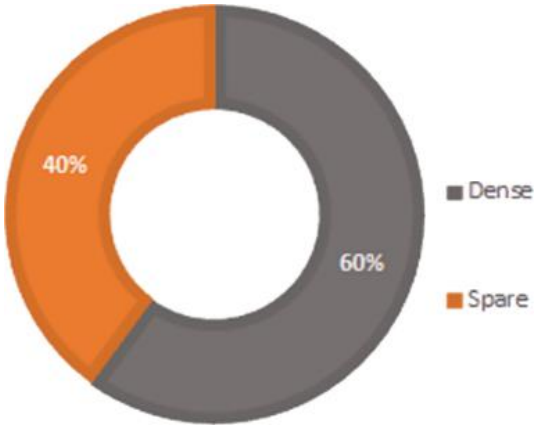


Figure 6.6: Chart showing density and frequency of dwelling.

Source: Primary survey, March 2023

6.2Demography

6.2.1 Population and its growth pattern

As per the 2011 census, Chavara and Panmana are the census towns. The population of Chavara is 42655 and Panmana is 29008. The population of study area 16 wards is 29977 persons. The number of females is 13185 and males is 12302. The area of delineated for study is 969.6324 ha.

6.2.1.a Population density

The population density is high in wards Thattashery (22) and Kolam (15) and low density in wards Panmana (20), Puthenkovil (21) and Kulangarabhagom (20) due to industrial pollution. Puthenkovil and Kulangarabhagom are fishing villages.

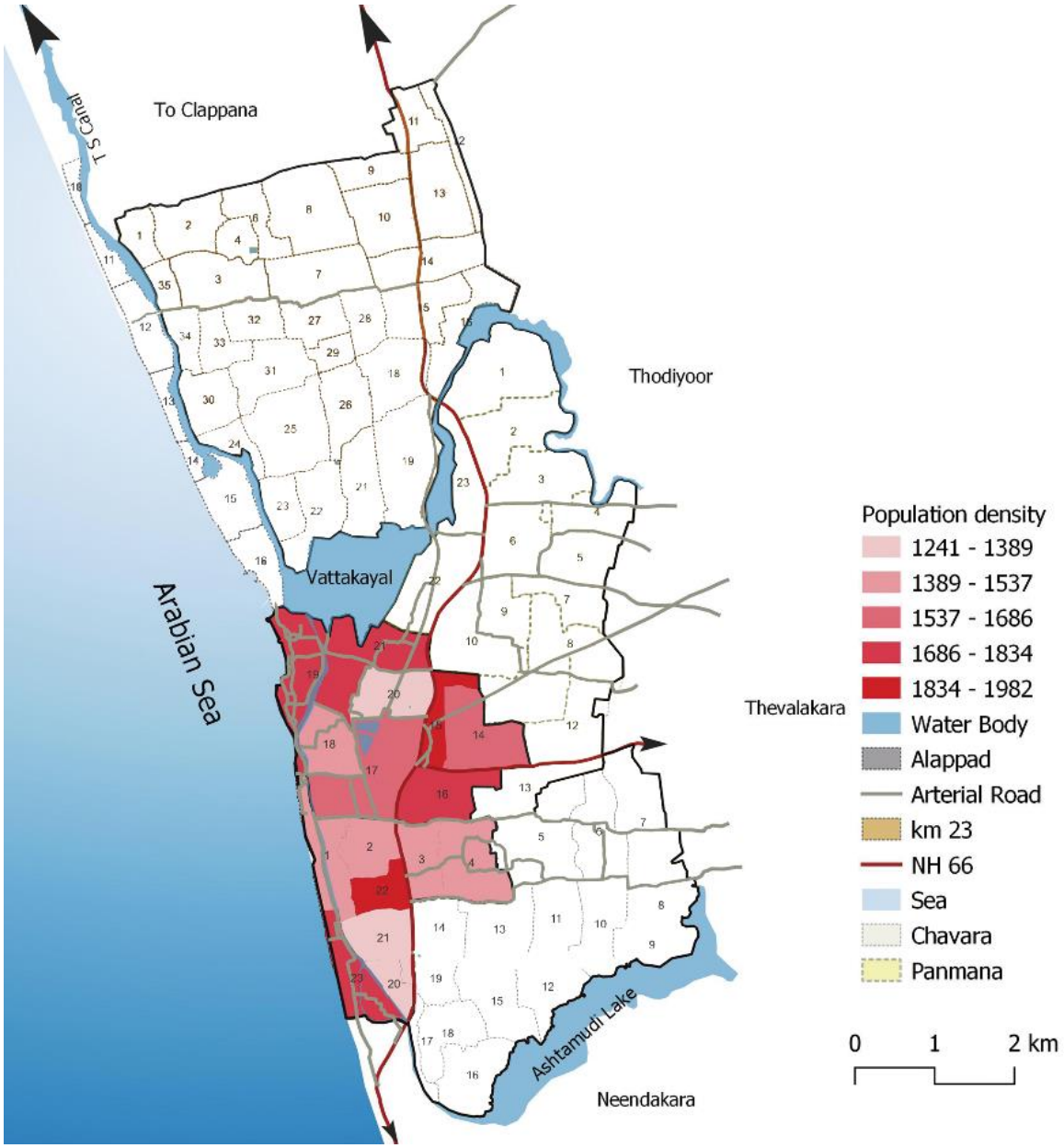


Figure 6.7: Map showing the population density of study area.

Source: Author generated using Qgis with reference to Sate Election commission ,2011

6.2.1.b Childrens population

The 1-18 age range the children population is high in Porurkara ward in Panmana Panchayat. The children's population (0-6 age) is increasing trend in Chavara and Panmana

panchayat so need more health infrastructures to meet disability due to pollution of industries.

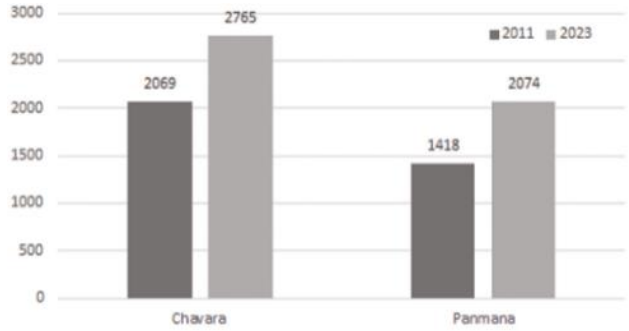


Figure 6.8: Chart showing the children's population of 0-6 age group.

Source: District census handbook,2011

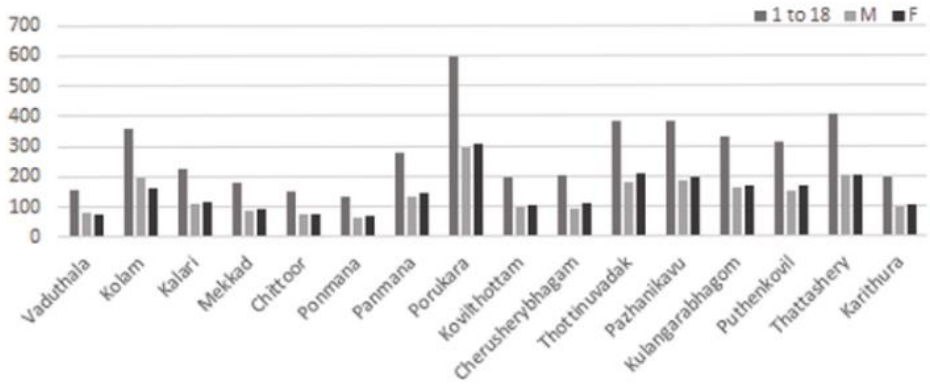


Figure 6.9: Chart showing the ward wise children's population.

Source: Community health center Chavara and Panmana, Primary survey, March ,2023

6.2.1.c Population change

The annual population change (2001 to 2011): - Panmana is - 0.050% and Chavara is 0,28%. In Panmana negative growth due to pollution of industry. The environmental degradation, lack of water for meeting basic needs, social unrest due to industrial pollution is the reason for negative population change.

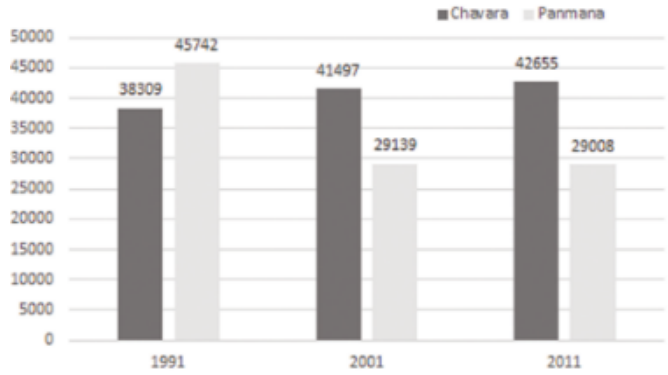


Figure 6.10: Chart showing the population change.

Source: District census handbook,2011

6.2.2 Household size

The number of households is more in wards near to industrial area that is Mekkad, Kalari and Kolam. The average household size was 4.04. The number of households is increasing in Chavara and Panmana.

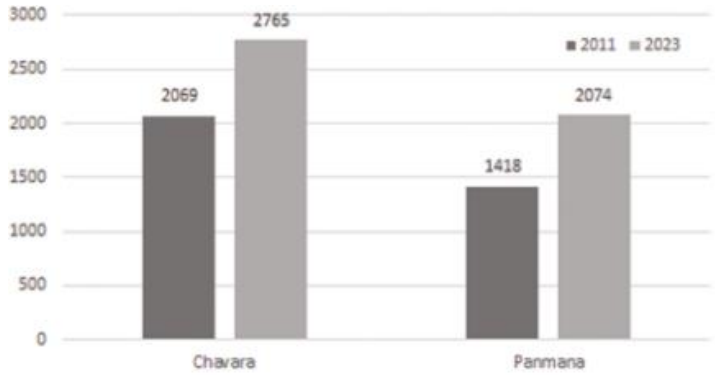


Figure 6.11: Chart showing the change in household.

Source: District census handbook,2011

Affected households of study area

The coastal wards have a smaller number of households most of the houses evicted due to mining activities. The most affected wards are Chittoor, Mekkad and Panmana of Panmana

panchayat. Kovilthottam (1 ward) is evicted only 3 houses remaining and residents is shifted to Mekkad and Cherusherybhagom due to sand mining.

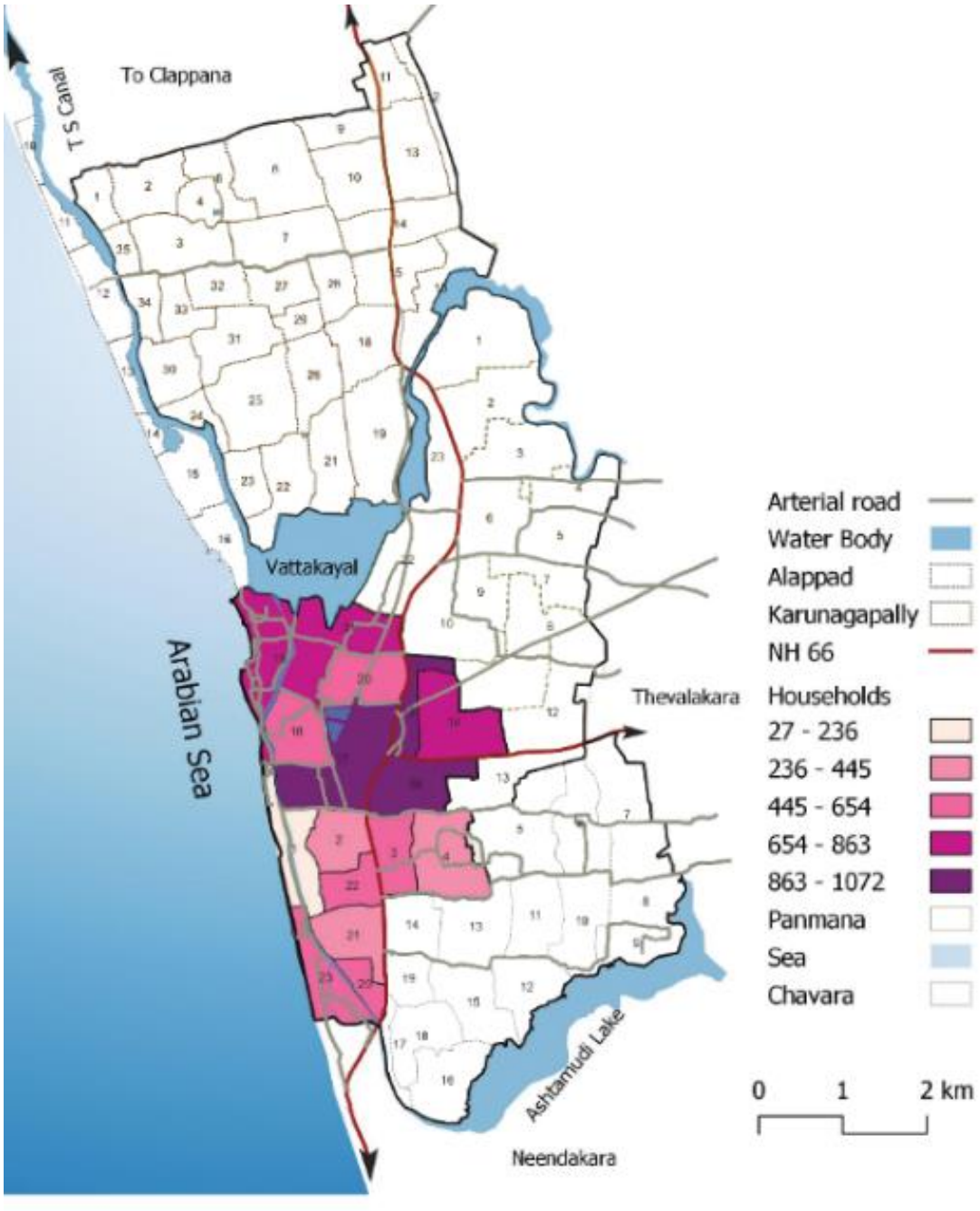


Figure 6.12: Map showing the population density ward wise.

Source: Author generated using Qgis with reference to Local self-government Department Chavara, Panmana,2023

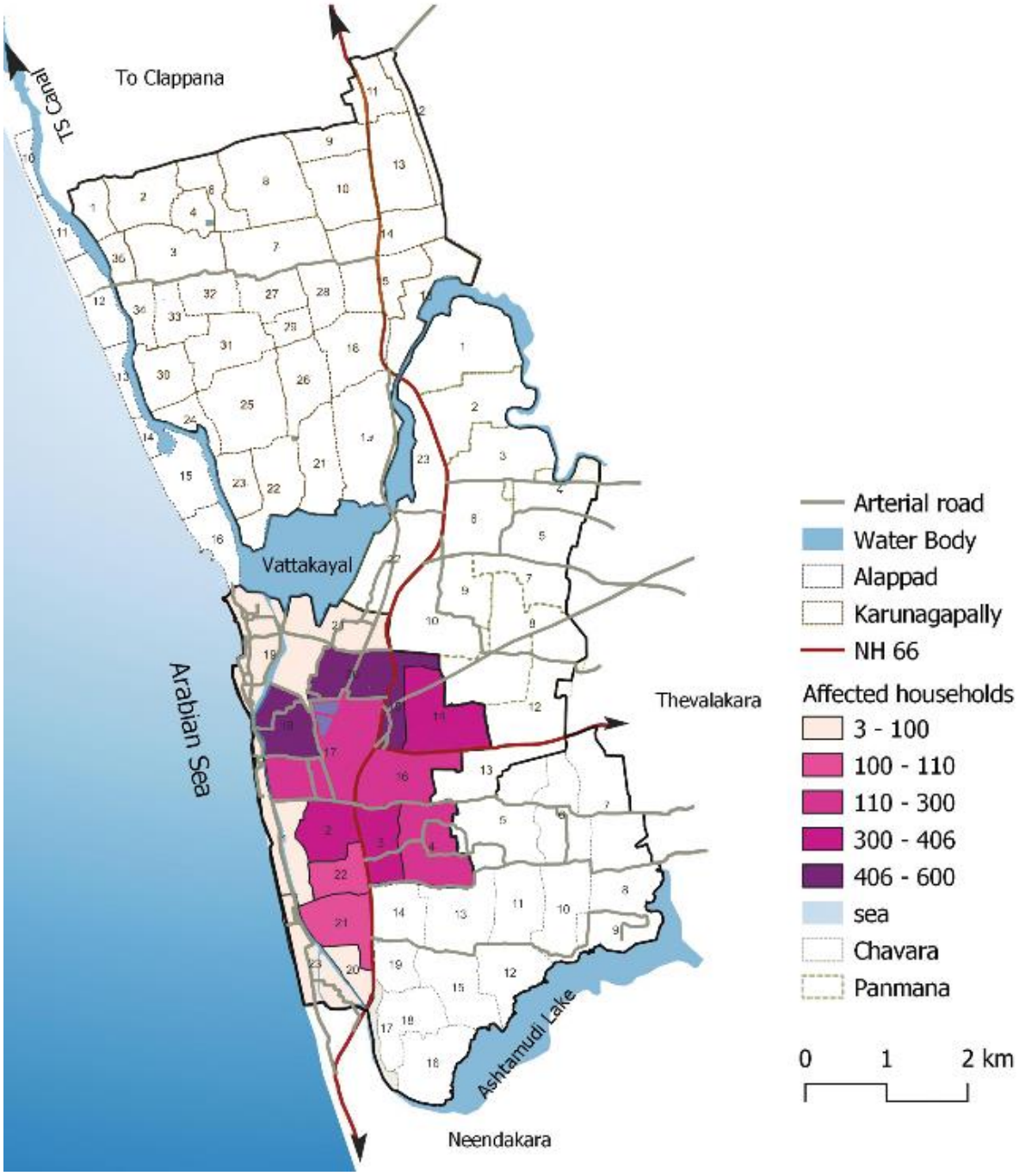


Figure 6.13: Map showing the affected wards.

Source: Author generated using Qgis with reference to Local self-government Department Chavara, Panmana,2023

6.2.3 Occupational structure

It is essential to know the occupation and means of livelihood as this helps while formulating the policies and programmes of rehabilitation and resettlement. Marginal workers (68%) are high in contribution to the economy in the Chavara panchayat. Marginal workers (69%) are the highest contributor to the economy in Panmana panchayat.

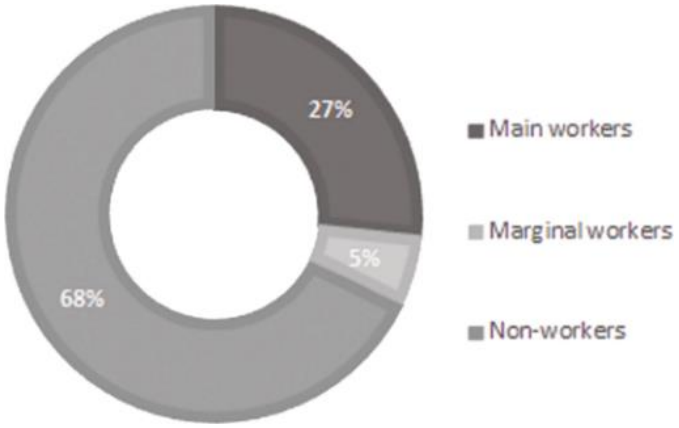


Figure 6.14: Chart showing the workers classification of Chavara.

Source: District census handbook,2011

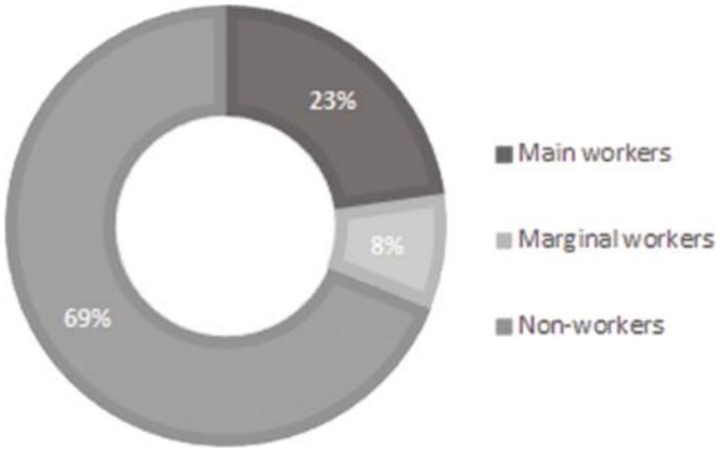


Figure 6.15: Chart showing the workers classification of Panmana.

Source: District census handbook,2011

The household industry with the highest percentage of workers in Chavara (4.19%) and has the lowest percentage of agricultural laborer's (2.46 %) in Kollam district that shows the

occupational shift primary to secondary sector. In Panmana other workers (8195) are high in concentration and followed by agricultural labor (379). The household industry workers are less.

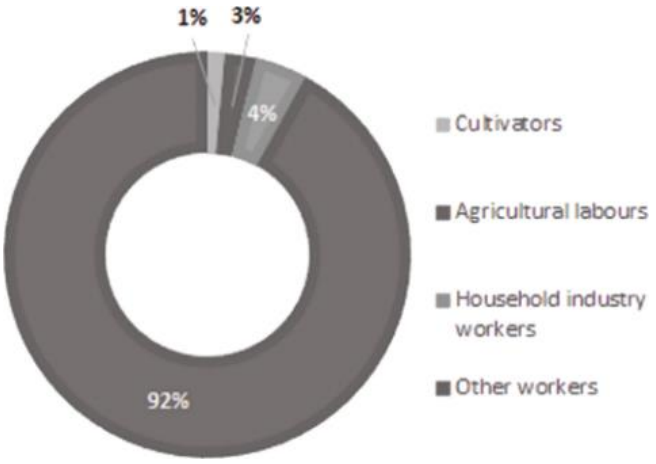


Figure 6.16: Chart showing the workers classification of Chavara.

Source: District census handbook,2011

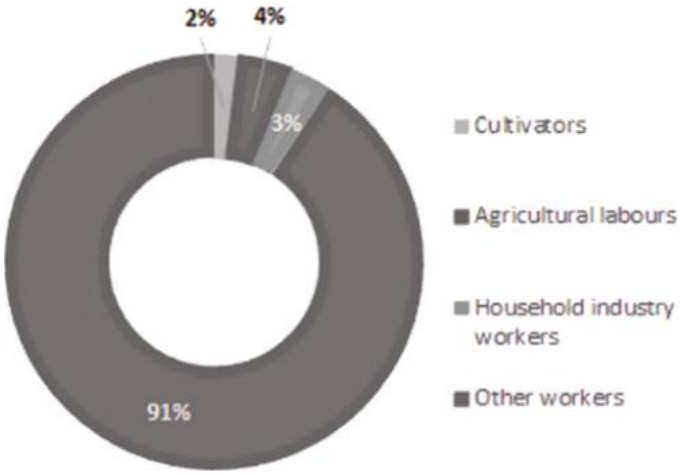


Figure 6.17: Chart showing the workers classification of Panmana.

Source: District census handbook,2011

Its total employee strength of 1770, 1067 are local people who were affected by the project. This represents 60% of the total employee strength. LAPA (Labor pension act) construction

and labor cooperative society ltd provide local workers to KMML for temporary works. This indicates the local people depend on industry for occupation.

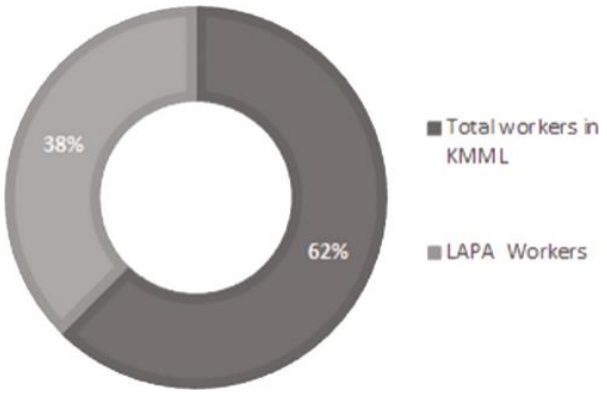


Figure 6.18: Chart showing the local workers in KMML.

Source: (KMML, 2022)

The fisherfolks in Kovilthottam, Thattashery, Cherusherybhagom is 336, Kalari, Mekkad , Ponmana is 312 and Karithura , Puthenkovil ,Kulangarabhagom is 279. The sand mining workers of India Rare Earth limited (dredging and mineral separation unit) is 427 (wage - 1522/day).

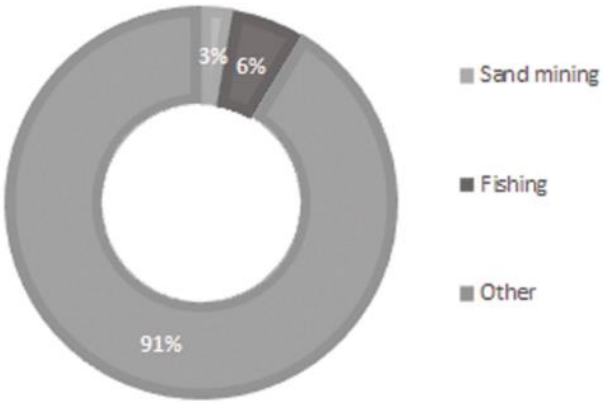


Figure 6.19: Chart showing the main occupation of study area.

Source: Primary survey March 2023

The fish landings in Kovilthottam -157, Ponmana-46 and in Karithura 1398 in the delineated study area. Neendakara harbor is in 22 km distance from KMML.

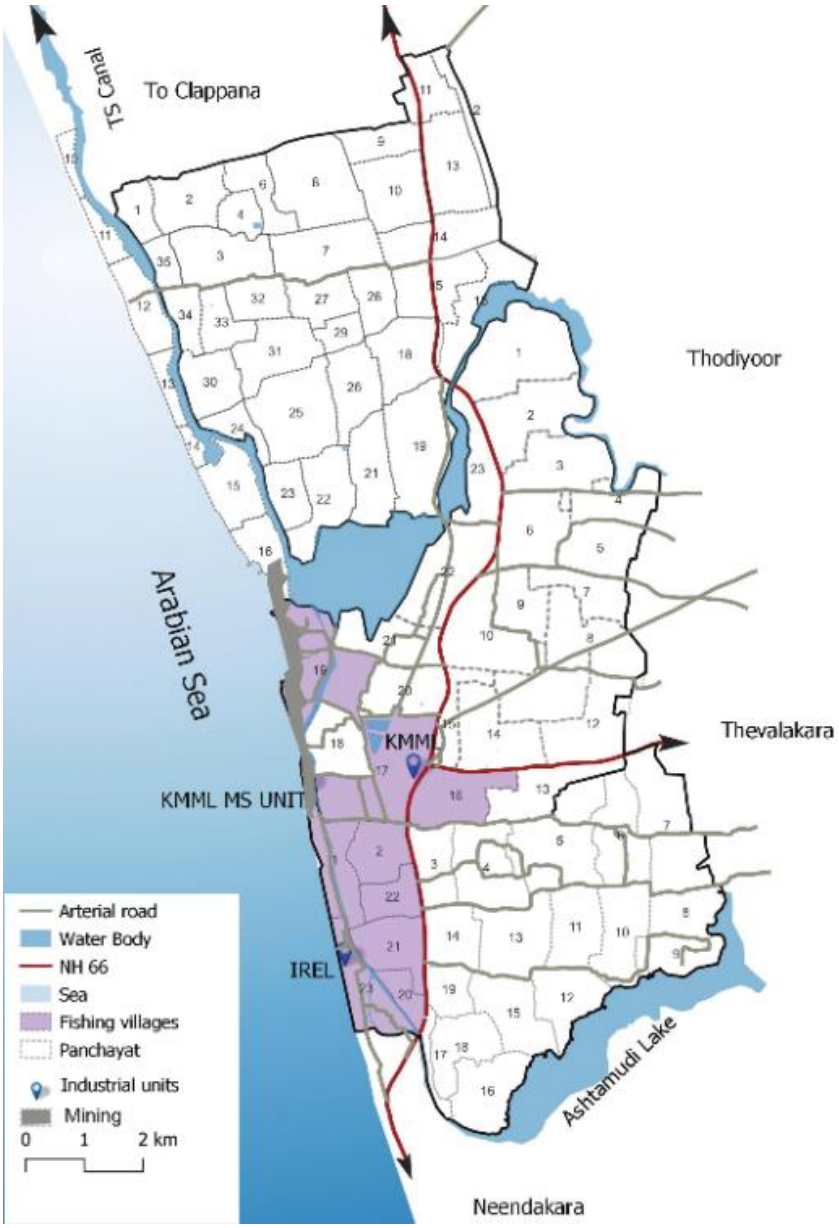


Figure 6.20: Map showing the fishing villages of study area.

Source: Author generated using Qgis with reference to Kerala State Coastal area development corporation Ltd,2023

6.2.4 Literacy

There is a drastic difference between educated and uneducated people. It contributes a lot to sophistication of behavior and understanding of issues. This shows that they are average

educated and literate and able to analyses the issues. The planning for educational institutions at time of resettlement and rehabilitation.

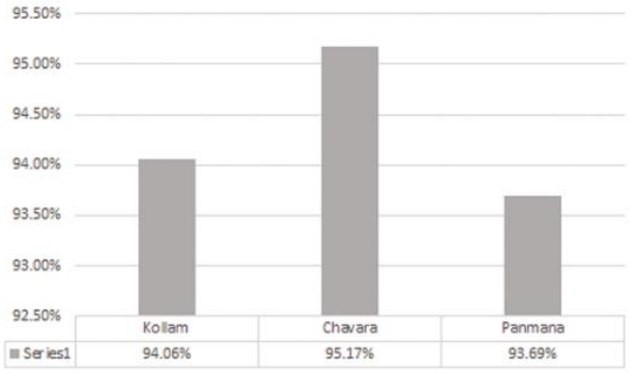


Figure 6.21: Chart showing the literacy of study area.

Source: District census handbook,2011

6.2.5 Sex ratio

Urban sex-ratio of the Kollam district (1096) and the lowest in Panmana (CT) (1058). The rural child sex ratio (0-6 age) is lowest in Chavara (946). The decline is due to the exposure to chemicals.

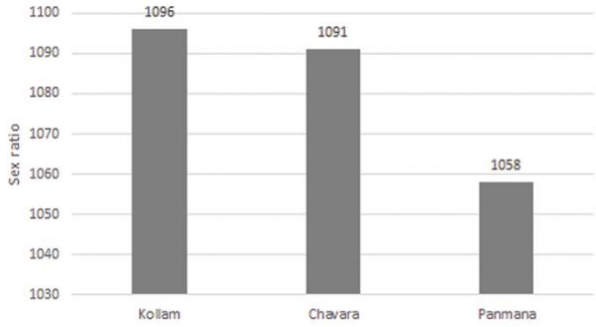


Figure 6.22: Chart showing the sex ratio of study area.

Source: District census handbook,2011

6.2.6 Inference

While planning, it is important to consider the pollution-related decrease in population density in coastal wards and wards close to industrial areas. The number of households is

high near the industrial area's wards 17, 16, and 15, and the number of impacted households is high in 18, 20, and 15, thus it is important that these households be relocated away from the industrial area. It is essential to know the occupation and means of livelihood as this helps while formulating the policies and programmes of rehabilitation and resettlement. The main occupation pattern is fishing, mining, LAPA, and other workers. The agriculture labor is decreasing indicates the occupational shift from primary to secondary due to industrialization of the area. is Controlling the pollution-induced negative population increase in Panmana Panchayat is necessary. As there are more children, any birth defects brought on by chemical radiation are a cause for concern. Given the high prevalence of literacy, education is a crucial aspect.

6.3 Land use

Development needs of the future population in each sector - be it physical, economic, or social - are addressed in the Integrated district development Plan of Kollam. The Plan identifies agriculture, animal husbandry, fisheries, and mining & geology as the potential development sectors of the district.

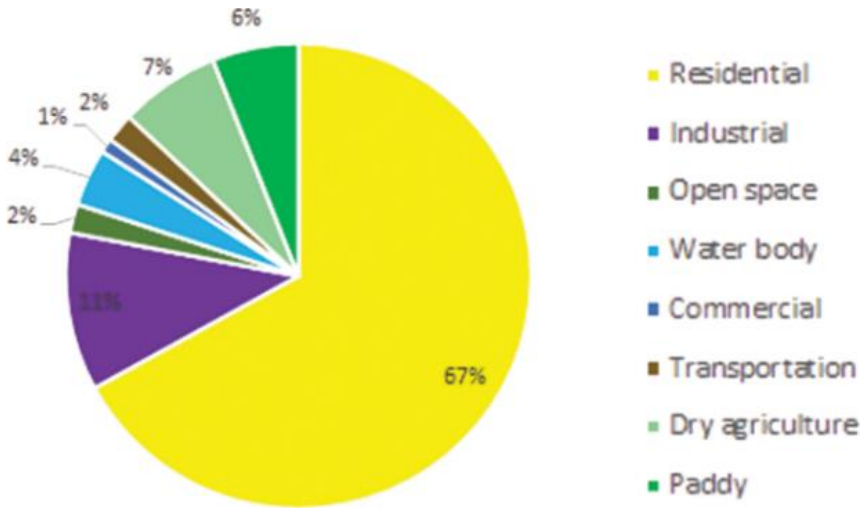


Figure 6.24: Chart showing the breakup of Chavara and Panmana 2009.

Source: IDDP report ,2009

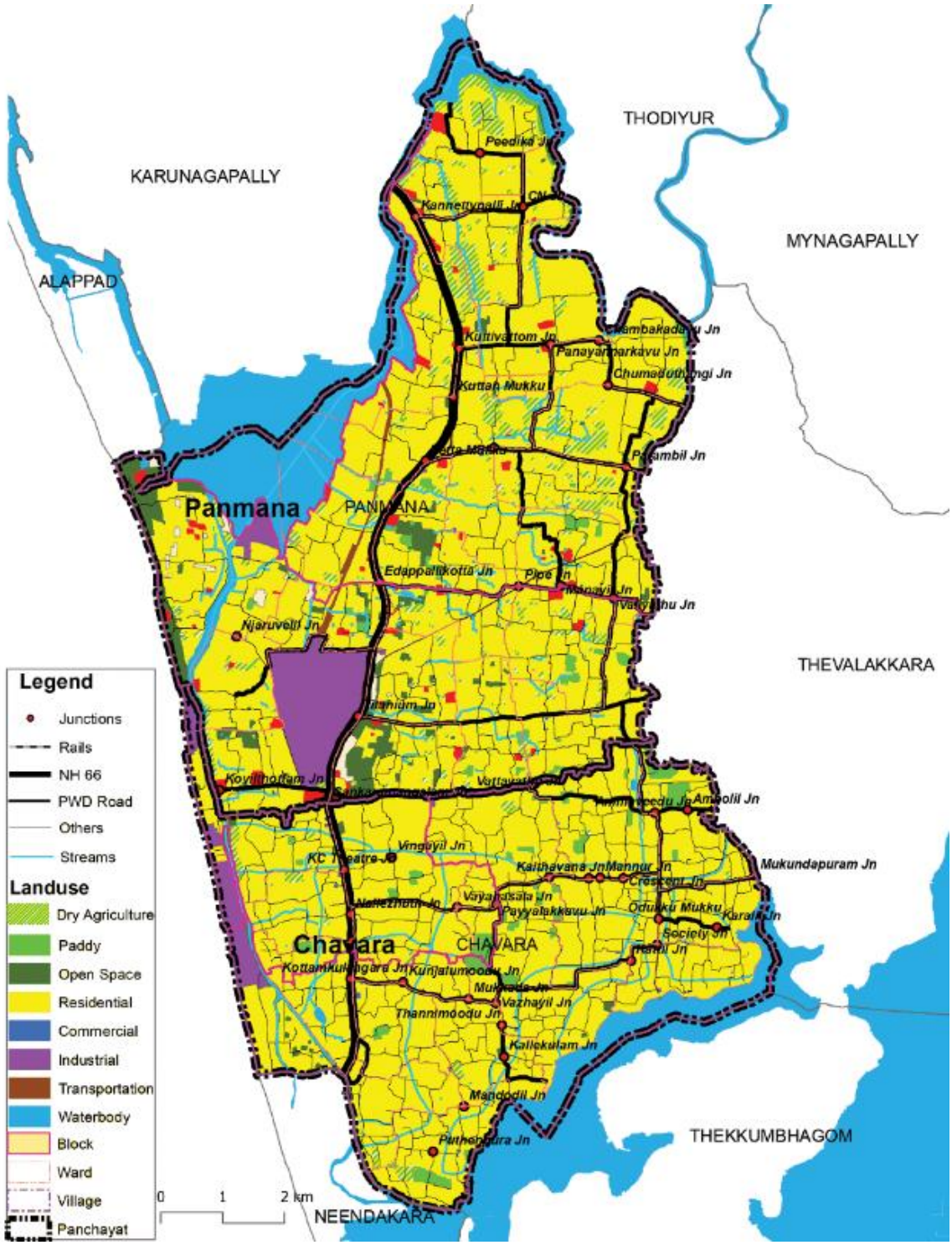


Figure 6.23: Map showing the land use of study area for the year 2009.

Source: IDDP report ,2009

In the 2009 land use breakup, the residential area is 67 %. It decreased in recent years due to mining, health hazards and pollution due to KMML and IREL like mineral extraction industries to 62%. The agricultural land in 2009 is 13 % but it decreased to 5% due to uneven developments. The water bodies decreased from 4% to 2% in recent years due to pollution of streams and ponds due to high iron oxide sludge content industry. It affected the drainage condition and availability of natural source of water supply in the area. In 2023, the Chavara and Panmana panchayat the residential concentration (62%) is high. The total vacant land is 45.55 hectares. In delineated study area vacant land is 122. 39 hectares and 16.53 hectares of acid fields.138.89 hectares of land are underutilized due to industrial pollution needed to revive through long term plans.

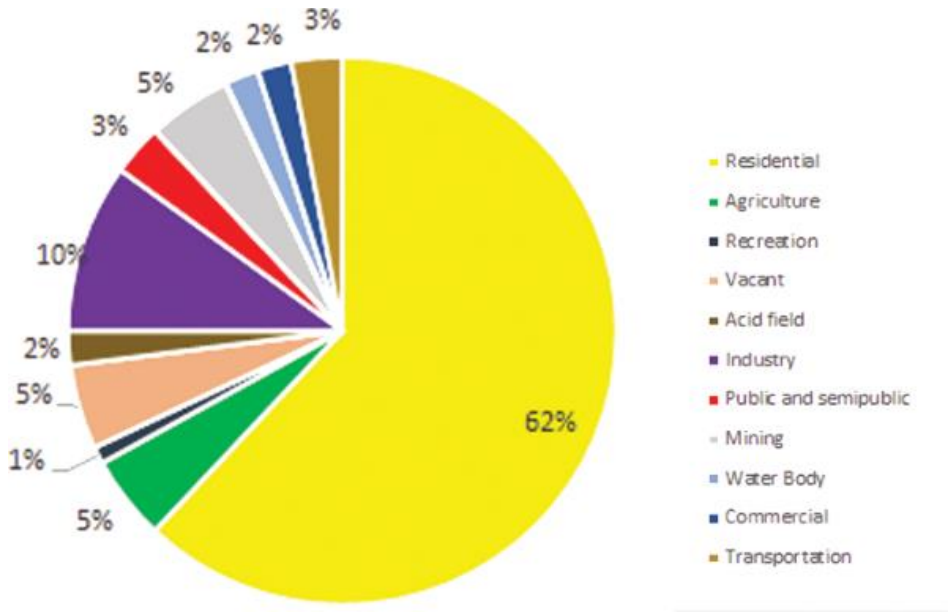


Figure 6.25: Chart showing the breakup of Chavara and Panmana 2023

Source: Author generated ,2023

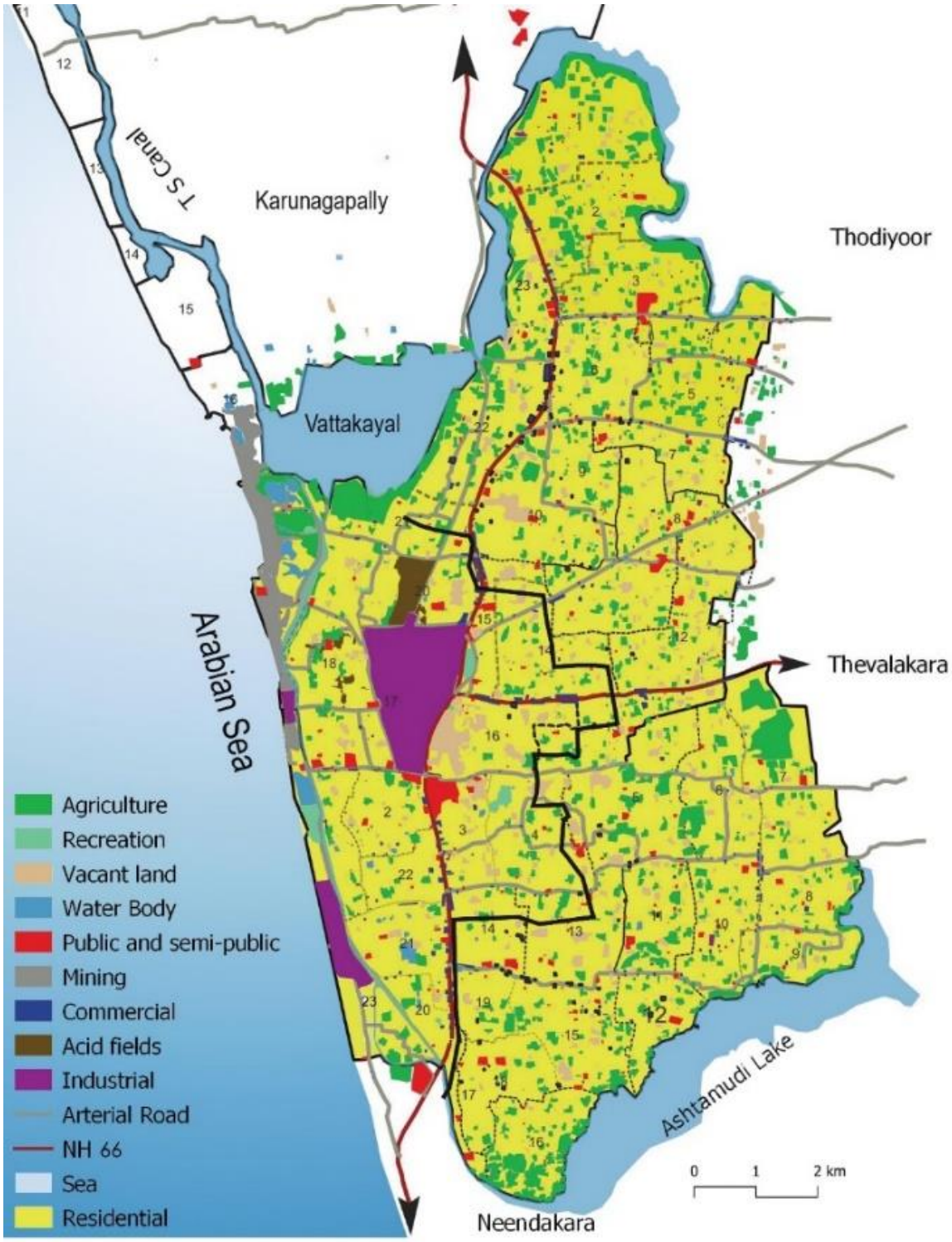


Figure 6.26: Map showing the land use of study area,2023.

Source: Author generated using Qgis 2023

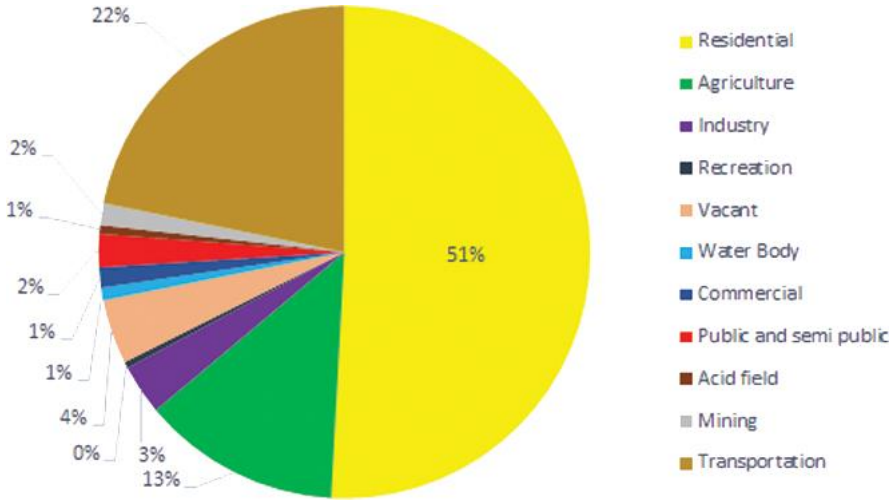


Figure 6.27: Chart showing the land use breakup of study area,2023.

Source: Author generated ,2023

In the defined study area in 2023, the residential area's concentration is higher around the industrial area by 51%. Along the national highway is where most of the commercial (1%) and industrial (3%) area is located. Due to the presence of acids in the soil brought on by the heavy metal effluents released from the industry KMML, the agricultural land is concentrated in the mid and high regions of the panchayat and is higher (13%) near water bodies like Vattakayal in the delineated study area than it is in coastal wards and wards close to KMML. When compared to open space (2%) of land use of 2009 prepared by IDDP of Kollam, the vacant land increased to 4% due to vacating of residents due to health hazards. Acid fields (1%) and mining (2%) in the study region replaced and lowered agricultural concentration. Coconut is one of the major crops of delineated study area, but its major portion is destroyed due to acid fields. The reduced coastal belt due to mining can push the marginalized section of society in the region more vulnerable to floods.

6.3.1 Inference

The economic share of study region is high due to major commercial and industrial concentration. This leads to uneven development distribution. The mineral extraction industries in the region pose a public health hazard causing vacated residential

concentration around the zone. The agricultural area is mainly concentrated in the mid and high regions of the panchayats. Towards the coastal belt the agriculture concentration is low. The reasons for this are the salinity of the water, mining and due to polluted water issues due to the heavy industries like KMML and IRE, which makes the ground water unsuitable for the agricultural purposes and coastal area more vulnerable to floods. The major occupational structure has also changed over time from agriculture to other work types. The industrial belt is along the national highway.

6.4 Economic aspects

6.4.1 Industrial Profile

The Kerala Minerals and Metals Limited' (KMML) is a Government of Kerala undertaking Public Sector Unit operating as a flagship unit and constantly generating profits & paying dividends to the exchequer. World TiO2 pigment installed production capacity was about 7.4 million MTPA and demand of approximately 6.5 million MT. Global TiO2 demand is expected to grow to 8.1 million MT by 2025.Globally, 80 percent of the world's TiO2 consumption is in coatings, plastics, and paper whereas in India these applications amount to 86 %. (Master Business plan -KMML 2021-2031, 2021)

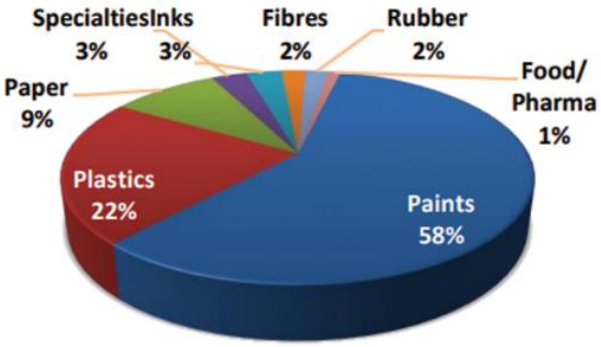


Figure 6.28: Chart showing the economic importance of KMML.

Source: Master Business plan -KMML 2021-2031

The industrial area is 94.69 hectares of land in delineated study area. It constitutes 3% of the study area. One of the major contributors of state economy.

Table 6.1 Table showing the worth of KMML.

Source: Master Business plan -KMML 2021-2031

Particulars	2016-17	2017-18	2018-19	2019-20	2020-21
TiO2 Production (in MT)	31256	34120	33514	30217	30444
TiO2 Sales (in MT)	37747	31867	35036	31000	31356
Turnover (Rs. in Lakh)	72704	74058	82970	71252	78200
PBT (Rs. in Lakh)	2882.12	18110	16464	4359	11200
PAT (Rs. in Lakh)	2194	12956	11662	3120	8400 (Prov)
Current Net worth of the Company is Rs. 880 Crores					

6.4.2. Occupational skill

It is very important to know the occupational skill of the people in the study area as this will help in framing effective Resettlement and Rehabilitation policies for them. This skill can be utilized by industry. They cannot depend on their limited land holding for sustenance, especially when the fertility of the soil is also diminishing due to mining. In short, land utilization for agricultural purposes is insignificant. The people in the area have different occupational skills but the majority of them are well versed in fishing only.

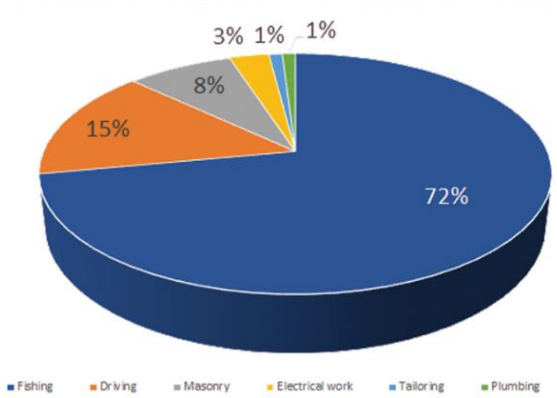


Figure 6.29: Chart showing the occupational skill.

Source: Primary survey March 2023

6.4.3 Agriculture profile

Agriculture concentration is high near water bodies of study areas such as Ponmana (19), Porurkara (21) and Karithura (23). The wards surrounding industrial area have less concentration of agriculture. There was no agriculture and cent percentage also indicated that they had no agriculture except coconut trees. This is mainly because of the reason that they have limited land and due to mining the fertility of the land has deteriorated. The core zone soil is basically sandy soil.

The mining will involve extraction of this sandy soil and dumping back the tailings in the mined-out areas. Since the heavy mineral extraction is a simple physical process, the sand which is dumped back will not differ chemically from the premising sand except that the heavy minerals are no longer present. The physical changes which will occur will be minor and will have no lasting impact. Mining will involve cutting down coconut trees leading to loss in coconut production. These trees, if required, can be replaced by new saplings of improved variety to improve the agricultural yield.

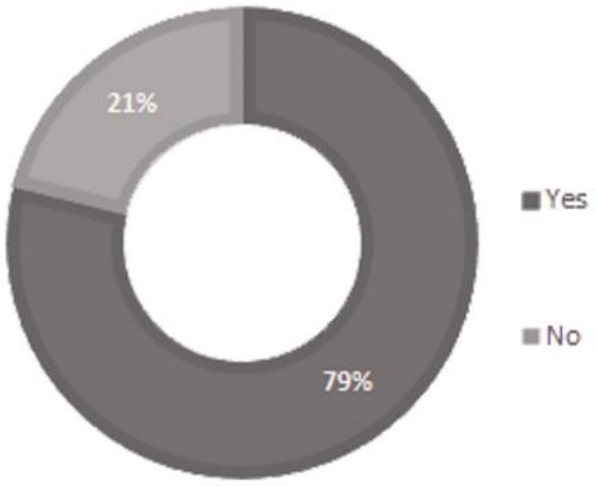


Figure 6.30: Chart showing the loss of agriculture.

Source: Primary survey March 2023

The acid fields in Chittoor (18 ward) from KMML and white sand deposit from IREL degraded the soil condition and loss of agricultural fields of public.

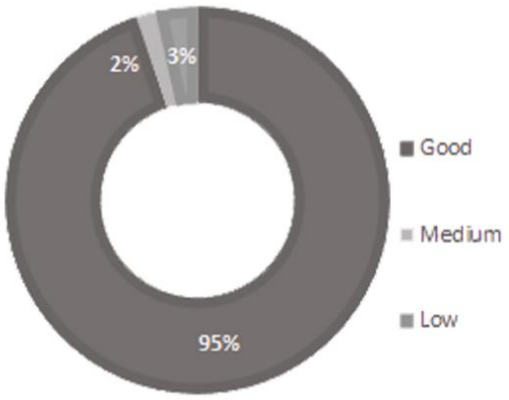


Figure 6.32: Chart showing the soil condition of study area.

Source: Primary survey March 2023

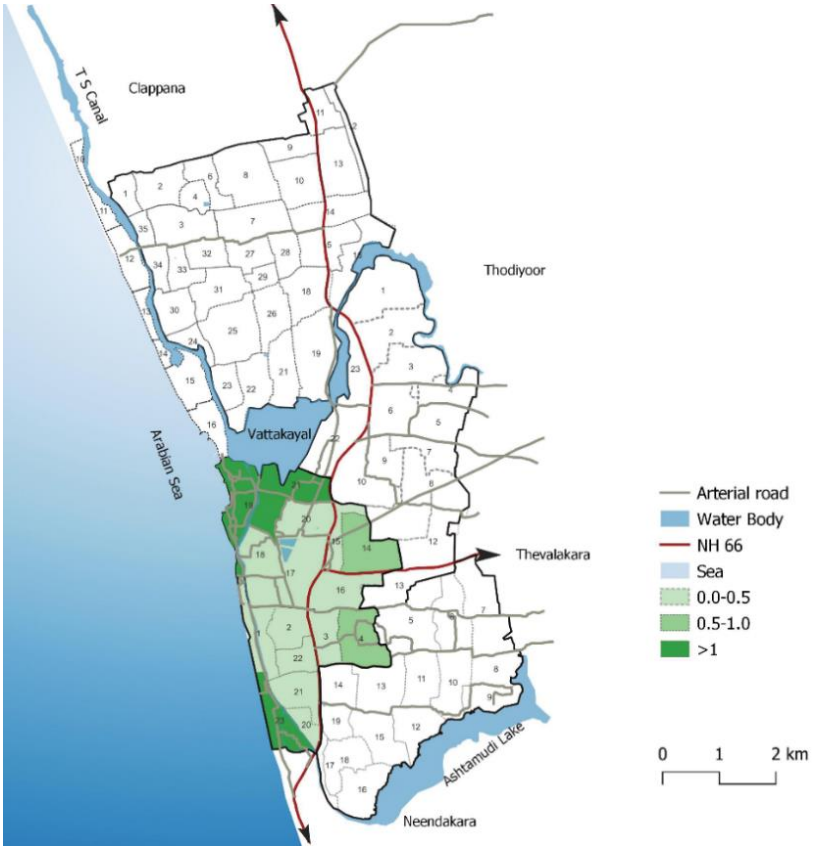


Figure 6.31: Map showing the agricultural concentration.

Source: Author generated using Qgis,2023

Figure 6.33: showing the white sand dumped after mineral separation.

Source: Primary survey March 2023

The 25-year analysis of the agricultural land in Panmana shows a decline in agricultural land and agriculture production. Low soil quality and damaged agriculture are present in the 6 wards of Panmana in the defined study area because of acid fields.

Table 6.2 Table showing the analysis of the agricultural area of Panmana.

Source: Local self-government Panmana, Primary survey, March 2023

	1996	2021
Total area	1685 ha	1685 ha
Total cultivable land	1500 ha	700 ha
Cultivated area	1200 ha	700 ha
Cultivable barren land	55 ha	7ha
Total area per year including recurrent cropping	1200 ha	700 ha
Agriculture labours	5250	5000

Figure 6.34: Destroyed coconut fields of Panmana.

Source: Primary survey March 2023

Table 6.3 Table showing the major crops and production of Panmana.

Source: Local self-government Panmana, Primary survey, March 2023

Crops	Area	Production
Paddy	3 ha	2.5 Ton/ha
Vegetables	10 ha	563
Banana	50 ha	60
Intercropping	50 ha	60
Pepper	20 ha	50

Table 6.4 Table showing the major crops decreased in Panmana.

Source: Local self-government Panmana, Primary survey, March 2023

Production increased crops	Production decreased crops
Vegetables	Paddy
Banana	Sesame
Intercropping	Pepper
Ginger, Turmeric	Tapioca

Table 6.5 Table showing the analysis of the agricultural area of Chavara.

Source: Local self-government Panmana, Primary survey, March 2023

Crop	2018	2023	Production
Rice	10 ha	5 ha	1.5 t/ha -3 t/ha
Coconut	943 ha	300 ha	50nuts/year- 80 nuts/year
Banana	5 ha	15 ha	10 kg /plant – 12 kg/plant
Pepper	8 ha	1 ha	1.5 kg /vine – 3 kg/vine
Vegetables	5 ha	20 ha	5t/ha-8t/ha
Tubers	16 ha	50 ha	2t/ha-5t/ha
Sesame	15 ha	5 ha	0.75 t/ha- 2t/ha

Production is decreasing; the cultivable land is decreased in Panmana. Agricultural laborers are also in a decreasing trend. The coconut fields of Chavara decreased from 943 to 300 ha. The decline in the agricultural sector is due to the degradation of soil and pollution of industrial effluents.

Coir Industry

The history of the beaches of Sankaramangalam and nearby areas is inextricably intertwined with the history of KMML. Precious, as was discovered in 1909 by the German scientist Dr. C. W. Schomberg who found traces of monazite in the sand flakes on the imported coir from Sankaramangalam. The beaches with a wealth of rare earth minerals became the center of scientific attraction. The traditional industry was coir manufacturing. Once the coconut fields became acidic, their productivity, area, and agriculture have all declined. The study area's wards 19, 21, and 23 have large concentrations of agricultural near to water bodies, while the remaining wards have lower concentrations of agriculture altogether. Intercropping, vegetables, ginger, and other crops grown in the study area in grow bags provided by

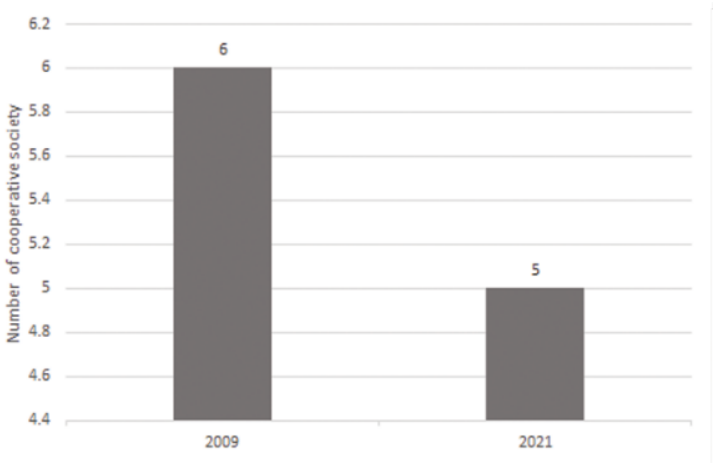


Figure 6.35: Chart showing the coir industry of Panmana.

Source: Kerala Institute of Labor and Employment (KILE),2021

6.4.4. Inference

KMML is a public sector unit undertaking by Government of Kerala its net worth is Rs 880 Crores, greater contribution to State economic growth. The mineral deposit of the Kollam coast containing Monazite is one of the richest in the world and reported to have the highest content of Thorium which helps to increase economy, but mining of these minerals causes

environmental degradation. Increase in industrial activities leads to pollution and diseases. The soil quality in the wards surrounding industrial area was deteriorated by the acid effluents from KMML and the mined sand after mineral separation known as White sand that has been dumped in coastal areas is bad for all crops. Coconuts are the main crop grown in the study area, and the LSGs are made of cocopeat and red soil.

6.5 Transportation

Trivandrum International Airport - 80.9 Km From KMML. Cochin International Airport - 145 km from KMML. Kollam - KottaPuram national waterway III (NH 3) connecting TS canal, Kallada, Ithikkara and Achenkovil River was an earlier mode of transport. -Major road connectivity is National Highway 66 (Kanyakumari-Panvel). Carriageway width varies from 10 to 15 meters. The roads in Oachira - Kollam stretch on NH-66, have dual lane carriageway width with 1.0m paved shoulders on both sides. Average daily traffic to the tune of 30000 Passenger Car Units (PCUs) per day.

Vehicle population

Table 6.6 Table showing the vehicle population.

Source: National Transportation Planning and Research Centre, 2010-2011

Sampling station	Two-wheeler	Auto-rickshaw	Pickup auto	Car	Multi utility vehicle	Light commercial vehicle	Bus	Truck	Total
Titanium junction	17922	6210	1380	10040	5176	2509	2877	2681	48795

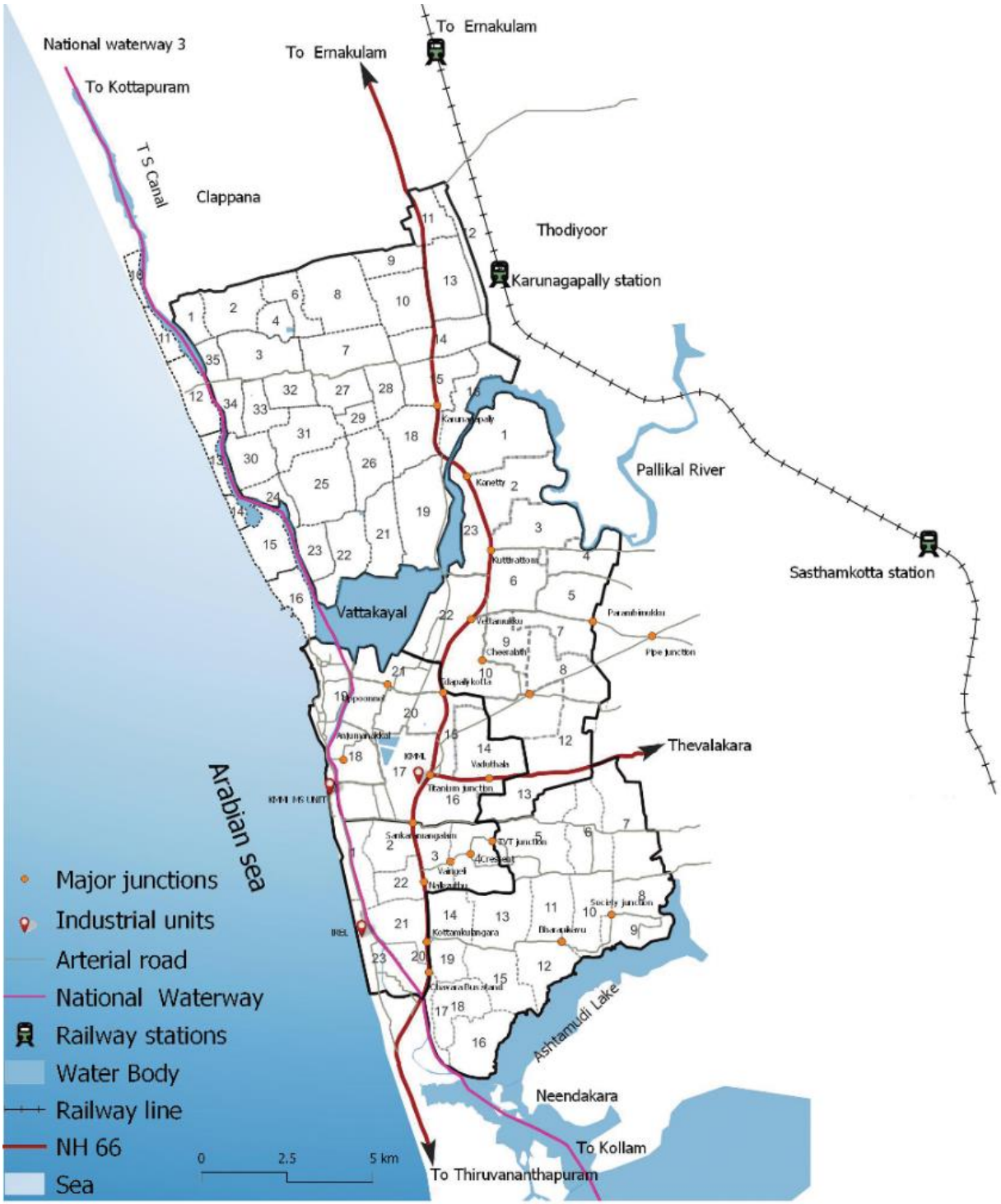


Figure 6.36: Map showing the connectivity.

Source: Author generated using Qgis,2023

Air quality index

Table 6.7 Table showing the air quality index.

Source: National Transportation Planning and Research Centre, 2010-2011

Sampling station	SPM levels (µg/m3)	RSPM levels (µg/m3)	SO2 levels (µg/m3)	NO2 levels (µg/m3)	CO levels (µg/m3)	API Values	Air Pollution Index
Titanium junction	73.97	40.78	28.24	27.19	517.22	52.81	**Moderate**

From the Volume/Capacity ratio analysis, it has been found that most of the road stretches on NH-66 are operating at double or triple times their design capacity. Due to this heavy traffic, congestion and delays are experienced on this road corridor during peak hours. The roads are developed with four-lane divided carriageway; the design capacity of National Highways can be increased up to 40000 PCUs.

6.5.1Transportation issues

The Kovilthottam-ward 1 coastal areas, which are close to mining sites, lack essential public transportation services. Heavy vehicle traffic worsens poor road conditions, creates dust, and makes it difficult for school children to safely arrive at school.

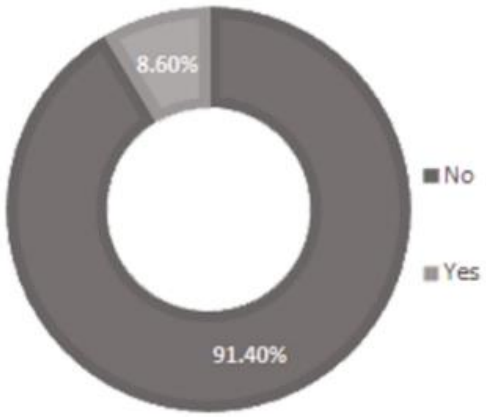


Figure 6.37: Chart showing the transportation issues.

Source: Primary survey March 2023

6.5.2 Import and Export of KMML

KMML's products are supplied to industries all over the globe, including countries like USA, Europe, Korea, UK, South Africa, Turkey, Mauritius, Dubai, and Sri Lanka. KMML daily requirements of raw materials are HCL from Travancore Cochin Chemicals Ltd, Furnace oil from M/s BPCL, and Petroleum coke from reliance Jamnagar, Petroleum coke for KMML comes from Gujarat by truck from Tuticorin to KMML factory.

Chlorine comes from Travancore chemicals, Kochi. KMML export of minerals is 100 containers per month. KMML requires 30,000 mt of furnace oil per annum. The NW3 channel is right behind the IRE plant boundary wall, separated only by a 10-foot road. IRE exports ilmenite by ships. -The cargo is transported by trucks to Quilon harbor and then by barge to vessel. Barge takes 1month to load ship of 25 000 MT capacities.

In view of long loading times and demurrage, IRE now sends its cargo to Kochi by truck and then to vessel for export.

In the recent past there have been no exports due to reduced production and higher domestic demand. IRE is supplying its products to CMRL and to TTB (Travancore Titanium and to (DCW) Dharangadhara Chemical works. The raw material requirement is coming from Vellanath Thuruthu in Karungapally taluk about 15 Kms away. HCl acid comes from Travancore chemical. It may be noted that Acid trucks are not allowed in Alappuzha during the day. Furnace oil is procured from BPCL (Bharat Petroleum Corporation limited).

Table 6.8 Table showing the IRE finished product.

Source: Existing EXIM Logistic Infrastructure in the region,2023

CMRL (Cochin Minerals and Rutile limited)	60,000 MT/ pa
TTB Titanium Travancore	70,000 MT/pa
Dharangadhara Chemical works (DCW) (TN)	40,000 MT/ pa

Figure 6.38: Travancore Titanium limited.

Source: Google images,2023

Figure 6.39: Cochin Mineral Rutile limited.

Source: Google images,2023

Rural roads

The transportation of mined material is through rural unpaved single lane road and concentrate is transported from MS plant to pigment plant is through bituminous topped public roads with six meters width. Mineral processing is done at Mineral Separation Plant situated in the mine lease area. Transportation of the heaviest is done by using tippers. 1.23 km to KMML TiO2 plant. Ilmenite produced from MS processing plant is transported to KMML captive pigment plant, for captive consumption.

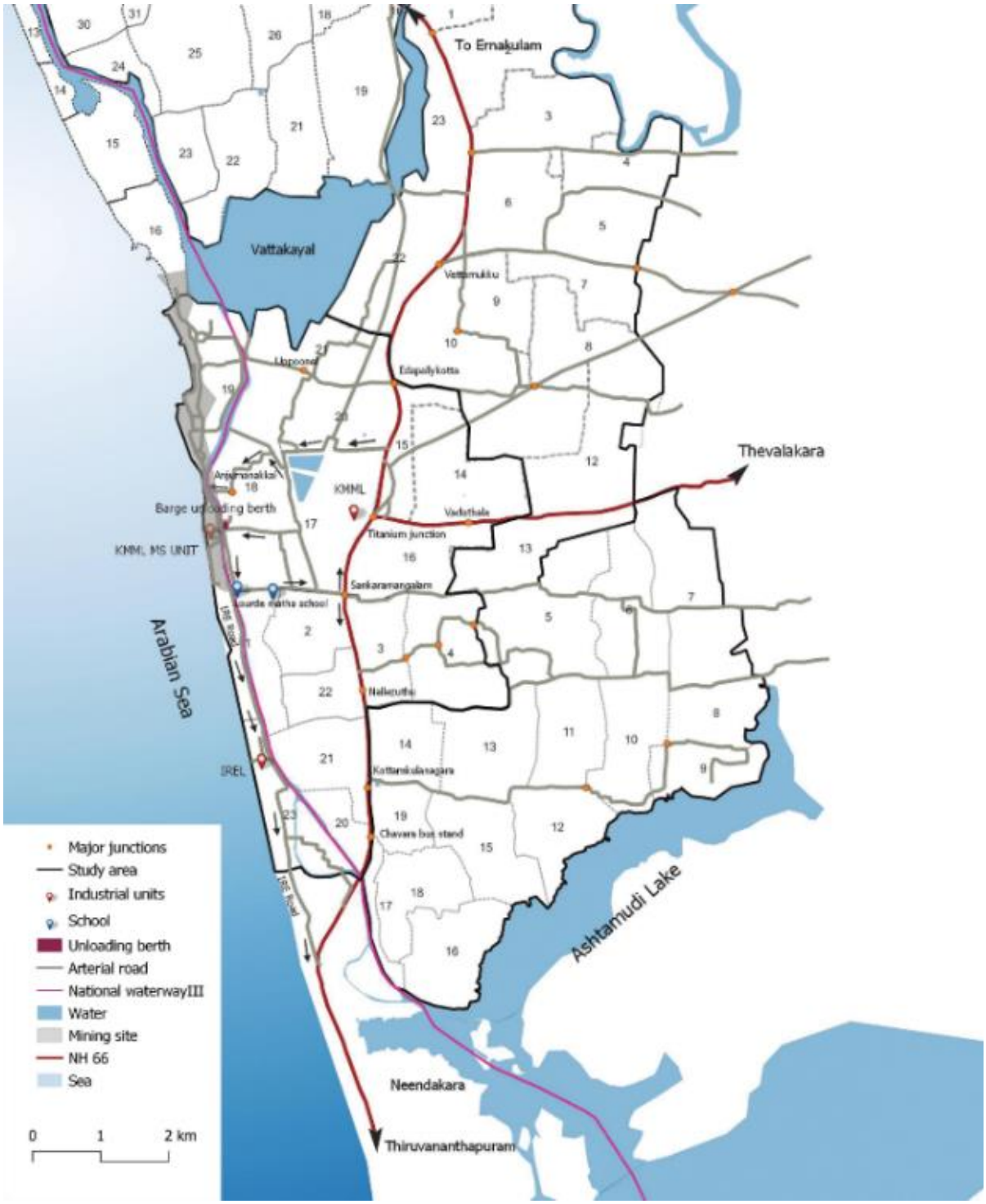


Figure 6.40: Map showing the rural roads.

Source: Author generated using Qgis,2023

Table 6.9 Table showing the transportation of trucks in KMML.

Source: EIA report of mining lease ,2017

Duration	Site		Number of trips
6: 00 am to 4:30 pm	From Ponmana and Anchumanakkal	With load	52
		Empty load	52
	From MS Plant to pigment plant	With load	10
		Empty load	10

The truck movement is stopped due to 2.30 pm to 4 pm on the road due to school time (Lourde Matha school) through the rural roads due to the protest of public.

Figure 6.41: Trucks parked in rural roads in front of IREL.

Source: Primary survey, March 2023

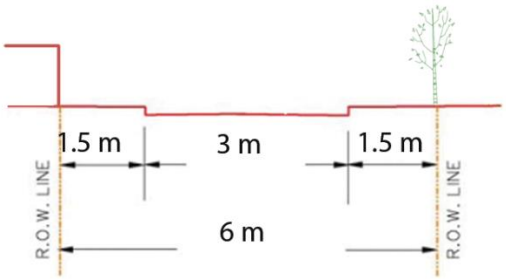


Figure 6.42: Cross-section of rural road.

Source: Primary survey, March 2023

Conventional mining equipment's by wheel loaders to 10ton/ 12-ton tipping trucks is transported through this unpaved road.

6.5.3 Inference

The fugitive dust emission is caused during the transportation of raw sand from Mining and beach washing to MS plant and Transport of mineral heavies from the MS plant to pigment plant. The existing roads connecting MSP and TiO2 plant should be resurfaced and maintained in good condition for heavy load vehicle movement. Trees should be planted on the sides. To eliminate traffic-related issues, the transportation of minerals to KMML from the mining area through barges or country boats through National waterway III. Public transportation facilities must be made easily accessible by controlling heavy truck movement in morning hours and peak hours like school time.

6.6 Social Infrastructure

6.6.1 Health infrastructures

In the study area there are 3 government healthcare facilities at a max distance of 3 km from the industrial area and 4 private clinics. Most people of study area prefer Government healthcare facilities nearby. The most used healthcare by the people is community health center Chavara.

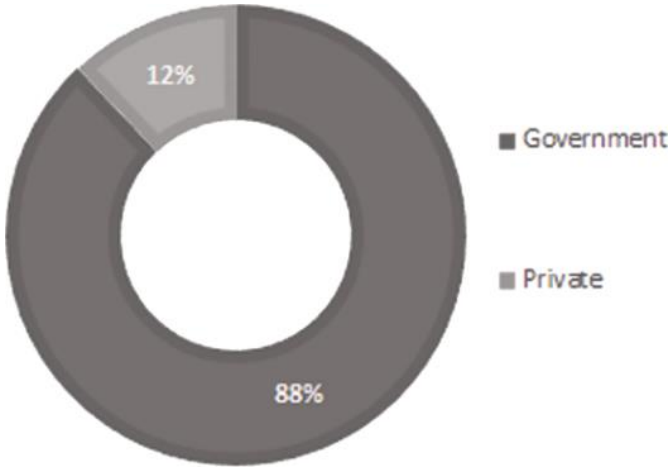


Figure 6.45: Chart showing the most preferred healthcare facilities in study area.

Source: Primary survey, March 2023

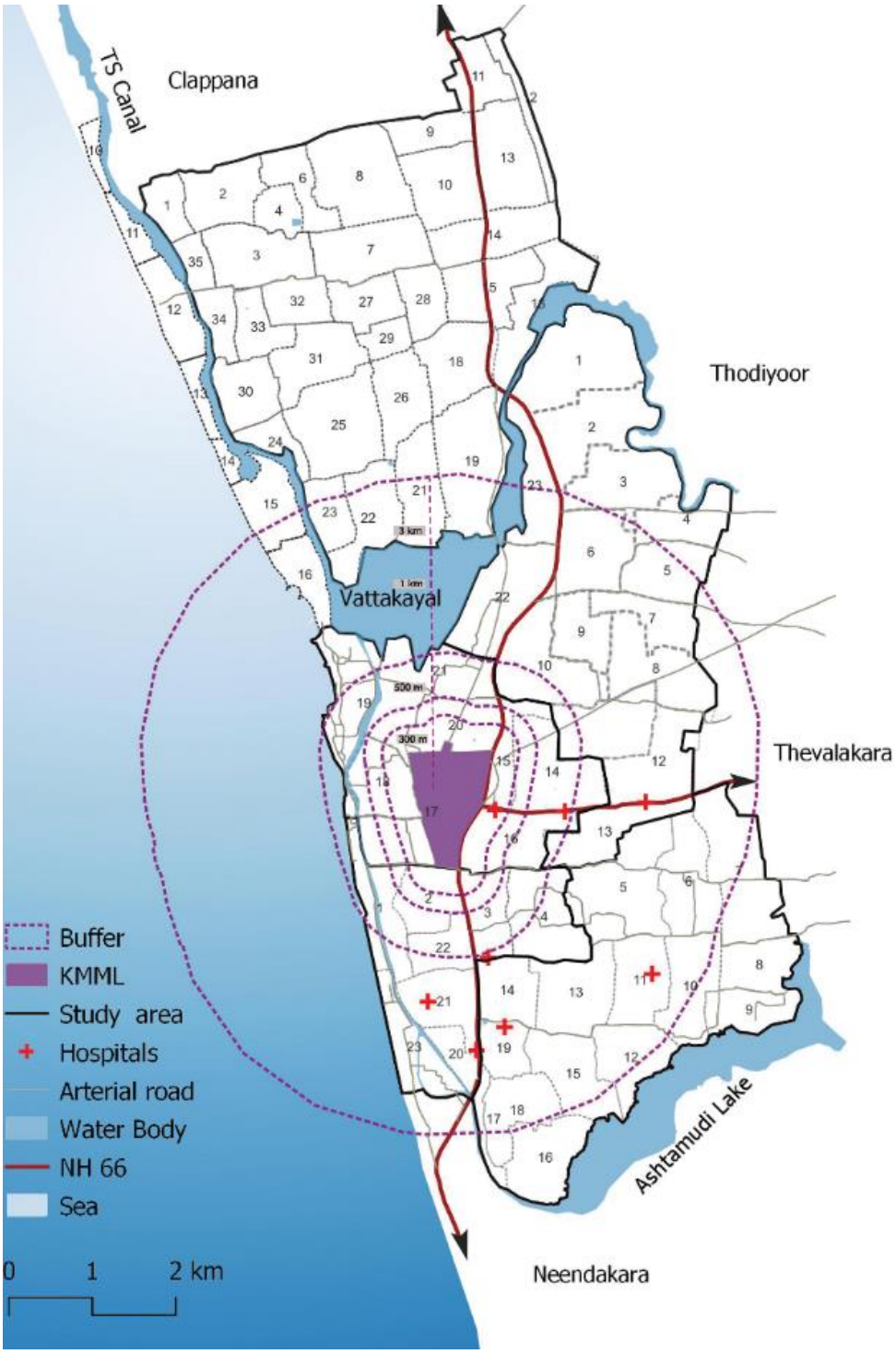


Figure 6.43: Map showing the social infrastructure.

Source: Author generated using Qgis,2023

Community health center Ayurvedic clinic

ESIC dispensary Chavara Arjun's clinic

Family health center, Panmana Aravind medical center

Figure 6.44: Health care institutions.

Source: Primary survey, March 2023

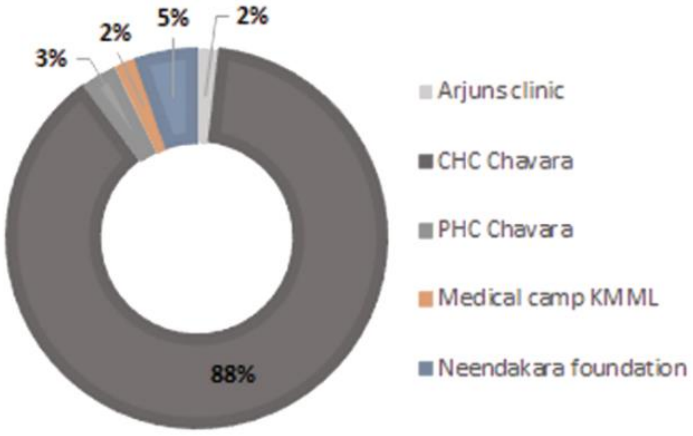


Figure 6.46: Chart showing the most preferred healthcare facilities in study area.

Source: Primary survey, March 2023

KMML medical aids

KMML is extending facilities to the nearby Public Health Centre, like supply of drinking water, medicines, oxygen cylinders etc. The company also conducts free medical camps for the local public. Supply of an autoclave to P.H. Centre, Chavara for sterilization of Medical Equipment. Supply of 9 numbers of oxygen cylinders and accessories to P.H. Centre, Chavara. Financial assistance to P.H. Centre, Chavara for procurement of medicines. An eye treatment camp for the residents of Chavara/ Panmana panchayaths1200 persons attended this camp. Out of them 78 were given further expert treatment at Aravind Eye Hospital, Thirunelveli. All expenses for the above camp and further treatment were borne out by the company.

A medical camp for the residents of affected wards of Panmana panchayath every month. About 700 patients attended the camp and free treatment/ medicines were extended to them. Medical assistance to many persons in Chavara / Panmana panchayaths. The company also provides financial assistance to needy individuals suffering from serious diseases. The public is not satisfied with the medical camp that the KMML is running. Many had difficulty taking the medication, and many of them did not receive any financial aid from the company for illnesses like cancer.

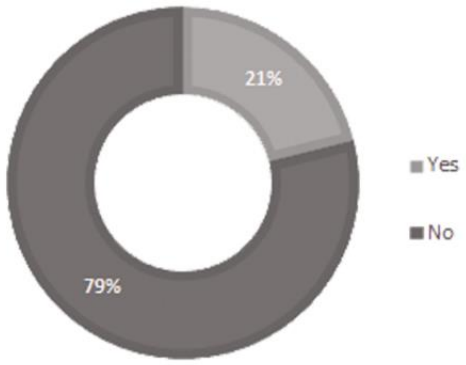


Figure 6.47: Chart showing the people are satisfied by the medical aids of KMML.

Source: Primary survey, March 2023

6.6.1.a Health pattern

The blood pressure and diabetes are 54.50 % is high. 15.20 % of people have cancer and heart diseases in the study area. Skin diseases (13%), allergy (8.60%) and Acute respiratory diseases (10.90%) are also identified in the area. The major group affected by cancer is 60-70 female category of the study area.

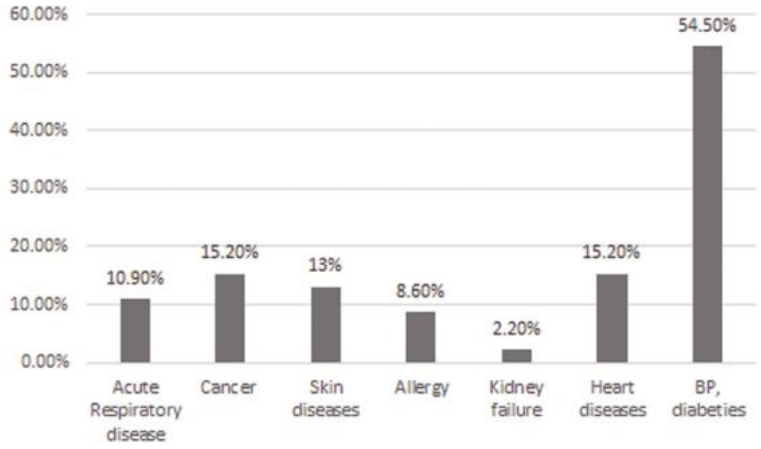


Figure 6.48: Chart showing the diseases in sample taken for study.

Source: Primary survey, March 2023

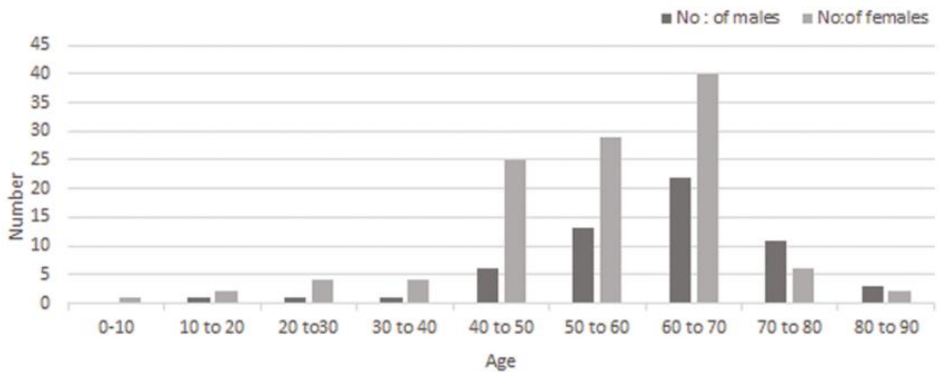


Figure 6.49: Chart showing the age group most affected by cancer.

Source: Community health centers of Chavara and Panmana, March 2023

The cancer patients increased from 69 to 96 in Chavara and 96 to 172 in Panmana. There is an increasing trend in cancer patients due to the radiation of chemicals from industry and black sand in coastal areas.

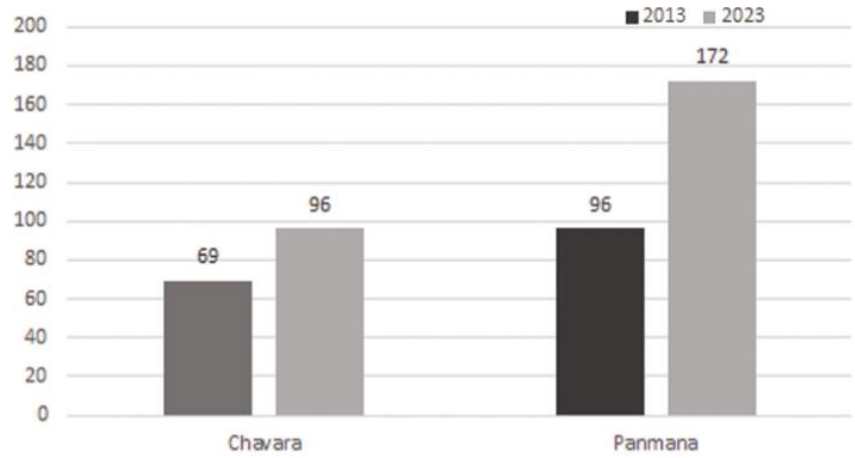


Figure 6.50: Chart showing the age group most affected by cancer.

Source: Community health centers of Chavara and Panmana, March 2023

Cancer patients are high in wards Karithura (23), Kulangarabhagom (20) and vaduthala (14). The 20 and 23 wards are coastal areas where the white sand is dumped after mineral separation, the radiation from this soil is the reason for cancer. The ward Vaduthala is located on the frontage of KMML industry and mainly face the issue of air pollution. Kollam number of cancer cases is (1102 in year 2014) its 0.23 % is in Chavara and Panmana in district.

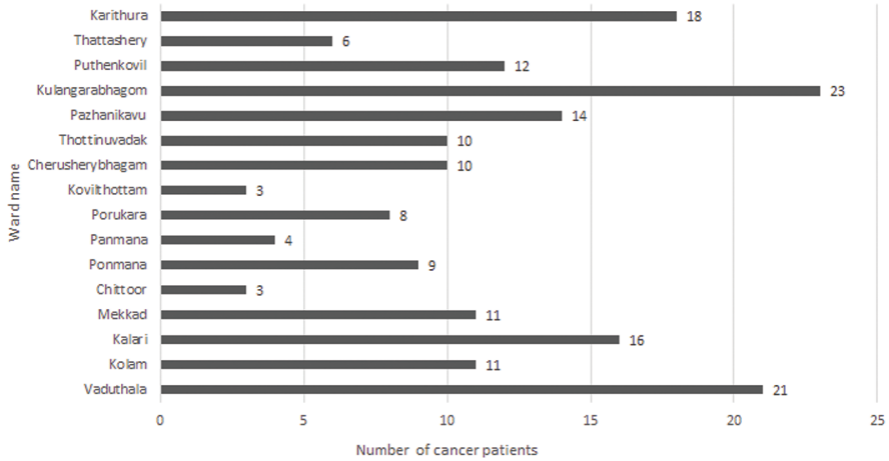


Figure 6.51: Chart showing the cancer patients in study area.

Source: Community health centers of Chavara and Panmana, March 2023

The ARI patients increased from 2457 to 2720 in Chavara and 2781 to 3180 in Panmana. There is an increasing trend in ARI patients due to air pollution. Industry releases Sulphur and chlorine gases in the morning at 7 am. These gases create bad odors and cause respiratory diseases.

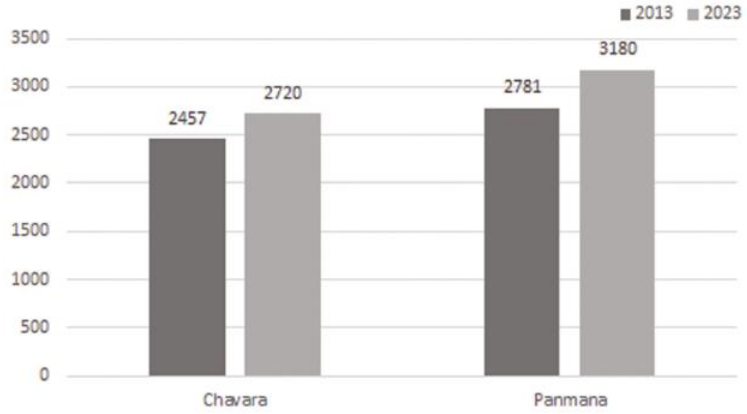


Figure 6.52: Chart showing the increasing acute respiratory infection in Chavara and Panmana.

Source: Community health centers of Chavara and Panmana, March 2023

Skin diseases

The acidic content in the soil due to effluents from industry create skin diseases and it is high in ward Chittoor (ward 18) of study area. But the CHC Chavara does not have a department for treatment of skin diseases, so the patients list related to it is unrecorded.

6.6.1.b Lack of health care facilities

Community health center

The CHC is located within 300 m of industrial area. (Bed count-46). It conducts medical camp for cancer patients of affected wards for 6 months. The medical camp conducted on 1st April 2023, 51 people participated. The major disease due to industry is skin diseases. The health center lacks a department for skin diseases or allergies. A mock drill is conducted on behalf of KMML on site emergency-contingencies, which was focused on rescue / evacuation in case of chlorine leak in CHC Chavara. About 620-800 patients visit

CHC per day. Lack of system, staff facility for data entry of patients, E- health facility to record the details of patients, many infrastructure facilities like ambulance, fund to conduct medical camp in every 3 months regularly. The family health center is within 3 km from industrial area it is not assess bile easily at an emergency industrial accident.

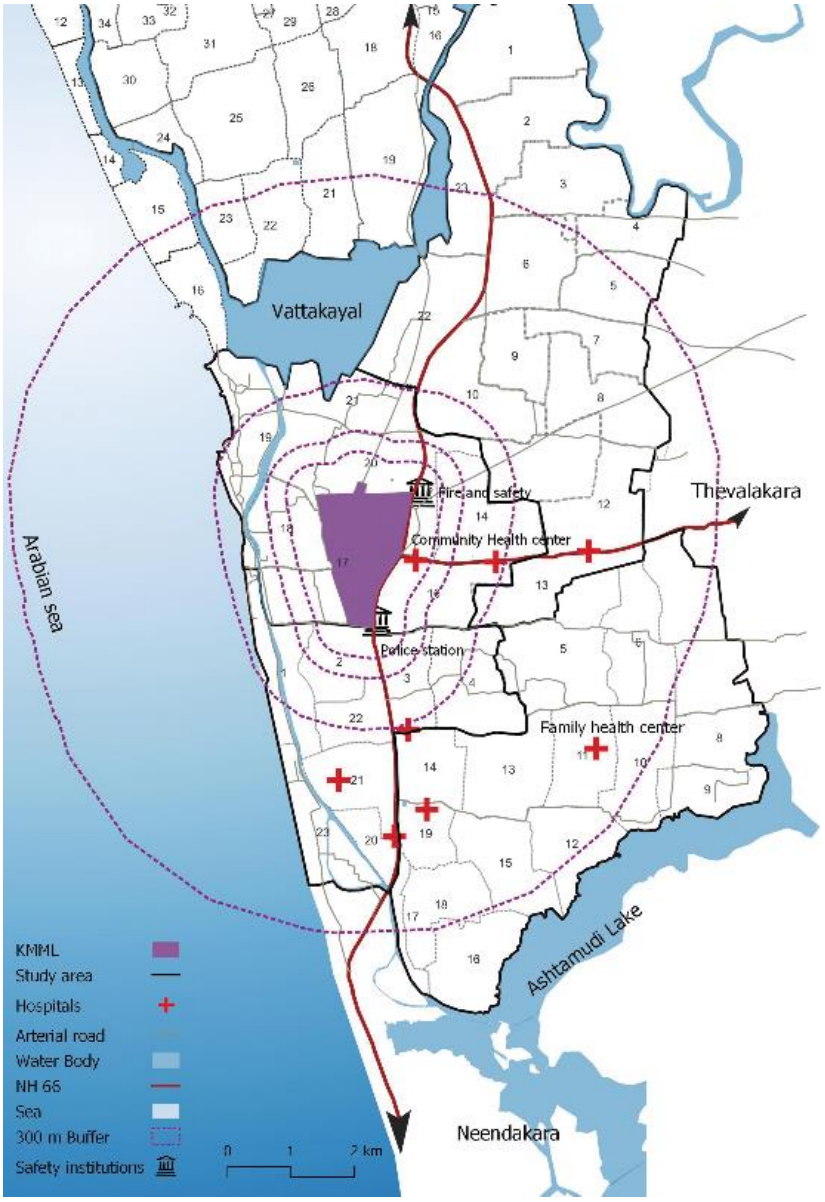


Figure 6.53: Map showing CHC, other emergency institutions for industrial accidents.

Source: Author generated using Qgis,2023

Chlorin gas leakage

70 children in Kollam in Kerala, who were hospitalized allegedly after a gas leak from a unit of the state-run Kerala Minerals and Metals Limited (KMML),16 children, all students from a government school in the neighborhoods, had been placed in the Intensive Care Unit (ICU) on complaints of nausea and breathing problems. The children were admitted in the Community health center Chavara for first aid. (Hindu, 2014)

Figure 6.54: Industrial accident in KMML.

Source: Hindu Newspaper article ,2014

Civic amenities

Within 300m of the fire and rescue station, the police station is there to meet an immediate industrial accident. Therefore, the emergency facilities are available in 3-5 min as per URDPFI. Specifically, fire stations to be located on the corner plot giving direct access to sub-arterial roads.

Police station Chavara Fire and safety Chavara

Figure 6.55: Civic amenities 3-5 mint distance from industrial area

Source: Primary survey, March 2023

6.6.2 Education

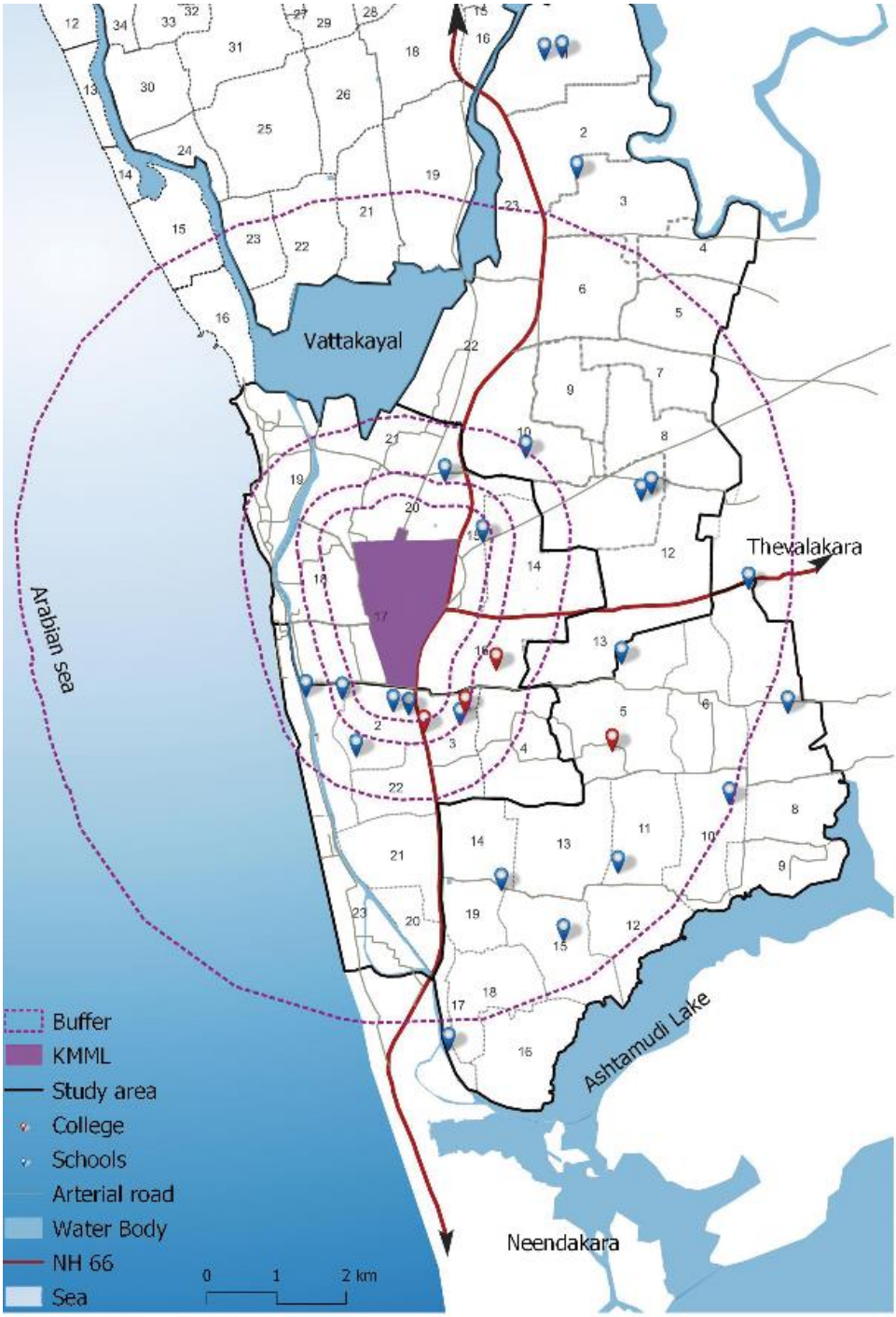


Figure 6.56: Map showing educational institutions.

Source: Author generated using Qgis,2023

The educational institutions GHSS Chavara, Baby John memorial college, Valiyam central school are within 300m from the industrial area. As per the URDPFI guidelines, when specifically planning for an Industrial area, service villages, hamlets, and rural settlements to be provided with a buffer of 100-300 meters for the expansion of the settlements, from a health & safeguard point of view.

Figure 6.57: Showing educational institutions of study area.

Source: Primary Survey,2023

Table 6.10 Table showing the students list of schools in 1 km buffer of industrial area.

Source: EIA report of mining lease ,2017

Name of school	Management	Class	Total number of students	Number of IEDC students	Panchayat
G.h.s.s chavara	Government	V - XII	2119	16	Chavara
Lourdes mata central school	Un -aided	I - X	653	0	Panmana
Valiyam memorial central school	Un -aided	I - XII	490	0	Panmana
G.u.p.s Chittoor	Government	I - VII	586	17	Panmana
Green mount public school	Un-aided	I - VIII	197	0	Chavara
Karuna special school	Un-aided	I - V	58	0	Chavara

Buds' rehabilitation center in Panmana with 25 students with mental retardation. This institution lacks many facilities for improving the student's talent. They lack physiotherapy, speech specialists and other education facilities. It is high in number in wards where industrial pollution is high due to radiation.

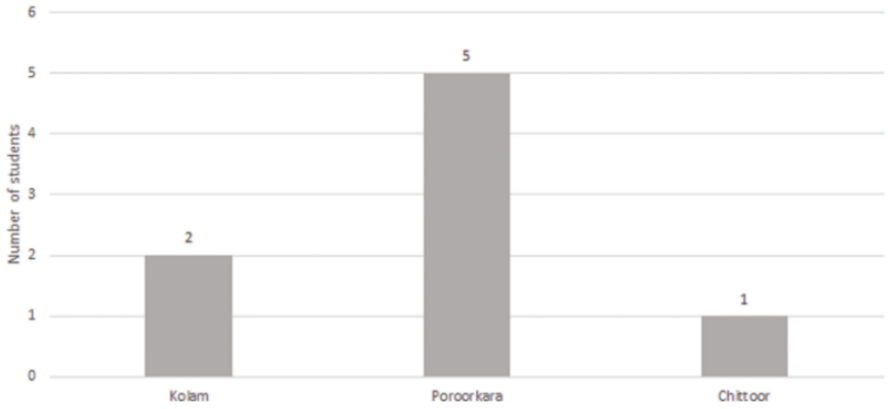


Figure 6.58: Showing the mentally retarded students' number of affected wards.

Source: Primary Survey,2023

The educational institutions nearby are most preferred by the students of affected areas so at the time of planning for industrial area the educational institution of the area also needs to be considered. The company shall provide regular grants to neighboring schools and constant encouragement for cultural activities in local villages.

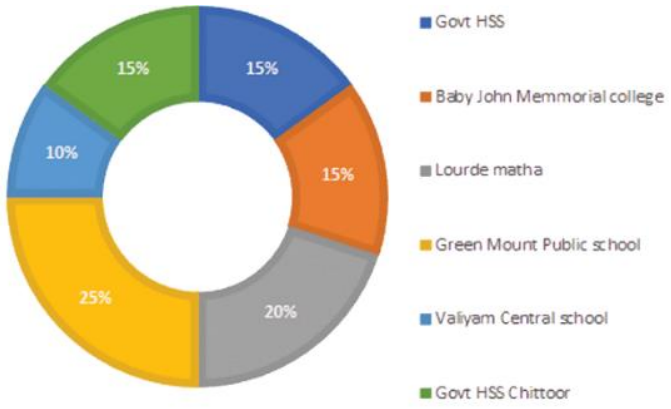


Figure 6.59: Chart showing the most preferred schools.

Source: Primary Survey,2023

6.6.3 Inference

The cancer patients, skin diseases and acute respiratory infection is an increasing trend in study area due to the acid effluents from the industry and the radiation from the white sand residue of mineral separated black sand dumped in the study area. The air pollution and release of chlorine like gases is the cause of acute respiratory infection in public. Proper curative and preventive action on the matter Otherwise the social unrest among the people will become a serious problem. The lack of health care facilities in the government hospital where the most public approach is also one of the major issues of the study area. Need of more cancer care and skin care facilities to meet the health hazard of the public as per the URDPFI guidelines the industrial area has fire and rescue, police station and health care within 300 m to meet an emergency industrial accident. Fire stations is located so that the fire tenders can reach the disaster site within 3-5 minutes. The schools are located within 300 m nearest to hazardous industrial area KMML, indicates a uneven development. The educational institutions require mock drills to face an emergency industrial accident.

6.7 Physical Infrastructure

6.7.1 Water supply and sources

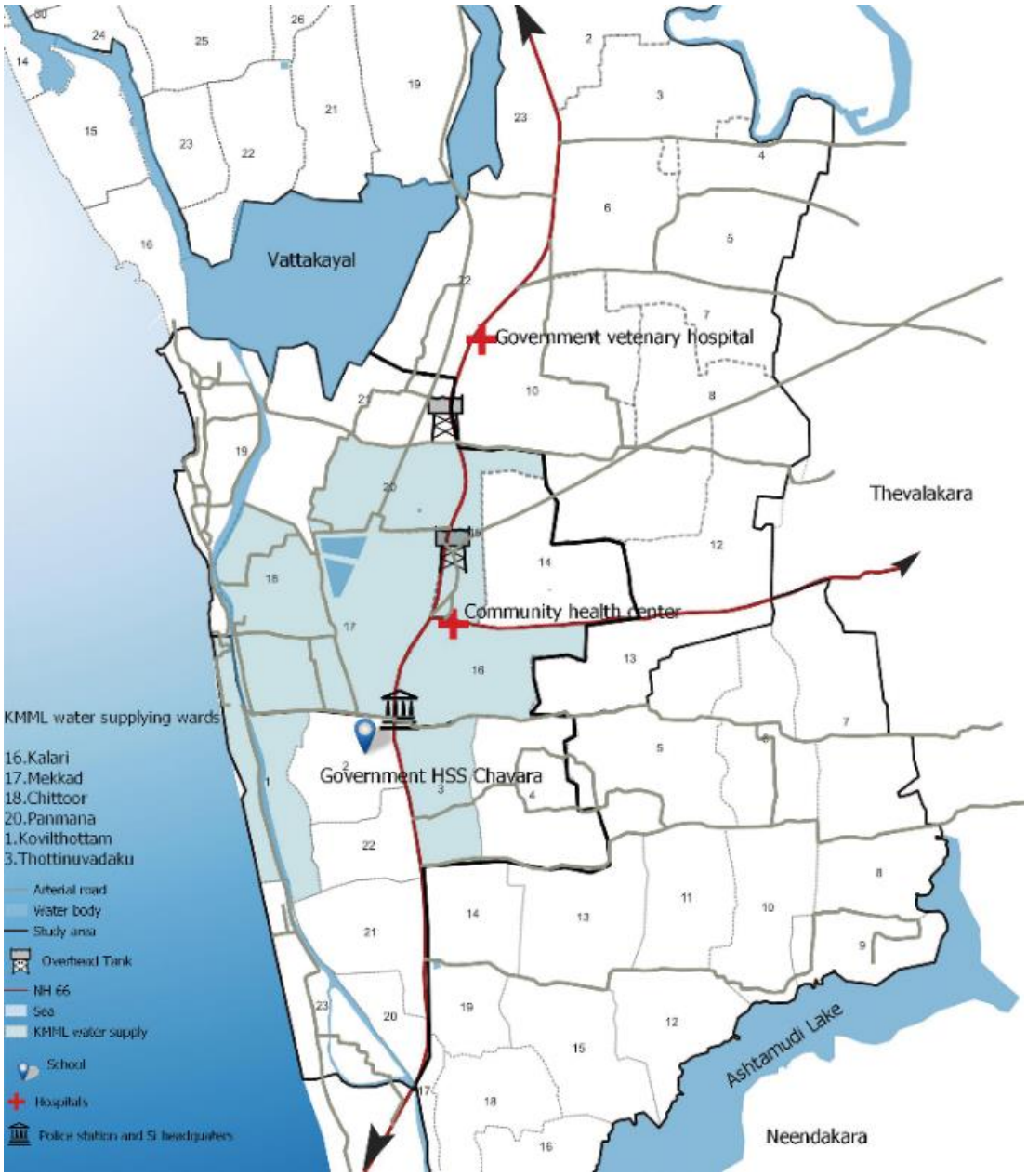


Figure 6.60: Map showing the areas where KMML supply water in the study area.

Source: Author generated using Qgis ,2023

1.Jalanidhi work

Kerala's government and the World Bank carried out with public involvement. Together with Jalanidhi, the Kerala Water Authority implements the programme. This plan is for providing Chavara and Panmana Grama Panchayats with purified water. Sasthamcottah Lake serves as the raw water source, and Sasthamcottah is also home to the 11 MLD treatment facility. The portion of the KWA-performed work is practically complete, as is the distribution network that Jalanidhi is supposed to lay. It is finished by 2009's end.

2.KMML water supply

The entire area of Mekkad, Chittoor, Panmana, and Kalari wards of Panmana Panchayath and Part of Thottinvadakku ward and Kovilthottam ward of Chavara Panchayath should be covered in the water supply scheme. At present KMML is providing 675 m3 /day to 725m3 / drinking water to the public by laying about 55 km of pipeline in different directions from the plant as a center. The investment cost of providing the pipeline network of KMML water supply scheme is around Rs.30 lakhs.

The company provides potable water to the entire area of Mekkad, Chittoor, Panmana, Kollam, and Kalari wards of Panmana Panchayath. The water supply scheme also extends to portions of Chavara Panchayath's Thottinvadakku and Kovilthottam wards. The system provides the public with about 3,60,000 liters of water per day. The supply period is now 2 hours each day. Additionally, Chavara P.H. Centre, Chavara Police Station, Chavara Veterinary Hospital, SI Quarters, and Chavara Govt. Higher Secondary School receive a continuous water supply. On express request continuous water supplies are set up nearby for events like weddings and housewarmings. The same supply is given to churches, mosques, and temples.

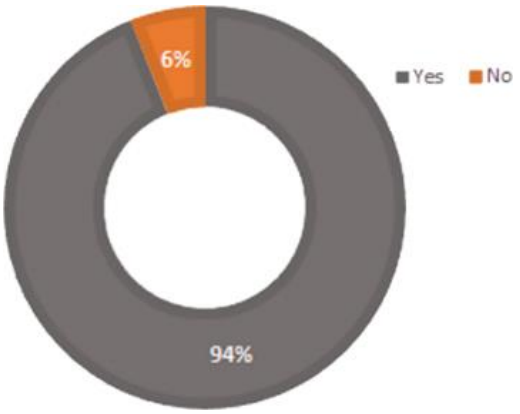


Figure 6.61 Chart showing the quality of KMML water supply.

Source: Primary Survey,2023

KMML industrial pipeline is most used in the study area (83%) and bore well (14%) and only 2 % of people use open well in the study area. The most of the open well of the study area is polluted due to iron oxide sludge of the industry. 90% of well water is of low quality in the study area.

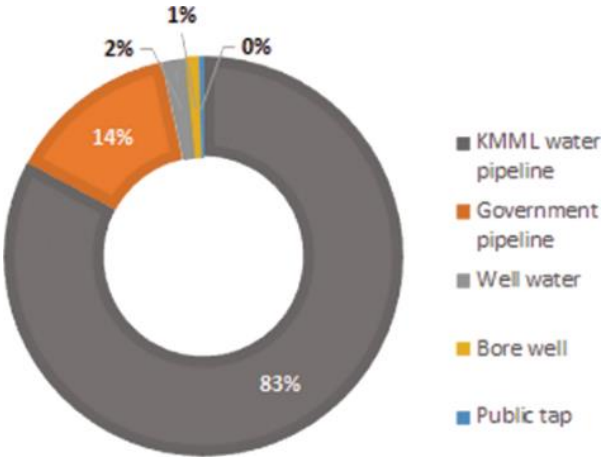


Figure 6.62 Chart showing the source of drinking water.

Source: Primary Survey,2023

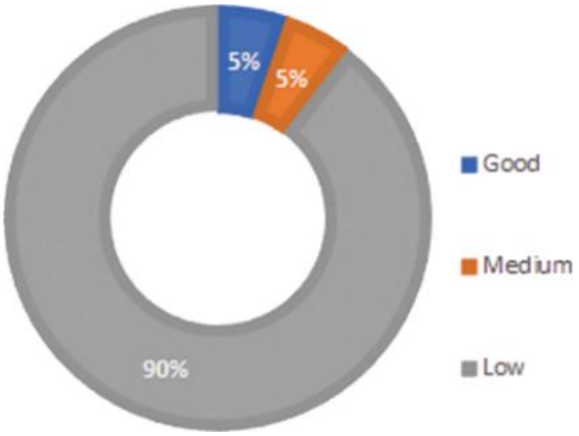


Figure 6.63 Chart showing the quality of well water.

Source: Primary Survey,2023

KMML water supply is only for 2 hours duration of a day, morning, and evening so people face scarcity of water.

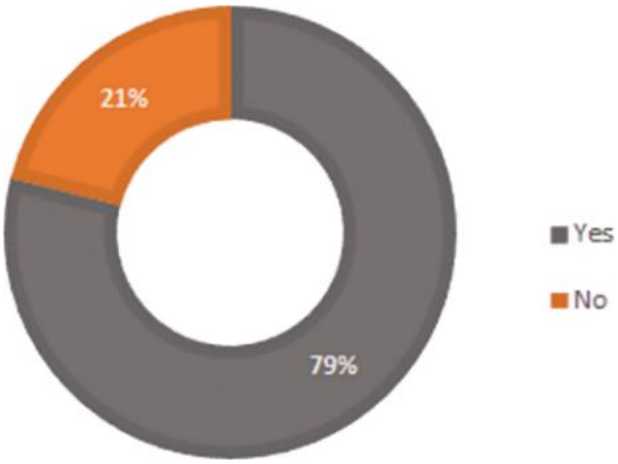


Figure 6.64 Chart showing the scarcity of water.

Source: Primary Survey,2023

Water demand

The affected population of 16 wards is 29977persons.70 Lpcd is the standard water requirement of a person per day as per URDPFI guidelines. The total water demand of

polluted areas is 0.21 MLD per day. The KMML supplies 3.6 MLD of water per day, so the water demand of the study area is meted by the industrial area.

Table 6.11 Table showing the water demand of study area.

Source: Source: Author generated with reference to URDPFI,2023

Population	Water demand	Industrial water supply
29977	**0.21 MLD**	**3.6 MLD**

6.7.2 Ground water

Fifteen open well samples were collected in one directionally within the range of 5km-6km around KMML from fifteen wells at a certain depth. All the samples were collected in bottles and preserved. Tests like conductivity, turbidity, pH, TDS, hardness were conducted within 8 days of sample collection. Again, the samples were collected from the same stations and their main tests were done.

Table 6.12 Table showing the ground water quality parameters.

Source: Water Quality Assessment of Ground water Around KMML Area Chavara, April 2016

Sample station	Distance	Chloride (mg/l)	COD (mg/l)	Iron (mg/l)	Ph	Hardness	Turbidity
1	-	338.76	144	3.285	7.29	236	63
2	0.03	327.31	100.2	2.859	7.24	214	59
3	0.8	308.04	80	2.192	7.02	180	44
4	0.9	294.94	68	1.492	6.74	192	32
5	1.1	283.21	56	0.895	6.74	136	28
6	1.3	274.914	51	0.784	6.79	104	23
7	1.7	259.94	47	0.761	6.72	76	18
8	2.1	169	42	0.706	6.70	69	15
9	2.7	114.96	37.98	0.685	6.68	62	13
10	3.0	74.97	31.06	0.527	6.65	58	12
11	3.1	54.98	28.80	0.244	6.63	53	10
12	3.7	59.98	25.60	0.222	6.42	49	08
13	5.0	45.76	22.40	0.231	6.34	46	06
14	5.4	36.21	20.00	0.197	5.93	41	04
15	5.8	29.99	12.80	0.091	5.72	42	03

All the well water near KMML exhibited high COD, TDS, total hardness, iron etc. which are sourced to industrial wastes being discharged into the surrounding areas. The values of

TDS, BOD, COD, and iron exceeded the permissible limit. Hence, the well water near KMML is unsuitable for domestic purposes, as confirmed by the water quality index. The consumption of the well water around the industrial area may cause health hazards to the residents. It is necessary to control the contaminant transportation and ground water pollution in and around KMML area.

6.7.3 Hazardous waste management

The waste was dumped in the company premises during the first decade of its functioning and thereafter vast unroofed ponds were constructed to hold Iron Oxide Sludge and ETP Sludge. They are called the old ponds which were provided with several vertical PVC pipes from below the base to above the pond top to release the ground water. 23,000 tons of iron oxide sludge generated per year reaches the ponds as slurry at the rate of 1,440 cub.mt. per day which means 52,56,00,000 liter per year.

Likewise, 20,000 tons of ETP sludge generated per year can be expected to pour in as 45,70,43,460 liters of slurry into the ponds and both slurries viz. iron oxide sludge and ETP sludge put together comes to 105,06,43,000 liters per year which means that the ponds will get filled up in two to three months in a year.ETP tank is about two lakh tons and effluent generation is about 50 metric tons per day. water consumption is about 6912 m3/day. and a maximum of 1200 m3/day of supernatant is discharged into the sea from the ETP settling pond.

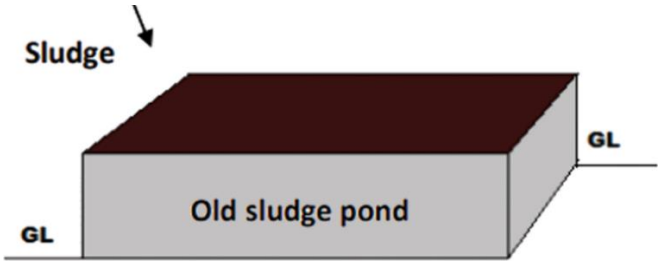


Figure 6.65 The existing sludge pond

Source: Report of the Kerala state pollution control board filed before the hon'ble national green tribunal, principal bench, new Delhi in the matter ,2022

6.7.4 Existing issues

The PVC pipes have started falling resulting in several holes in the base with the result the liquid portion of Iron Oxide sludge and ETP slurry started draining into the ground polluting the soil and the ground water. During the rainy season more pollutants are dissolved and carried down to the ground and groundwater to far away areas due to lack of drainage facility. As Kollam has an average rainfall of 2.6 meter per year, the rainwater falling over the old ponds of nearly 5-hectare area results in generation of 130 million liters of polluted water per year spreading downward and outward contaminating the ground water.

Figure 6.66 Polluted well of study area due to KMML.

Source: Primary Survey,2023

6.7.5 Inference

The ETP (Effluent treatment plant) acidic iron sludge of the KMML has begun to seep through the containment and contaminated the wells of the residents, making them all unpotable. The old sludge pond should be roofed and a new sludge pond without seepage to groundwater needs to be constructed. All the residents have been warned that the water should not be used for drinking, bathing or even for toilets. Water is now being supplied by the company, but it is inadequate due to duration and other uses. Need a greater number of overhead tanks to meet the needs of people. Containment of the breached sludge pond is an urgent necessity as the entire groundwater may become permanently damaged and unfit for use. Immediate maintenance of dilapidated pipelines to prevent leakage of

effluents into soil. Rainwater harvesting methods and new water supply schemes should be implanted in every household. Periodic inspection and maintenance of water distribution systems like pump houses, pipelines etc.

6.8 Environment

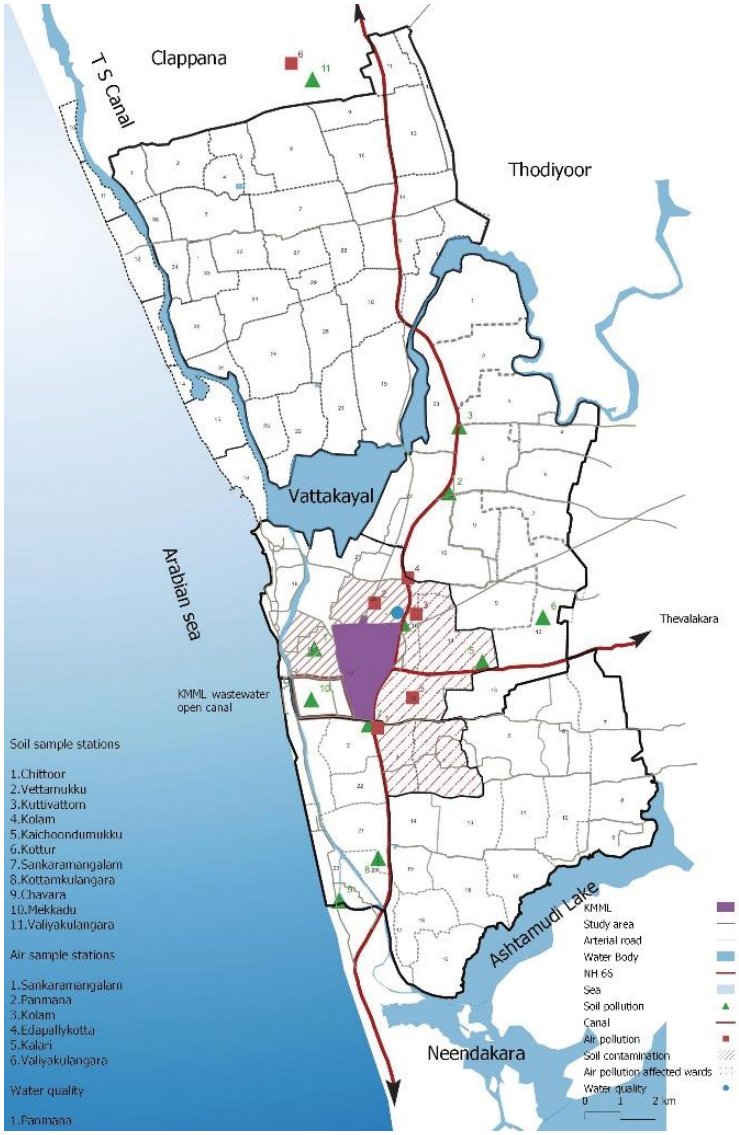


Figure 6.67 Map showing the sample stations for analysis of soil condition.

Source: - Author generated using Qgis with reference to Evaluation of soil contamination in the surroundings of Kerala Minerals and Metals Limited (KMML) industrial area in Kollam District, Kerala, South India ,2016

6.8.1 Soil pollution

The major source is the leakage of iron effluents from the industrial pipeline through the study area. Extensive field survey of the entire study area including Chavara block and Oachira block in Kollam District was conducted and the sampling stations were selected. The soil type of study area is sandy loam. Soil samples were collected from eleven different stations situated in the northern, eastern, southern, and western direction of the KMML factory.

Table 6.13 Table showing the concentration of pollutants for analysis of soil condition.

Source: - Evaluation of soil contamination in the surroundings of Kerala Minerals and Metals Limited (KMML) industrial area in Kollam District, Kerala, South India ,2016

Concentration of heavy metals	Permissible limit
Pb: -61.2 mg/kg	32 mg/kg
Zn: -102.5 mg/kg	300 mg/kg
Cd: -0.27 mg/kg	0.4 mg/kg
Cr: -298.4 mg/kg	100 mg/kg
Fe: -28021 mg/kg	19755 mg/kg
Mn: -327.4 mg/kg	153 mg/kg

Heavy metal content in the soils of study stations is in the order iron > manganese > chromium >zinc > lead > cadmium. The concentration of heavy metals Pb, Zn, Cd, Cr and Mn in the stations, S1, S4, S7 and S10 nearest (within half kilometer distance) to the KMML industry were found to be higher than that in the control station. The results of the study also show that soil in the vicinity of KMML industrial area have been contaminated with heavy metals at levels above the background concentrations in soil, which may give rise to various health hazards. There should be a provision to measure toxic metals in industrial effluents before dumping.

Figure 6.68 Acid fields of Panmana.

Source: Primary Survey,2023

6.8.2 Water pollution

From around the large compound wall of KMML, reddish brown water (untreated or partially treated) flows into the drainage build right around it and from there it makes it way to Vattakkayal. Vattakayal is connected to the National water way. The national water way enters Ashtamudi Lake between Palliyadiyil and Mananthara Stretches. This explains the presence of various heavy metals in Ashtamudi Lake and thus polluting the entire district of Kollam as the Ashtamudi is fanned out across 22 Local bodies of Kerala.

Figure 6.69 Wastewater canal and dead fishes due to pollution of KMML

Source: Primary Survey,2023

Hundreds of dead fish along the National Waterway III near its mineral separation plant in Chavara

Wetlands

Paddy fields in the area have become effluent ponds. Untreated radioactive and acidic trade effluents are discharged unhindered into the paddy fields and Ponds.

Figure 6.70 Acid fields of Panmana

Source: Primary Survey,2023

Table 6.14 Table showing the water quality.

Source: - Kerala State pollution control board ,2020

Code 2315	At KMML				
2020	pH	EC	BOD	TC	FC
Unit		µmhos/cm	mg/l	MPN/100ml	MPN/100ml
Max	7.9	262	1.7	110	49
Min	6.8	224	1.1	100	49
Mean	7.4	243	1.4	105	49
Std.Dev	0.8	26.9	0.4	7.07	0

6.8.3 Noise pollution

Noise includes sound generated by the Mineral Separation Plant (MSP) and other mining and separation activities.

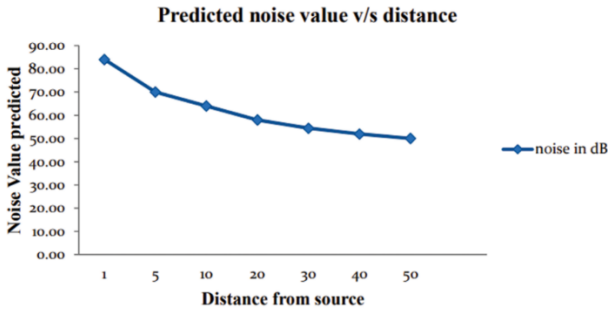


Figure 6.71 Chart showing the change of noise with respect to distance.

Source: EIA study for renewal of mining lease of KMML Block III and enhancement of mineral sand production to 7,50,000 TPA (ROM) along with mineral concentration and separation plant ,2017

The noise levels do not cross the limits as prescribed by the standard limits by CPCB norms. The noise values are within limits. The outburst of the noise from the Mineral Separation Plant is limited to 40 meters as the noise level does not go beyond that limit. The nearest inhabitants (settlements) from the MSP are more than 250 meters and the temple located nearer to the plant is 340 meters away.

6.8.4 Mangrove

The riparian vegetation along TS canal were found to be flourished with mangrove species where there is no human habitation. The TS canal was identified as National Water Way (No.3) and NWAI carries out the widening and dredging of the canal for safe navigation. The mangrove floral density was found to be low along the riparian areas of TS canal, which may be due to the construction and up-gradation work of National Water Way III.

Figure 6.72 Mangroves of study area

Source: Help foundation,2019

6.8.5 Air pollution

The air pollution due to PM10 and Chlorine in the residential areas in the vicinity of KMML industry causes different health problems in the residents, especially in children and aged people. The concentration of free chlorine in ambient air of the study area recorded highest value (60.75 µg/m3) in station 2 that is near to the factory (200 m) in the northern side. The free chlorine contamination in the study stations S1, S2, S 3, S4, S5 detected in the present

study, the quality of air in the surroundings of the KMML factory is bad. The people in the study area who are unusually sensitive to ozone/chlorine may experience respiratory symptoms. Therefore, to manage the air pollution in the study area, it is recommended to install high efficiency air pollution control devices at the KMML factory. The factory authorities may also take steps to plant air pollution tolerant creepers in the surroundings of the industries to reduce air pollution problems in this area.

As there are no permissible standard limits for chlorine in the ambient air in industrial/residential areas, Ministry of Environment and Forests (MoEF), Government of India should take necessary steps to promulgate Ambient Air Quality Standards for chlorine in industrial area.

Table 6.15 Table showing the air quality.

Source: -Air Quality Assessment in the Surroundings of KMML Industrial Area, Chavara in Kerala, South India ,2014

Sampling stations	Air quality index	Air quality status
1	124.1	Moderate
2	82.8	Good
3	107.0	Moderate
4	126.0	Moderate
5	123.4	Moderate
6	62.3	Good

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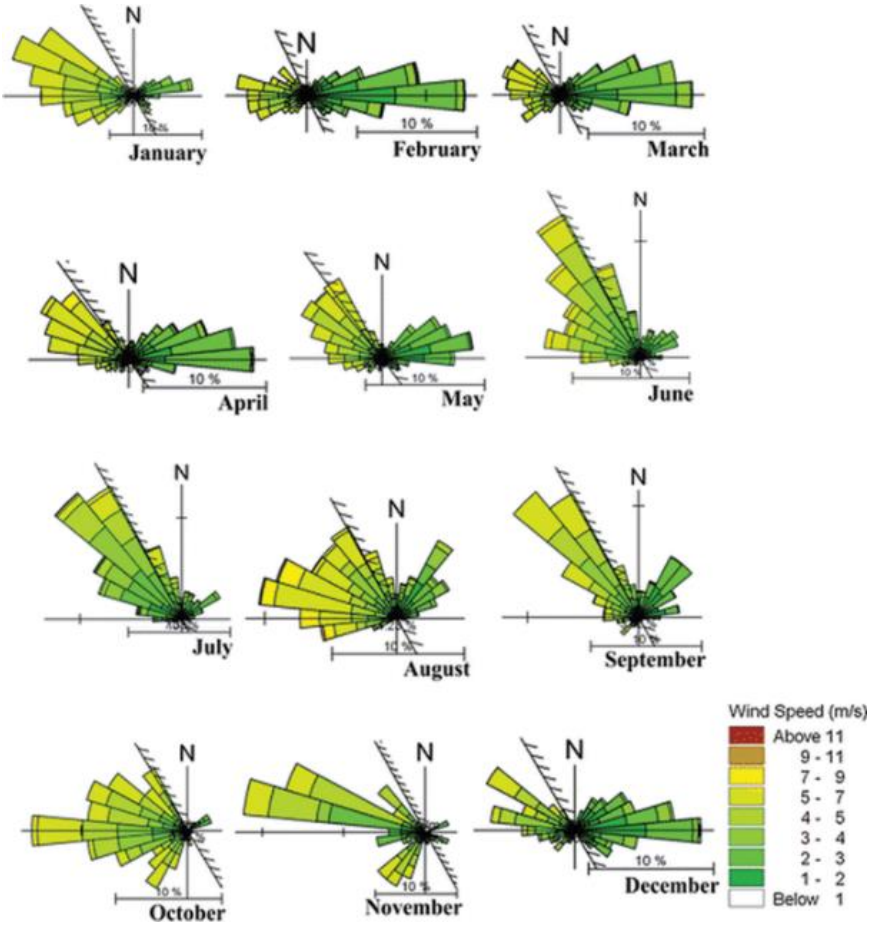


Figure 6.73 Windrose diagram of study area

Source: Erosion and heavy mineral depletion of a placer mining beach along the south-west coast of India: Part I— Nearshore sediment transport regime,2016

As per the wind rose diagram of Chavara the wind is towards the frontage of industry so the wards such as Kolam, Vaduthala are more affected due to air pollution.

Figure 6.74 Air pollution of study area

Source: - Primary survey, March 2023

6.8.6 Coastal regulation zone

The heavy mineral sand deposits of the coastal stretch of Kollam and Alappuzha districts are one of the richest in the world. These sands contain Ilmenite, sillimanite, rutile, leucoxene, zircon, and the highly radioactive monazite which were being mined and separated by the IREL & KMML during the last thirty odd years.

As per the Kerala Coastal Zone Management Authority (KCZMA) has forwarded the proposal in respect of Block I, III, V and VII on 25.01.2014 for prescribing the Terms of Reference to the MoEF under the CRZ Notification, 2011. MoEF has not granted CRZ clearance. Further no application has been received from KMML for EC under EIA Notification, 2006 for mining activity in the said four Block Nos.I, III, V & VII. MoEF is examining the matter for acting in accordance with law.

This has been a source of sizeable revenue for the Govt., and due to pressure of land and CRZ restrictions for mining in the coastal stretch, the KMML and other industrial users must find suitable locales for sustained retrieval of the strategic raw material without causing any environmental imbalance.The mining operations in the very loose unconsolidated sand near sea may upset the stability of land area which is only about 1 to 2.5m m above mean sea level. It is also stated that Tsunami which has occurred on 26.12.2004 has left significant impact in the coastal area of southern Kerala particularly in Chavara area where erosion was predominantly noticed between Chavara Bridge and further north near the Azheekal sector.

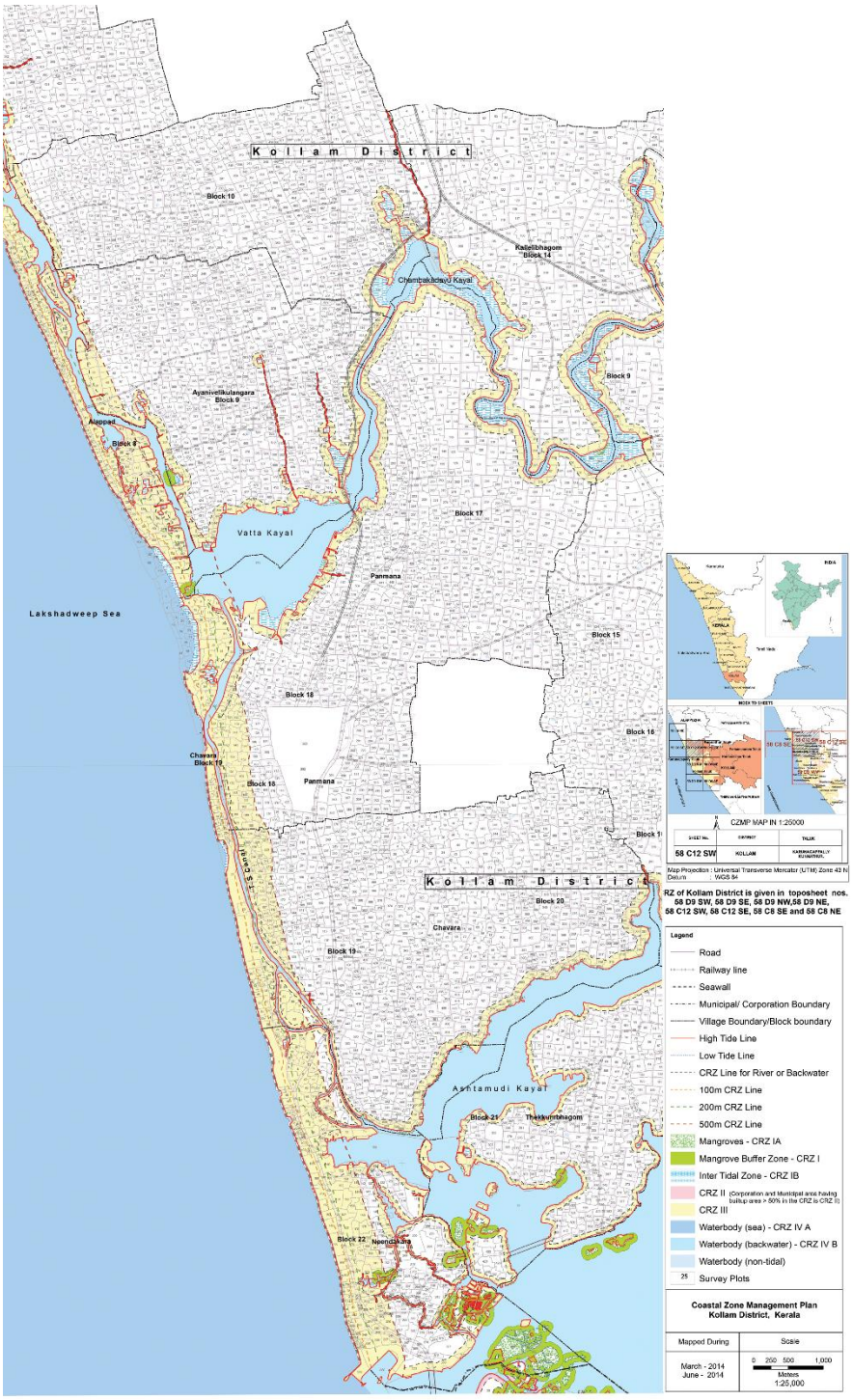


Figure 6.75 Costal regulation zone of study area

Source: - Coastal zone management plan of Kollam district Kerala,2014

The Kovilthottam (ward 1) of Chavara the majority of household is evicted by giving a compensation of 20,000 for 1 cent of land, since their occupation and residing in the place for 15-20 years they forced to move to nearby areas Mekkad, Cherusherybhagom (also affected by industrial pollution). The remaining 3 houses in Kovilthottam are not willing to move but they are forced to leave the land due to mining.

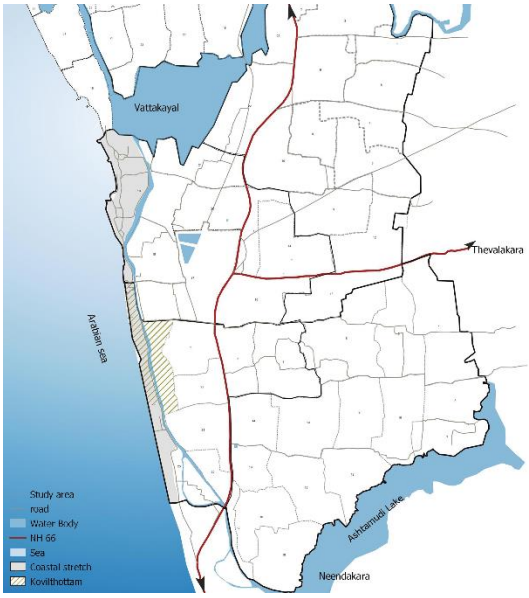


Figure 6.76 Map showing the affected ward and mining area of coastal belt.

Source: - -Primary survey, March 2023

Figure 6.77 The coastal stretches of study area

Source: - Primary survey, March 2023

6.8.7 Inference

Primary and secondary data on meteorology, air, noise, water, soil, land use, ecology was collected and analyzed. Pollution is a serious threat to the inhabitants of the mining area. The mining machinery, transport vehicles and other mechanized equipment create air and noise pollution. The mining activity has also dried up most of the wells in the area and whatever amount of water is available in the remaining wells, they are contaminated due to toxic seepages. The fertility of the soil is also diminishing due to mining. In short, land utilization for agricultural purposes is insignificant.

The people in the area have different occupational skills but most of them are well versed in fishing only. All these aspects adversely affect the people in the locality, especially their health and tranquil family life. It is a fact that the company is very slow in reducing pollution at all levels. More and more precautions are to be taken to reduce pollution in the best manner and within the shortest possible time. As a priority, the company must take steps to intensify the water cleaning process and other issues which have a direct bearing on the health and wellbeing of people in the area.

Coastal protection measures against sea erosion and Tsunami are a major part of the environmental management plan to be implemented in the area. Human settlement and rehabilitation-They are not favoring the land acquisition for the mining project. A small portion of the people in the locality are willing to let the land acquisition happen but on certain conditions especially in the land value and proper R&R. The coastal protection measures undertaken include Seawall construction and Groins, by the state government and KMML in its mining areas. These measures are also being taken up by KMML over the stretches of mining areas every year for controlling erosion.

6.9 Swot analysis

This table lists out the strength, weakness, opportunity, and threats of study area based on these proposals is formulated for the study area.

Sectors	Strength	Weakness	Opportunity	Threat
1.Demography		▪ A **negative population change** as a result of KMML contamination in Panmana Panchayat.	▪ Planned industrial zone can mitigate the adverse impacts of industrial area and deal with this shift.	
2.Land use	▪ The industrial sector KMML (224 ha), which makes up 3% of the study area is one of the **major industrial attraction of Kerala.**	▪ **Lack of buffer area** for separating industrial area and residential area to reduce impacts in public	▪ **The company can purchase the 300-metre (URDPFI) radius impacted houses, create a green belt around the industrial sector, and rehabilitate the residential area beyond the buffer**.	
3.Economic aspects	• The worth of the KMML is **Rs 880 Crores** . The major contributor of economy	▪ The industry backs foreign currency, **but the socio-economic impact** due to the industry involves a good number of issues of pollution create social unrest in people. ▪ They cannot depend on their limited land holding for sustenance, especially when **the fertility of the soil is also diminishing due to pollution.** In short, land utilisation for agricultural purpose is insignificant and declining.	▪ The **planned industrial area can promote educational tourism(** Industrial visit)can economic growth and reduce socio –economic impact. ▪ Reviving of contaminated soil by phytoremediation and maintaining the existing agricultural land. ▪ Alternative job opportunities should be provided based on the occupation skill of study area.	
4.Transportation	▪ The KMML is located near national highway 66 and national water way III ,so the efficient import and export of products and raw materials.	▪ It is **difficult for people to move around on rural roads** because of the air pollution caused by trucks' excessive traffic and dust emissions.	▪ The conveyance of the mined sand is done through trucks, and the road from the mining area to Mineral separation plant is also in bad shape. **The national waterway III can be utilised as an alternative for transportation issues in rural roads**	

5.Social infrastructure	▪ **The community health centre within 300 m from the industrial area to meet industrial accident.**	▪ **The cancer, acute respiratory infection and skin diseases are in increasing due to the radiation of chemicals and pollution in study area.** ▪ **Due to a lack of funding, the current community health centre is unable to address the hazards to the public health caused by the industry. The lacking facilities include periodic medical camps for cancer, ambulance, and dermatological department.** ▪ **The three educational institutions are within 300 m vicinity of industrial area violating URDPFI guidelines.**	▪ **KMML shall provide regular grant to neighbouring schools, hospitals and encourage them for their upliftment. Mock drills for emergency industrial accidents in schools and for public awareness.** ▪ **Regular medical check up and provision of free medicines is needed to reduce the fear and anxiety of the people that cancer and other diseases are on the rise in the study area.**	
6.Physical Infrastructure	▪ KMMl daily water supply is the one of the major source drinking water of polluted areas.	▪ The duration of supply is only 2 hrs a day in morning and evening is inadequate for the public needs. ▪ **The groundwater is polluted** due to iron oxide sludge from industries and cannot be utilised for any basic need of people. ▪ Lack of proper effluent management leading to degradation of natural source of water.	▪ **Regular water supply** is most essential need of any household. So, an effective water supply scheme, which takes care of the needs of the households in the area on a regular and consistent basis, must be formulated and implemented by KMML. ▪ **Maintenance of dilapidated effluent pipelines** through residential area and construction of proper sludge ponds for efficient disposal of waste.	
7.Environment		▪ **Air pollution** :-Due to release of gases from the KMML, The continuous passage of vehicles carrying soil in village create dust emission ▪ **Water pollution** :-The water in the well has become dry and other sources are contaminated with acid and not useful for domestic consumption or other purposes ▪ **Soil pollution** :-The soil has become polluted due to the leaching of iron oxide from KMML titanium plan. ▪ **Sea erosion** :-The stagnant water in the mine pits has become a breeding ground for mosquitoes, increasing the incidence of mosquito related diseases, skin ailments and allergic disorders. Sea erosion due to over mining of sand in coastal areas.	▪ The **existing village roads should be widened, resurfaced and should be maintained in good condition. Measures for developing green belt on the roadsides to be promoted**. ▪ The company must take steps to intensify **the water cleaning process** and other issues which have a direct bearing on the health and well being of people in the area. ▪ The **company shall earmark a part of their profit for corporate social responsibility**. ▪ **Coastal protection** such as sea walls need to be constructed to prevent natural disasters due to erosion.	▪ **Threats of environmental deterioration continue to be ignored by authorities due to the difficulty in regulating an industry that produces resources of high strategic importance.**

CHAPTER 7 BEST PRACTICES

In this Chapter the case studies are selected and studied in detail. The case studies are international level Arkansas in United States and Kwinana Industrial area in Western Australia area is selected to adopt their successful strategies to tackle issues in study area.

7.1 Privately owned scrap yard, Arkansas

7.1.1 Selection criteria

The one of the major issues of the KMML industrial area is the acid fields (16.53 ha) that leads to environmental degradation and health hazard to the public. So, these brownfields to Greenfields through Phytoremediation. Phytoremediation is the in-situ (onsite) use of plants to reduce contamination of soil, sediments, surface water or groundwater. By harnessing the natural capabilities of plants, we can remove, degrade, or stabilize contaminants. It can be a low-cost, but time intensive alternative to traditional remediation on sites where toxins are at shallow depth. It can also be an effective approach to reducing the leaching of contaminants through. soil or groundwater and can be used in combination with other remediation techniques. (Brownfields to greenfields, 2011)

7.1.2 Arkansas

This location has been contaminated for many years by automotive parts, scrap metal, and packing materials. To a depth of two feet, petroleum hydrocarbons and PCBs were discovered. Red mulberries that were one foot tall and were planted in a 2x2 foot grid in April 2001. Then, seeds for Bermuda grass were dispersed amongst the trees. After 18 months and again after 28 months, soil samples were collected. Tolerable low occupancy levels were reached for both TPH and PCB values. The 2-acre site's overall project expenditures came to about $140,000. Phytoextraction and phytodegradation is the process of Arkansas for reviving soil. (Brownfields to greenfields, 2011)

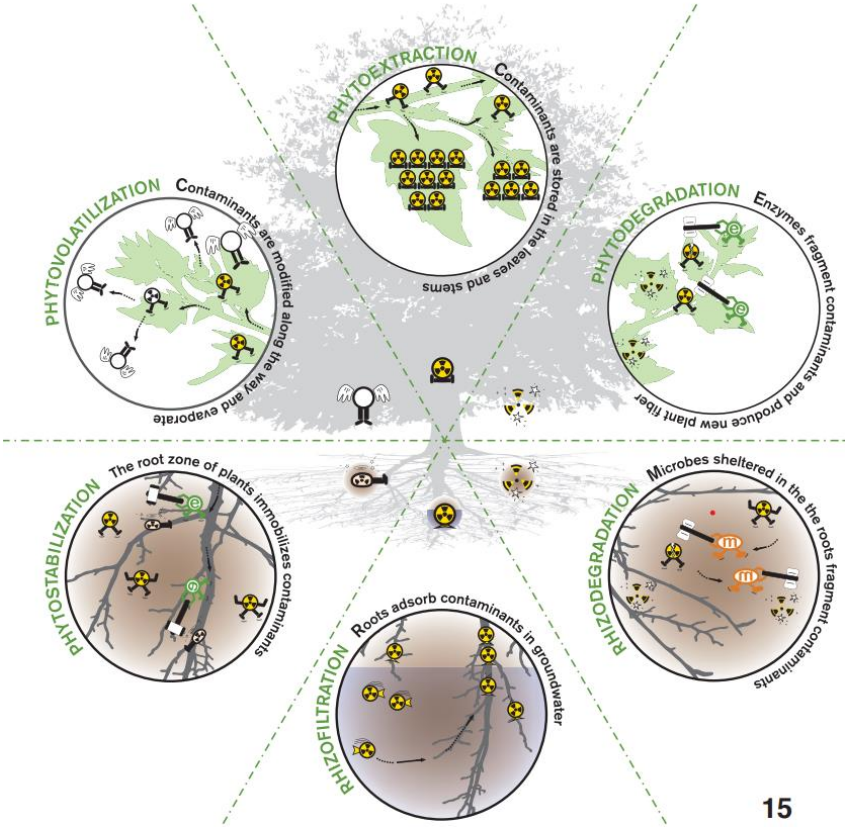


Figure 7.1 Figure shows using nature to clean the soil with heavy metal contaminants like lead, iron, cadmium.

Source: Brownfields to Greenfields,2011

Phytoextraction

With the help of their roots, plants absorb pollutants, primarily metals, metalloids, and radionuclides, which they then store in huge quantities within their stems and leaves. Hyperaccumulators are another name for these plants. (Brownfields to greenfields, 2011)

Phytodegradation

Through the release of enzymes and metabolic processes such photosynthetic oxidation and reduction, plants absorb and degrade pollutants. In this procedure, organic contaminants are broken down in the soil or degraded and absorbed into the plant. (Brownfields to greenfields, 2011)

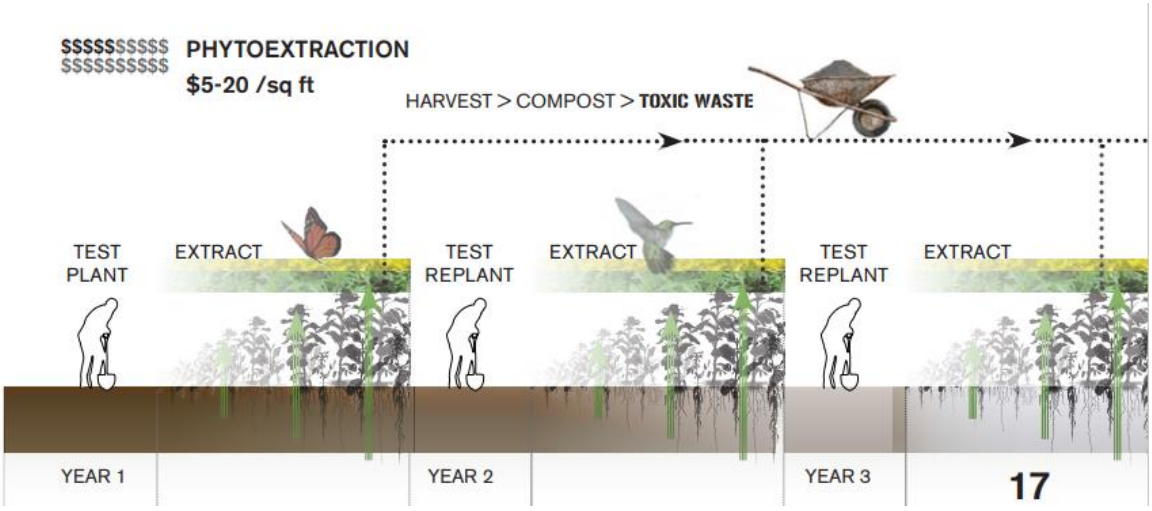


Figure 7.2 Phytoextraction.

Source: Brownfields to Greenfields,2011

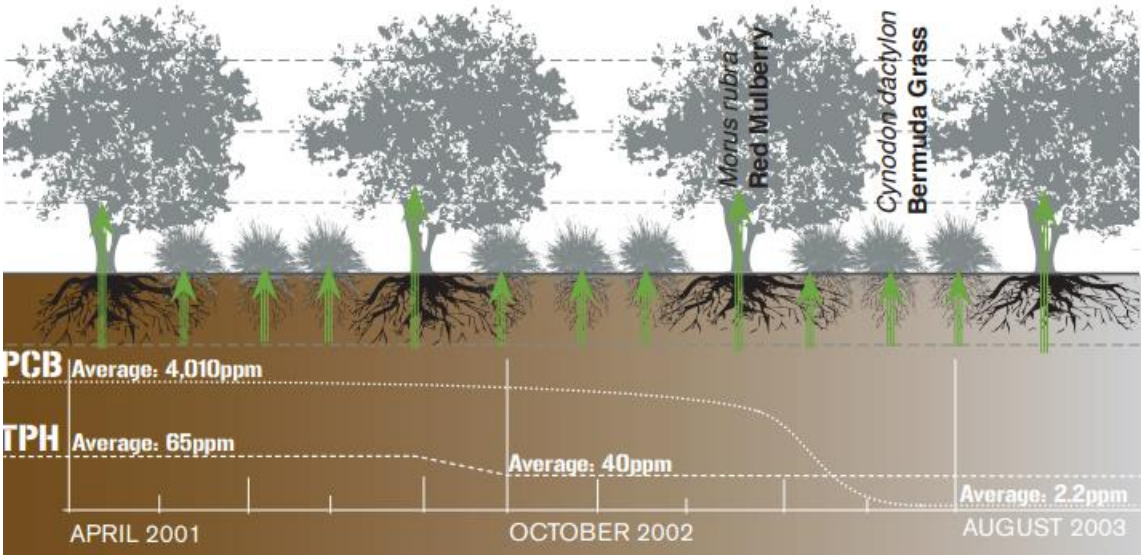


Figure 7.3 shows the reduction of 80% of contaminants in Arkansas.

Source: Brownfields to Greenfields,2011

7.1.3 Arkansas Phytoextraction process

When selecting plants for a remediation project, additional care should be taken to not introduce invasive species in areas where those species would have the tendency to hinder growth of other native plants.to eliminate contaminants from the soil, so you will likely plant more densely than normal, in a concentration that will cover the entire soil surface. (Brownfields to greenfields, 2011)

1.Planting and growing

In locations where invasive species have a propensity to impede the growth of other native plants, extra caution should be given while choosing plants for restoration projects. You will probably plant more densely than usual, in a concentration that will cover the entire soil surface, to remove toxins from the soil. (Brownfields to greenfields, 2011)

Figure 7.4 shows the planting and growing.

Source: Brownfields to Greenfields,2011

2.Harvest and dispose

Take advantage of the annual plants after about 14 weeks. not eat these plants, gather them Willow and poplar trees are examples of perennial plants that do not require yearly harvesting. Over time, they will spread their roots deeper and improve as remediators. Test the plant material you gathered. That determines if your harvested plants, when disposed

of at a landfill, would run the leaching chemicals back into the earth and deeper into groundwater. If the test is positive, they must be placed in a container and dumped in a hazardous waste landfill. Although it is unlikely, be ready to pay the price if it does happen. Additionally, it indicates that your remediation was a huge success. (Brownfields to greenfields, 2011)

Figure 7.5 shows the harvest and dispose.

Source: Brownfields to Greenfields,2011

Once your plants have grown to a particular size and are no longer threatened by weeds, some weeds may even be beneficial in reducing soil erosion. Persistent weeding will help your plants survive.

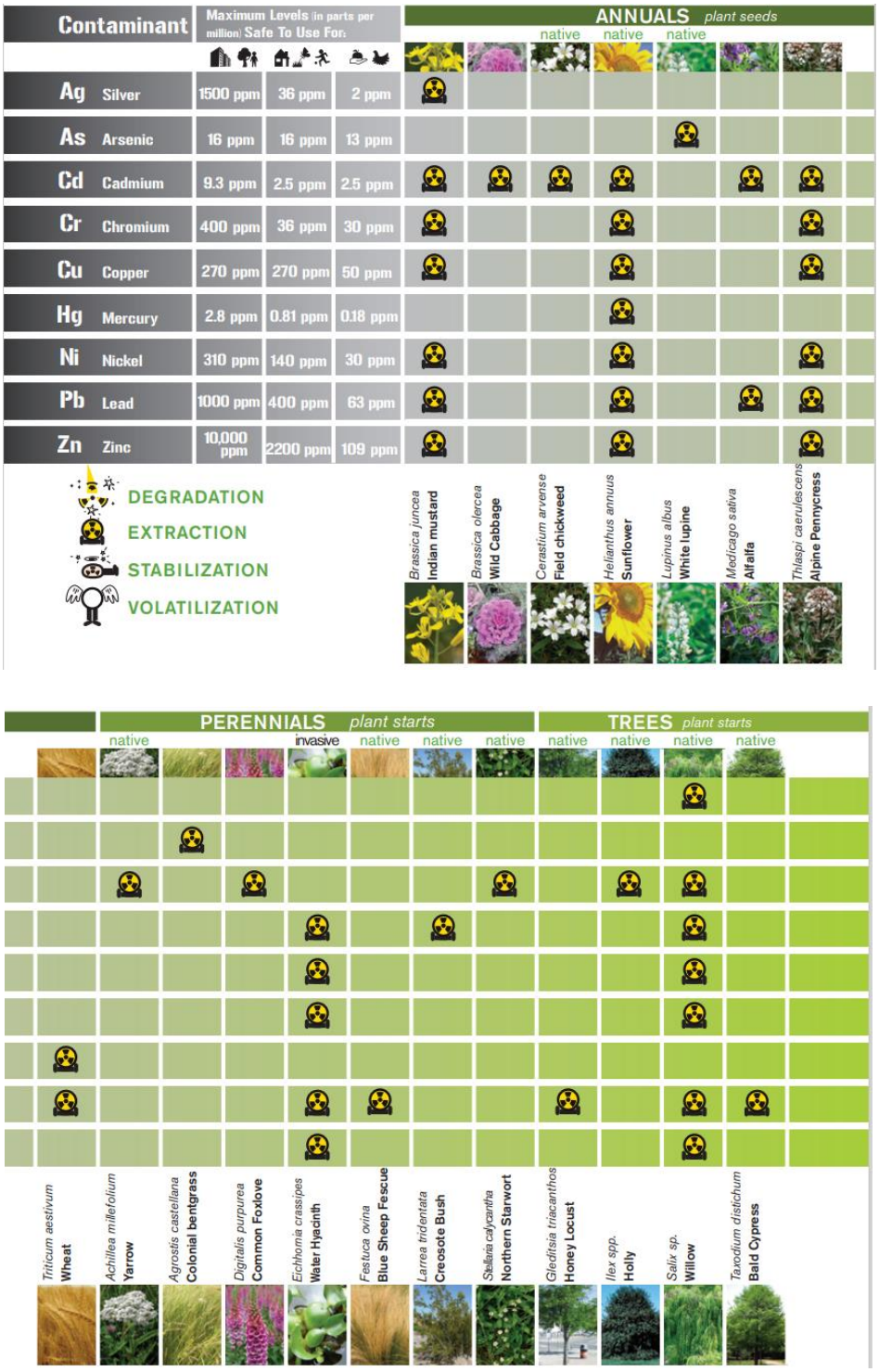


Figure 7.6. Common urban contaminants and their natural enemies

Source: Brownfields to Greenfields,2011

7.1.4 Inference

This phytoextraction can be used as a strategy to revive the acid fields of KMML industrial area. One of the greatest limitations to using phytoremediation is time. Reducing the level of contamination in soil may take several planting cycles or it may take several years for trees to develop roots deep enough to treat deeper levels of contamination. The native plants such as Indian Mustard, Wheat, Sunflower can be planted and the existing riparian mangrove forest on the banks of Vattakayal can be retained and can be provided as the green belt surrounding industrial area.

7.2 Kwinana industrial area in Western Australia

The Kwinana Strategic Industrial Area (SIA) is one of Western Australia's most important strategic industrial areas and is part of the State's premier heavy industrial zone, the Western Trade Coast. covering an area approximately 8km north-south and 2km east-west, on the eastern side of Cockburn Sound some 30km south of the Perth CBD. Approximately 270ha. The Kwinana Industrial Area (KIA) is the top-heavy industrial district in the State and a premier illustration of industrial fusion. It serves as the economic backbone of Western Australia. The KIA is one of the few places in the world where so many businesses collaborate with their industrial neighbors and the surrounding community to accomplish a variety of environmental, social, and economic benefits. (Kwinana Industrial Area Integrated Assessment , 2007)

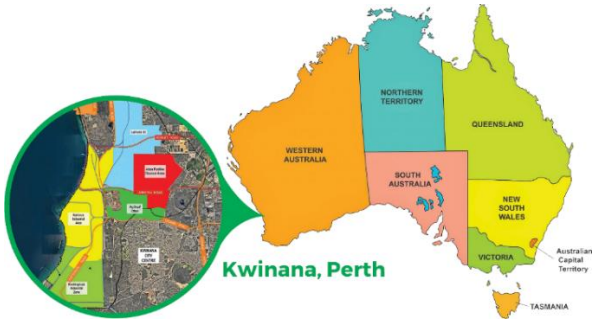


Figure 7.7. Location and zoning of Kwinana

Source: -The Kwinana Industrial Area Integrated Assessment (SKM, 2007)

7.2.1 Selection criteria

Development planning processes are efficient and as sensible as possible. Regulation of industry is sensible, consistent, and transparent. Decisions are made promptly. Cluster buffer zones are well protected from the encroachment pressures of influential residential property developers. Long-term strategic planning ensures the integrity of the cluster for the long term.

7.2.2 Demography analysis

Based on the 2011 census, the current population of the City of Kwinana is 28,657. Since 1996 the City of Kwinana has experienced a population growth rate of 49.4% between the period 1996 and 2011. The highest period of population growth was between census years 2006 and 2011, where the population increased by 25.2% (from 22,880 to 28,657 residents).

Year	1996	2001	2006	2011
Population	19,186	20,765	22,880	28,657

Figure 7.8. Population growth 1996 to 2011

Source: - Western trade coast integrated assessment ,2014

7.2.3 History and overview

A special Act of Parliament created the Kwinana Industrial Area in the 1950s, securing a 120 square km area to support the growth of significant resource processing enterprises in Western Australia. The KIA has a developed infrastructure, availability to trained labor, close ties to the local community, and the benefit of coexisting with a variety of supporting sectors. It is situated 40 km south of the center of Perth, close to the protected waters of the Cockburn Sound. The Kwinana Industrial Area is a top-notch industrial estate because of its many features. Its deep-water port can handle bulk goods, and it is connected by road and rail to the Fremantle container port and Australia's eastern states. The estate is 30 minutes by motorway drive from Perth's central business Centre. Kwinana is ideally situated for export markets since it has easy access to Southeast Asia via ships. (Kwinana Industrial Area Integrated Assessment , 2007)

Figure 7.9. Kwinana Industrial council

Source: -The Kwinana Industrial Area Integrated Assessment (SKM, 2007)

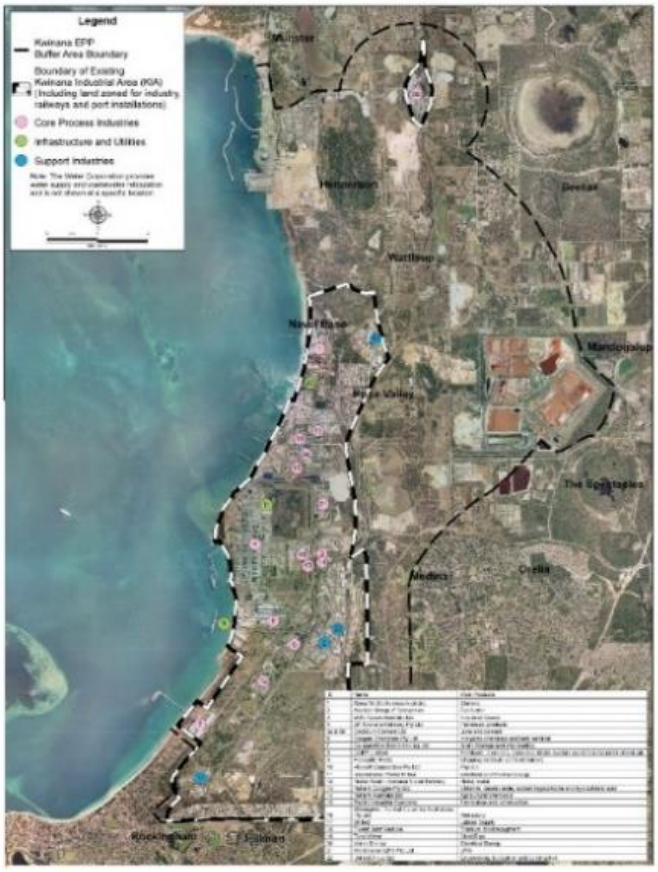


Figure 7.10. The Kwinana integrated assessment boundary from 2007

Source: -Western trade coast integrated assessment ,2014

Figure 7.11. The Kwinana integrated assessment boundary from 2014

Source: -Western trade coast integrated assessment ,2014

7.2.3 Key Strategic issues

1.Buffer area

2.Heavy transport linkages

3.Governance

4.Land availability for industrial expansion

5.Water availability and disposal

6.Simple regulations

7.Environmental, Social and Economic impact of chemical industries on local community.

7.2.4 Strategic Industrial Area Planning of Kwinana

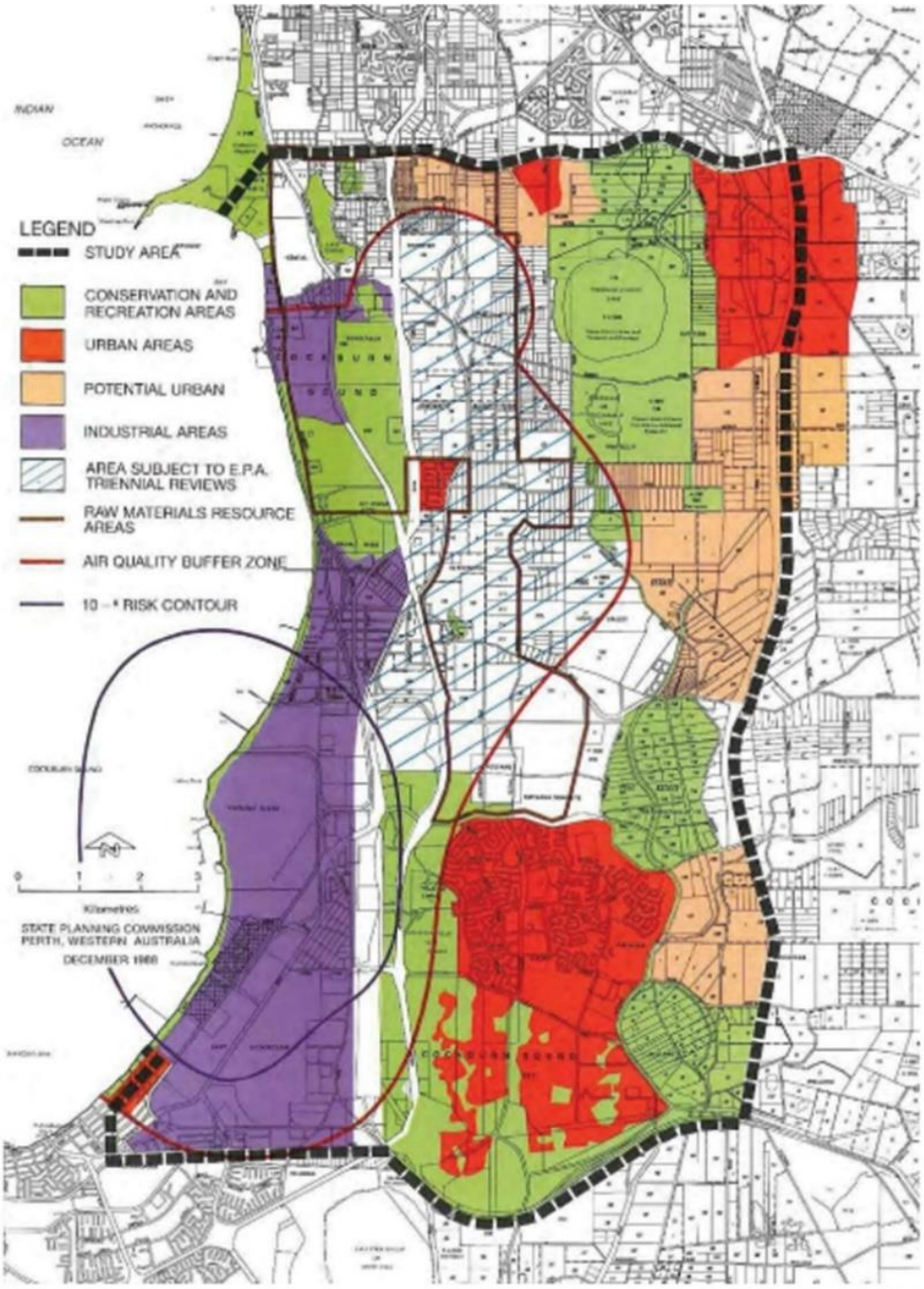


Figure 7.12. Kwinana regional planning

Source: -The Kwinana Industrial Area Integrated Assessment (SKM, 2007)

1. Buffer area: - Since the 1950s, when the Kwinana Industrial Area was established, the idea of a buffer for industry has been fundamental to its operation. According to its history, the buffer zone was first established to create a barrier between residential areas and companies that release Sulphur dioxide (SO2). Environmental Planning Policy (EPP) and State Planning Policy (SPP) of Kwinana both safeguard buffer zones.

Figure 7.13. The buffer of Kwinana Industrial Area

Source: -Western trade coast integrated assessment ,2014

2.The Kwinana Water Reclamation Plant (KWRP) is now a crucial component of the process water supply story since it transforms a significant amount of treated wastewater from the Woodman Point Wastewater Treatment Plant into high quality water suited for industrial processes. Perth's "drinking water" and groundwater supplies are partially met by the KWRP, which yearly generates about 5 billion liters of process water.

Figure 7.14. Water reclamation plant

Source: -Western trade coast integrated assessment ,2014

3. Managed Aquifer Recharge: - Transmit high-quality secondary treated wastewater to the aquifer east of the industrial area. For every additional kiloliter of MAR-water given to the groundwater supply, the same might be extracted downstream for industrial applications. The natural flow of groundwater is in a westerly route towards the coast. Physical removal of plumes is necessary, and this is accomplished by regularly pumping bores to remove contaminated groundwater and purify it. Regardless of the technique, the overall goal of cleanup is to prevent plumes from entering Cockburn Sound through the regular groundwater flows.

Figure 7.15. Managed aquifer recharge

Source: -Western trade coast integrated assessment ,2014

3.Kwinana Power Station can use either natural gas, coal, or distillate to fuel its power generating plant. Kwinana air quality buffer zone was created and formalized by the 1992 Kwinana Environmental Protection Policy. The buffer assists industry and the State Government to manage industrial emissions to maintain a healthy level of air quality for employees and surrounding communities.

4.In 2005 Kwinana Industries Council (KIC) commissioned Herring Storer Acoustics to undertake an update of data developed in 2001 from a cumulative environmental noise propagation model developed for industries within the Kwinana Industrial Area (KIA).

5. Waste management: -By products are useful and their use can be profitable. They often contain embodied energy. By-products are the resultant material, water, or energy, from production, processing and manufacturing operations that are not sold as core products. In 2003, the Eco-Efficiency Committee initiated a study to identify strategic solid waste management issues and opportunities for the KIA. (Kwinana Industrial area, 2023). Cleanaway provides hazardous waste solutions in the heart of the Kwinana Industrial Area.

- Treatment of titanium tetrachloride
- Transport and disposal of large volumes of contaminated liquids
- Storage, repacking, and disposal of naturally occurring radioactive waste.

6. Risk management: - Industries within the Western Trade Coast, and certainly within the KIC membership, carry out our various incident exercises each year, collectively and individually. The objective of debriefing sessions is quite simply to better prepare the people who are likely to be involved in an incident in the future.
(Kwinana Industrial area, 2023)

7.The KIC is committed to positive and socially responsible action to help the community through sponsorship, data collection and comparability to better appreciate and present industries' performance, conducting research aimed at a better understanding of the interaction of industry activities and the local community. maximizing transparency consistent with good governance and commercial confidentiality.

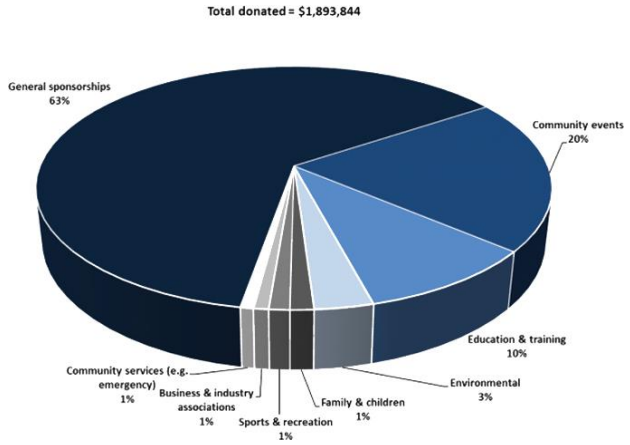


Figure 7.16. Chart showing the sponsorship of the company to the community.

Source: -Western trade coast integrated assessment ,2014

The bulk of donations were classified as general sponsorships. One participating industry reported a contribution that represented 58% of the total donated by reporting industries.

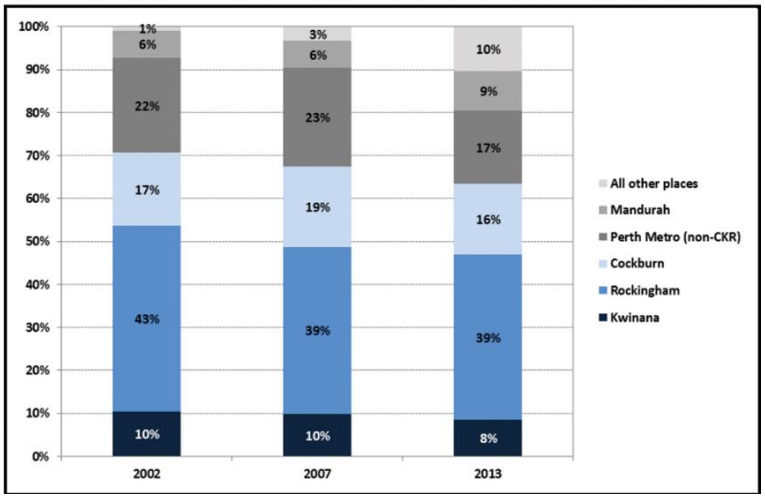


Figure 7.17. Employee residence

Source: -Western trade coast integrated assessment ,2014

Increase in employees reported as living outside Perth or Mandurah (Suburbs). Better road linkages and more housing in regional centers, allowing workers to live further from the industrial area. This point is reinforced by the increase in WTC employees reported in 2013 to reside in Mandurah.

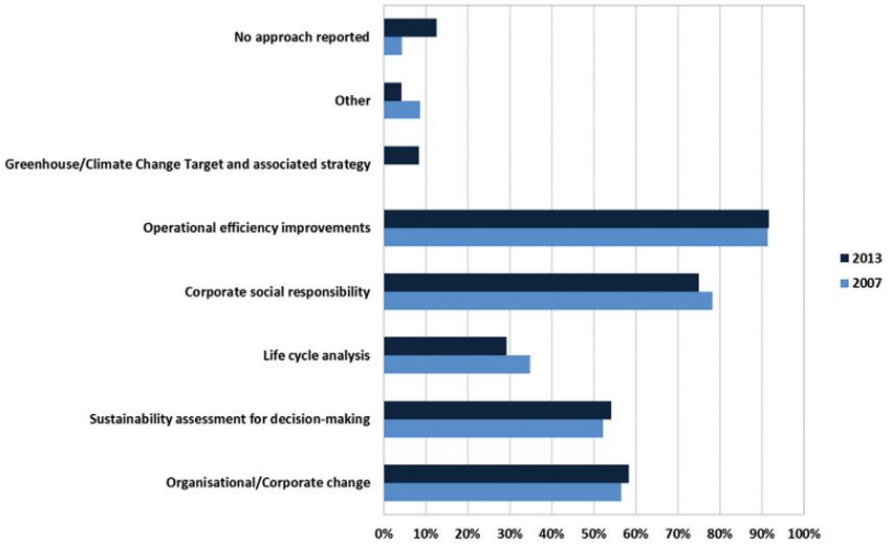


Figure 7.18 Sustainability approach of the industry

Source: -Western trade coast integrated assessment ,2014

Eco-efficiency and industrial ecology- to promote industrial ecology, cleaner production, closing production loop and efficient use of resources. Corporate social responsibility and industry sustainability covenants go beyond regulation to utilize policies to encourage social, environmental, and economic integrated benefits. It was envisioned in 2003 that, as economic reforms for sustainability took effect in WA, the shift of capital to investment in sustainability would accelerate.

8.**Access to heavy transport linkages – road, rail, ports,** located within the KIA are numerous pipeline corridors, and these are of great use in delivering the inter-industry product exchanges that make the industrial area world renowned for its industrial symbiosis. Western Trade Coast is governed under the one local government - Simple regulation. The WTC is some 6,000ha in area, with about one third already developed.

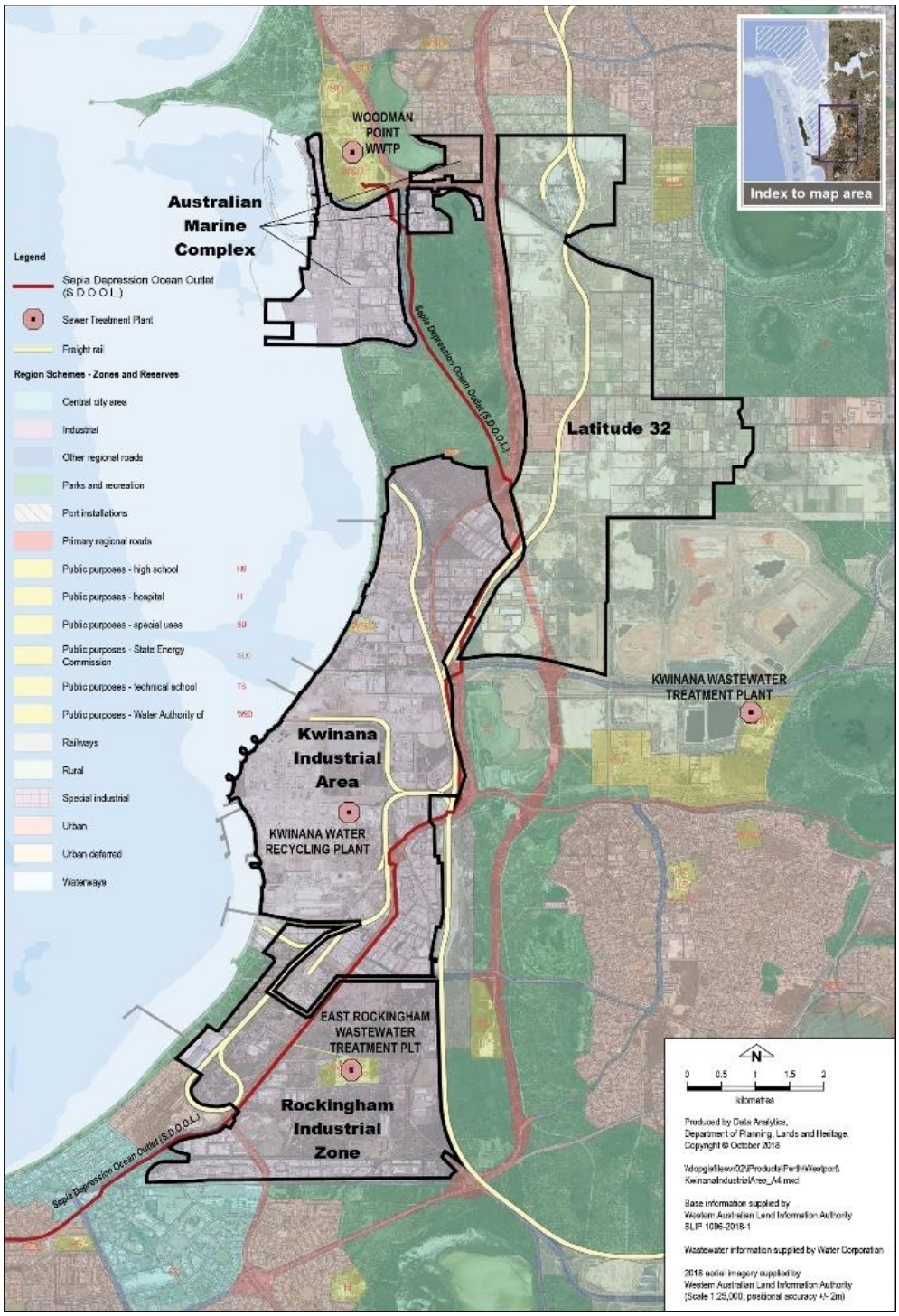


Figure 7.19 Western trade coast

Source: -Western trade coast integrated assessment ,2014

Figure 7.20 Review of Kwinana air quality buffer

Source: -Western trade coast integrated assessment ,2014

7.2.5 Inference

The increased environmental focus of Kwinana industry has resulted in several improvements through reductions in air emissions, cleaner production, waste minimization and water conservation and wastewater reuse. Through a commitment to open and honest communication, building enduring relationships with its neighbors that are based on mutual respect and long-term commitment, the KIC supports a range of forums including: Communities & Industries Forum, Kwinana Environmental Health Forum, Kwinana Industries Education Partnership, Kwinana Industries Noise Reference Group and Cockburn Sound Management Council. Employs more than 4,800 people directly, 64% of whom live locally. Contributes a high degree of social benefit to employees and their community with a high level of employee services and at least half of community partnerships invested locally.

CHAPTER 8 PROPOSALS

This chapter provides the study area's proposals formulated based on its issues identified through primary and secondary data analysis. After the analysis the suitable sustainable environmental practises, innovative technologies and infrastructure developments from best practises is adopted for the study area. These are proposals for converting the deteriorating industrial area into a well-planned industrial area.

8.1 Aim

To develop planning strategies for promoting and contributing to the sustainable co-existence of the KMML industrial area, its community, and the Environment.

8.2 Strategies

The strategies are formulated mainly to achieve the three missions mentioned. The table below provides a full breakdown of the planning strategies used, their implementation, timing, and the goal they aided to achieve.

- **Enhance the community**: - To maintain and enhance the community environment to the benefit of both the community and industry. Conducting research aimed at a better understanding of the interaction of industry activities and the local community.

- **Innovative environmental practises: -** To ensure sustainability for the long term to bring positive economic benefits. Adequately protected buffer zones are a critical enabler of industry, laid down to protect the health and amenity impacts on nearby residential areas, to keep them properly separated.

- **Strategic industrial area planning -** The KMML is strategically important to the State, hosting specialist chemical and resource- based processing installations, and bulk materials import and export operations. The SIA is serviced by heavy freight road and waterway. When an industrial area is identified by SIA status it is then afforded protection under either of two high level Statutory Planning tools. The one offering the strongest protection is

called a buffer area, and the one coming in at a reasonably close second is an Improvement Plan for the area.

Goals	Strategies	Long term /short term	Scale of planning	Implementation
1.To maintain and enhance the community environment for the benefit of both the community and industry.	1.Training of safety awareness programs 2.Formation of **local area environmental protection committee** 3.On site emergency plan : Formation of local crisis groups and district crisis group as part of disaster management plan.	**Short term**	**Neighbourhood**	**KMML industry and Local self government through safety wellness programme mock drills can be conducted in schools ,individual housing level and in CHC**
2.To ensure sustainability for the long term through innovative environmental practices  Figure : Illustration of horizontal view of buffer *Source : Google images*  Figure : Illustration of phytoremediation process *Source : Google images*	**1. Green Belt** **Type I :- Green loop surrounding industrial area** **A)**Acid fields **spread over 500 m** surrounding industrial area so the buffer is provided in this stretch. **B)**The **three-tier plantation comprising of tall trees, medium size trees and shrubs** are recommended for development of greenbelt around the industrial area. **C)Deciduous trees** (Neem ,Indian Gooseberries)can be used with less spacing for more effectiveness for air quality **Type II :- Green corridor** **A)**The **200 m length** green corridor for **mining area with mangroves and coconut palms.** 2.Revegetation of heavy metal contaminated soil **1)Phytoremediation** is the in-situ (onsite) use of plants to reduce contamination of soil, sediments, surface water or groundwater. By **harnessing the natural capabilities of plants, we can remove, degrade or stabilize contaminants .(Indian mustard,Sunflower)** **3. Coastal protection** 1.To prevent coastal erosion , **groynes** must be constructed for the land reclamation. **Built to "protect" buildings that were built on a beach that is losing sand.** 2.The strict laws must be enforced as per **CRZ rules to reduce over dredging in coastal areas.**	**Long term** **Short term**	**Neighbourhood** **Meso**	**KMML industry and Local self government** **2.Local area environmental protection groups for plantation-Through environmental monitoring programmes the local govt and Kmml , invoving local people of area can create a green belt for 854.48 acre** **Green corridor - 0.59 acre land afforestation.** **KMML and State government** **The Petronet LNG Ltd, Kochi can be taken up the construction of coastal protection structure and groyne.The company has obtained technical assistance from IIT for coastal protection.***(Source : EIA for mining lease .2017)*
3. To ensure safety and high quality governance in social infrastructure	1.The **existing community health care (CHC) should be upgraded to super speciality hospital .** 2.Regular **medical checkup surrounding industrial area for ensuring public health.** 3.Since **cancer and skin diseases of study area is in increasing rate . Cancer care and skin care centers are required.** **4.Safety wellness program for schools within buffer to meet emergency accidents**	**Long term** **Short term** **Short term**	**Meso** **Meso** **Meso**	**KMML and State government** **KMML medical examinations and periodical medical care should be done by the company medical team and CHC together freely. Sponsorship for medical care for cancer patients and medical aids for the CHC to meet the need of local people.**
4.Integrate transport system to accomodate the industrial sustainable growth	**Harbour or terminal facility** 1.The industrial core can **rely on terminal for the import and export .**The **national waterway nearer the industrial area can be utilized for the import and export of raw materials and products of the industry and also promote tourism (educational)** 2.The **local roads used for heavy movement trucks need to be** widened and resurfaced.This can **reduce the dust pollution** due to movement of heavy trucksThe truck movement should be in **non peak hours (night)** and it should be strictly enforced. Speed limit of the trucks-> 25 km/hr.	**Long term** **Short term**	**Macro** **Meso**	**NW- 3 is the project of the Inland Waterways Authority (IWA) of India, Noida by Central government. The state government can involve a terminal in KMML industrial area under this project for heavy goods transport.The local roads can be resurfaced by KMML. Speed limit and duration strict laws must be enforced by government.***(Source : EIA for mining lease .2017)*

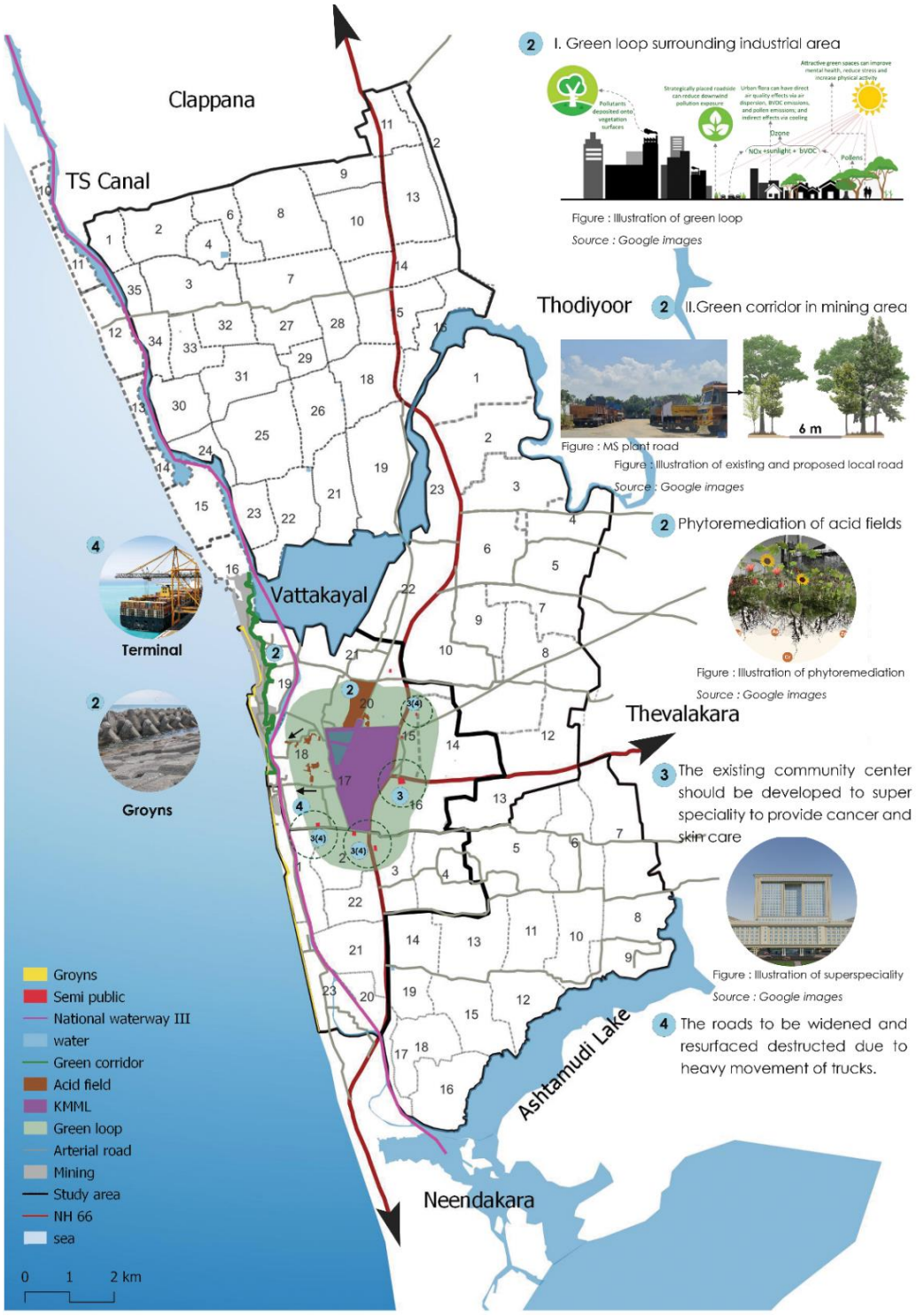


Figure 8.1: Map showing the proposed strategies (1-4) in study area.

Source: Author generated with reference to study 2023

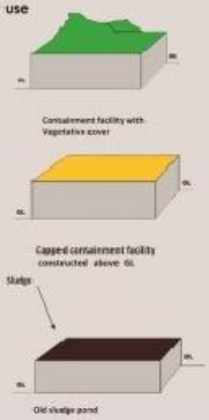
Goals	Strategies	Long term /short term	Scale	Implementation
5.To exhibit excellent industrial symbiosis, sustainable practices in physical infrastructure	**1. Water reclamation plant** 1. The **water before released through waste water canal nearer the TS Canal , it should be treated efficiently in such a manner it should not pollute the perinnial Vattakayal** 2..The large volume of treated **wastewater from the industry can be converted to high quality water suitable for industrial processes .** **2. Managed Acquifer recharge** Deliver good quality secondary treated wastewater into the aquifer of the industrial area. This recharges groundwater and reduce groundwater pollution. **3. Desalination plant for consistent water supply** 1.The **desalination plant** using **Perennial TS Canal/Vattakayal as a water source** to meet the need of drinking water demand 0.21MLD consistently. for public purpose.Since the existing water supply is Treated groundwater from KMML and it is under depeletion stage.	Long term Long term Long term	Meso Meso Meso	KMML industry can invite Thermax Company Pune India for waste water treatment .20, 000 installations across various industries like food & beverages, textiles, pharma, automobile, steel, power, chemical, fertiliser, oil & gas, petrochemical and the urban sector by Thermax in India Green Method Engineering Pvt limited Kochi can be invited by KMML for desalination plant.GME is an Approved 'A Class' consultant of Kerala State Pollution Control Board and Approved consultant of Kerala State Suchitwa Mission.
6.To recycle the waste products, on the premise that a material (wastewater in this case) is not a 'waste' until it has no further use  	**1.The iron oxide sludge management of KMML** **1)Secured iron oxide ponds** The iron oxide sludge and ETP sludge content in the old ponds should disposed in a secured containment system a) Construction of an **in-situ secured containment system within the existing old sludge pond** b)Construction of **ex-situ secured containment system adjacent to the existing old sludge pond.** c) The in-situ **secured contentment system, it is recommended to divide the disposal area into the number of containment cells with part by part excavation construction and disposal in secured containment cell.** After the entire quantity of sludge in the old sludge pond are removed and disposed, the cells are recommended to be capped permanently. **2.Acid regeneration plant** a.Existing acid regeneration can be modified to Acidic free iron oxide sludge generation and to facilitate converting to saleable products. **3.By- products** Converting iron oxide sludge to usable products such as **iron oxide bricks. Thus value addition to iron oxide sludge.**	Short term Short term Short term	Meso Meso Macro	KMML identified M/s Renuka Equipments Pvt. LTD, Nagpur for iron oxide management for construction of secured ponds.*(Source : National green tribunal action plans for KMML 2022)* KMML invites Global tender for it. The offer submitted by M/s INDROX GLOBAL PVT. LTD is under evaluation for the modification of acid regeneration plant.*(Source : National green tribunal action plans for KMML 2022)* M/s Miracle sand and Chemicals, Tuticorin is invited for use iron oxide residue for bricks by using iron oxide sludge of industry.*(Source : National green tribunal action plans for KMML 2022)*
7.To provide resettlement / rehabilitation of affected households	**4096 affected households need to be rehabilitated as per the** R&R plan based on the relevant state/national rehabilitation & resettlement policy such as **National Rehabilitation and resettlement policy 2007.**(In this affected household LIG is 34% , MIG is 40% and HIG is 26 % can be rehabilitated in the vacant land identified most accessible and nearby area). **1.Land value :-Land value** based on current market value by revenue authorities.**Value for trees** and structures to be added.**Shifting charges** to be provided.A list of evictees will be maintained **to provide employment on priority basis wherever there is an opportunity.** **2.Fishermen community** can be engaged in **transporting heavy minerlas and maintain green belt.** **3.**A section of **local youth** shall be trained in phases so that they can take up contractual jobs (mining, **civil, transportation, supply of materials and other small scale rural business developments or similar indirect jobs & business and educationall tourism)**	Long term Short term	Meso Macro	KMML industry should implement the Resettlement and Rehabilitation package of affected people along with Indian Rare Earth Minerals the mining company. KMML industry ,Government and Indian Rare earths can utilize the local workforce.

Table 8.1: Showing the housing details for rehabilitation in identified land.

Source: Generated based on building rules

Identified land	Area	Ward	Structure	No : of blocks	No : of units	Built up area	FAR
Land 1 (LIG)	7.072 acre	5 th ward	G + 3	87 Blocks	1392	466 Sqft	2.12
Land 2 (MIG)	12.72 acre	10 th ward	G + 3	103 Blocks	1639	724 Sqft	2.15
Land 3 (HIG)	24.79 acre	13 th ward	G + 3	67 Blocks	1065	1000 Sqft	1

The housing layout for identified vacant lanfor the low income group, middle income group and high income group of affected areas is shown below

Figure 8.2: Housing layout for LIG

Source: Author generated using AutoCAD 2023

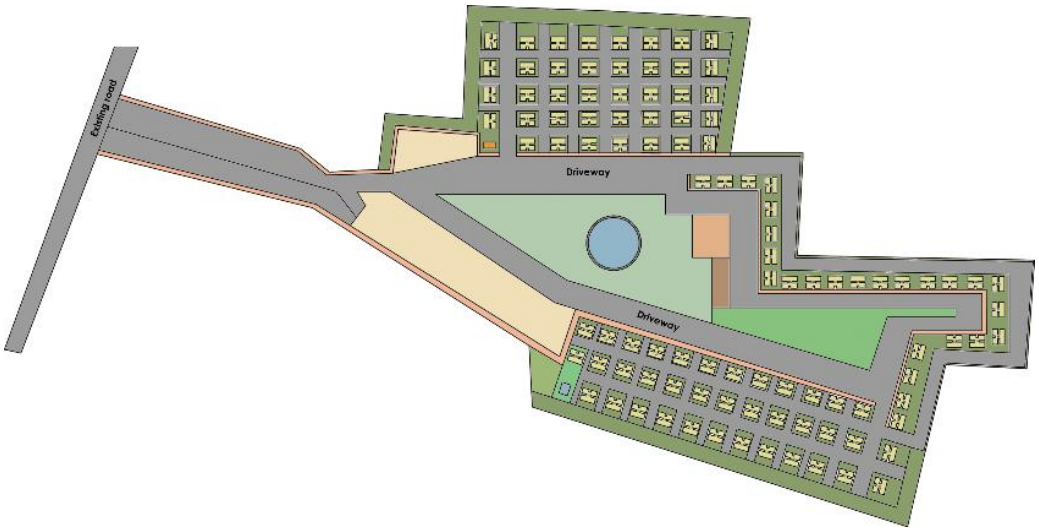


Figure 8.3: Housing layout for MIG

Source: Author generated using AutoCAD 2023

Figure 8.4: Housing layout for HIG

Source: Author generated using AutoCAD 2023

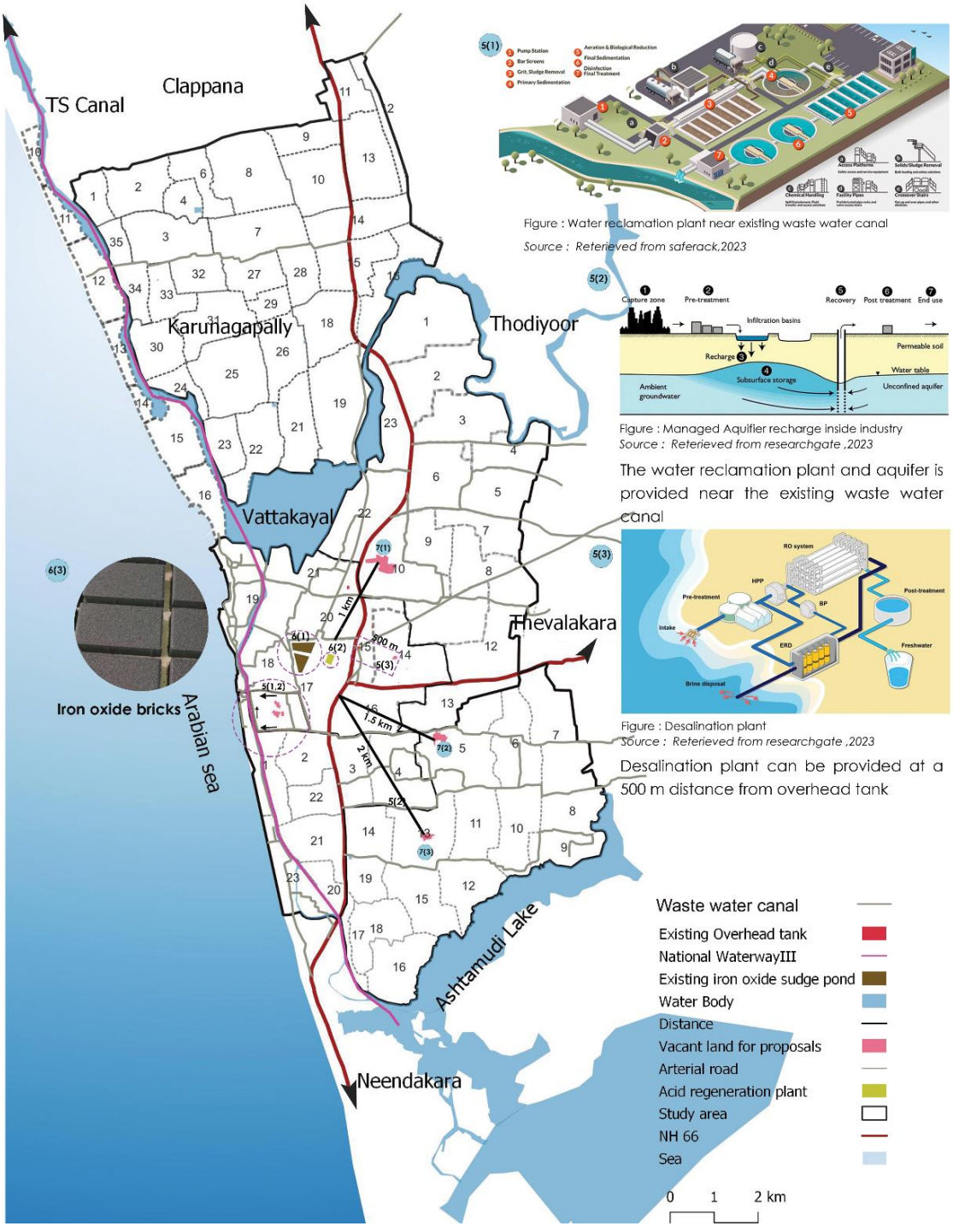


Figure 8.5: Map showing the proposed strategies (5-7) in study area.

Source: Author generated with reference to study 2023

8.3 Existing issues in study area

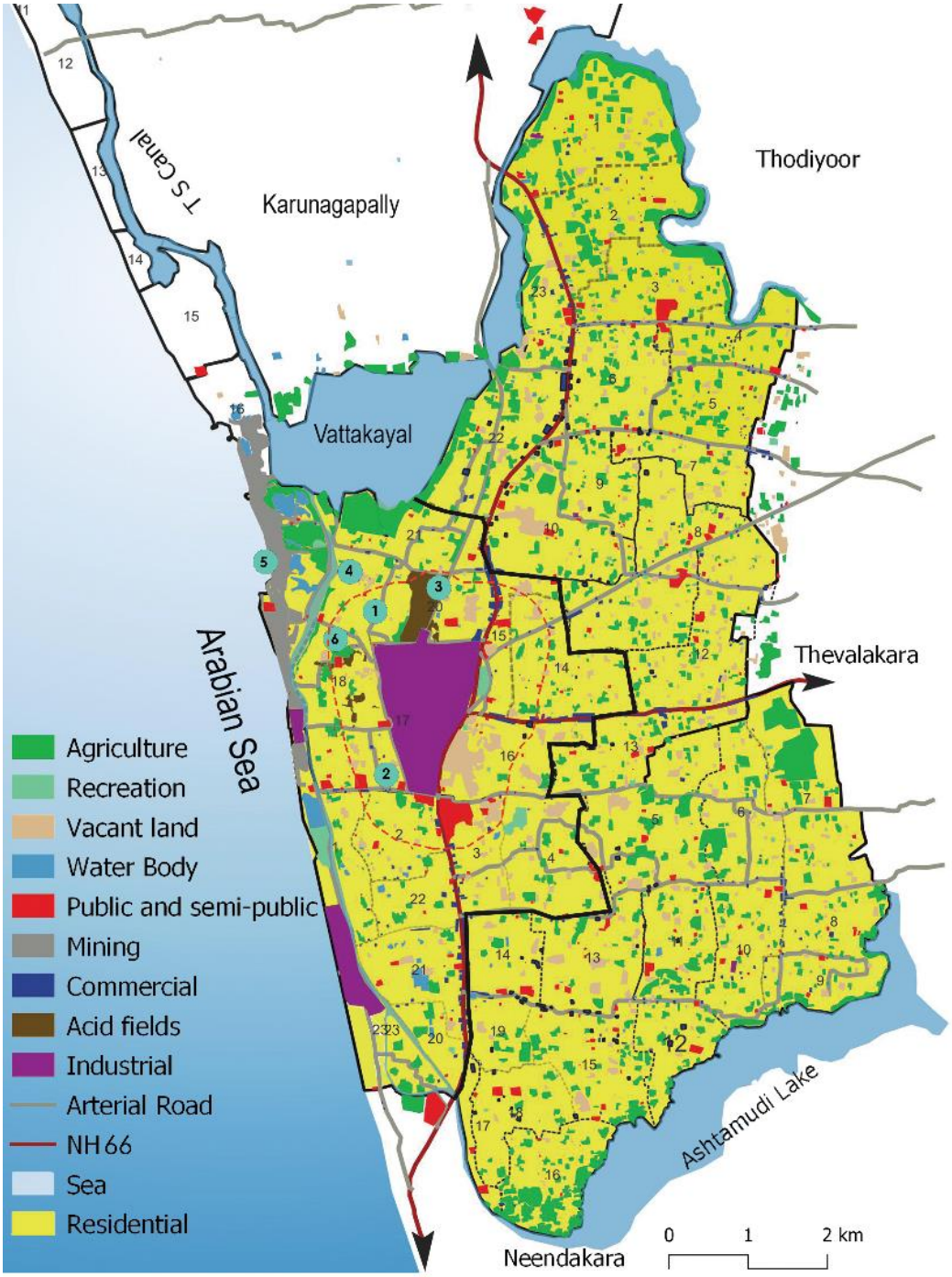


Figure 8.6: Map showing the existing issues of study area.

Source: Author generated with reference to study 2023

1. The educational institutions are nearer to industrial area within 300 m distance need sensible planning measures.
2. The acid fields of Panmana extending to 500 m stretch from the industrial area one of the major environmental degradations.
3. The TS Canal connecting Vattakayal flowing near to industry polluted due to iron oxide sludge effluent waste canal.
4. The over mining in coastal areas lead to coastal erosion and violating CRZ regulations.
5. The local roads are used for heavy goods transportation, these roads need proper maintenance.

Figure 8.7: showing the issues of study area.

Source: generated with reference to study 2023

8.4 Proposed strategies in existing land use

The KMML is strategically important to the State, hosting specialist chemical and resource-based processing installations, and bulk materials import and export operations. The

regulation of industry is sensible, consistent, and transparent in these sectors. Long term planning for 1-5 yrs. and short-term planning within 1 year.

Figure 8.8: The sectors focused for improvement.

Source: generated with reference to study 2023

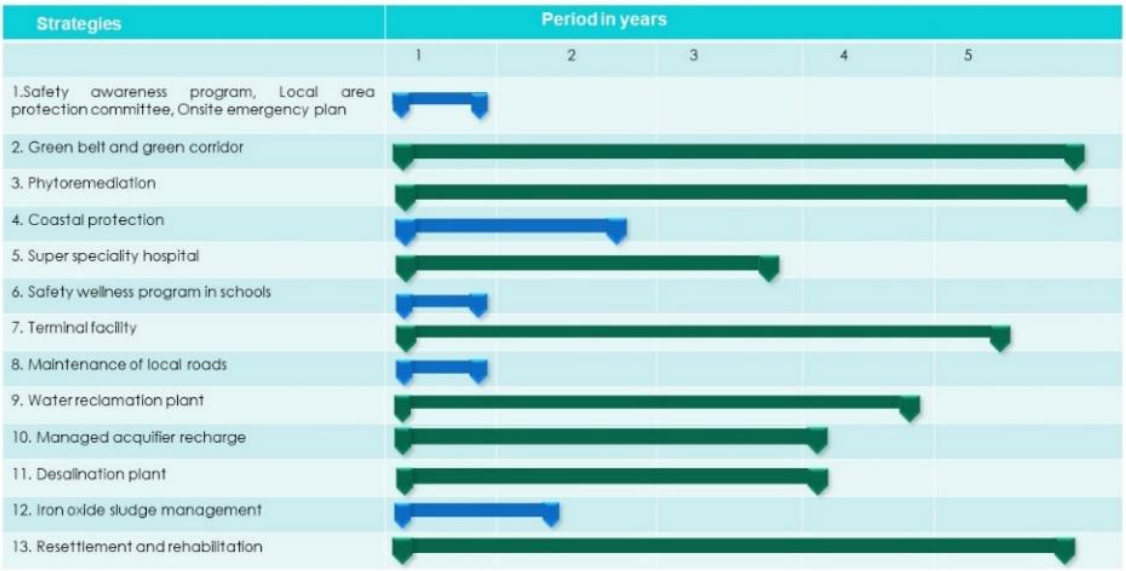


Figure 8.9: Gantt chart showing the implementation time of strategies.

Source: Author generated with reference to study 2023

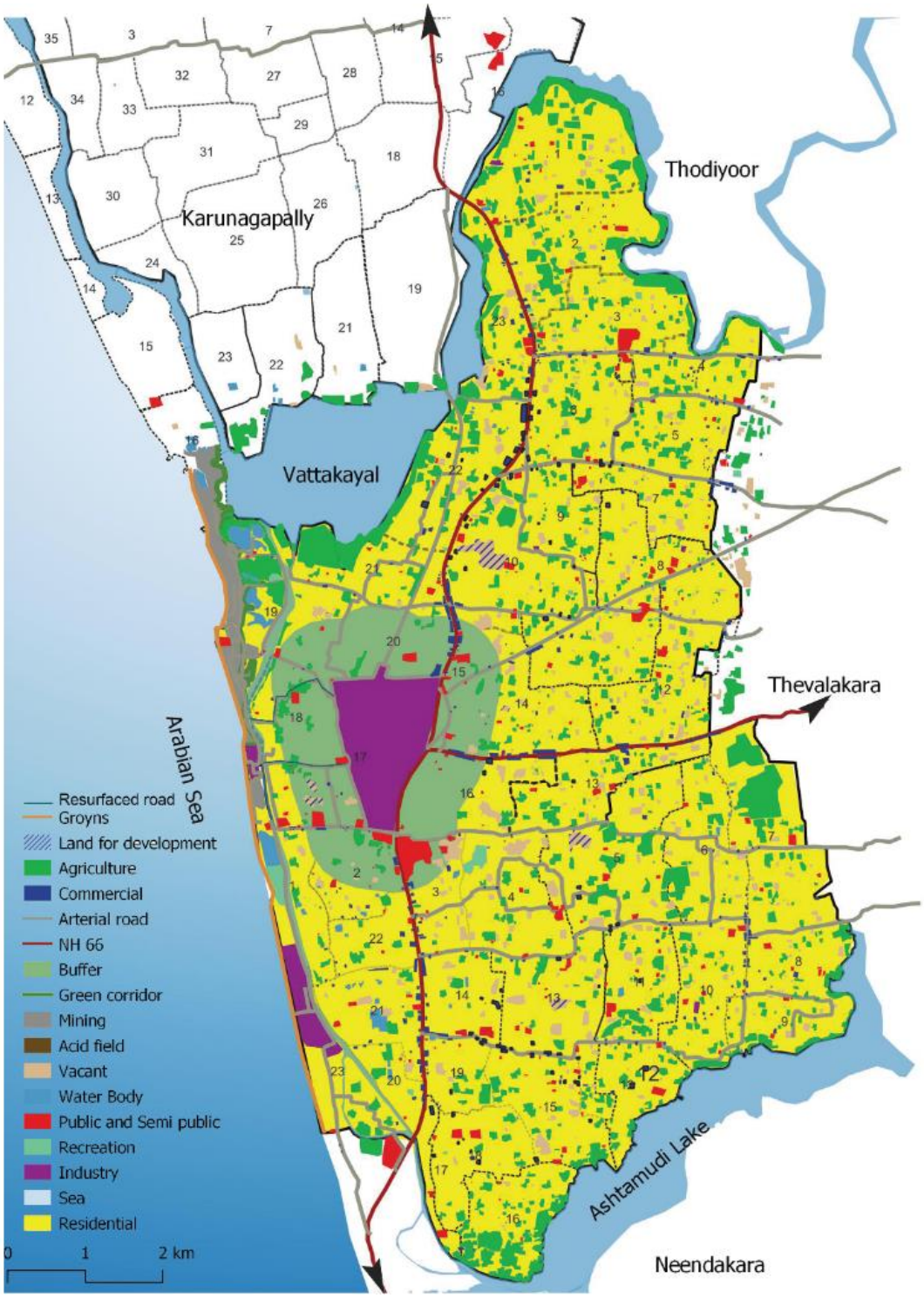
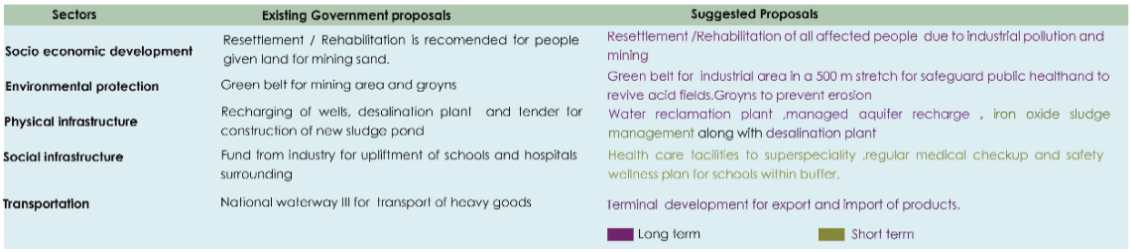


Figure 8.10: Map showing the proposed land use.

Source: Author generated with reference to study 2023



Sectors	Existing Government proposals	Suggested Proposals
Socio economic development	Resettlement / Rehabilitation is recomended for people given land for mining sand.	Resettlement /Rehabilitation of all affected people due to industrial pollution and mining
Environmental protection	Green belt for mining area and groyns	Green belt for industrial area in a 500 m stretch for safeguard public healthand to revive acid fields.Groyns to prevent erosion
Physical infrastructure	Recharging of wells, desalination plant and tender for construction of new sludge pond	Water reclamation plant ,managed aquifer recharge , iron oxide sludge management along with desalination plant
Social infrastructure	Fund from industry for upliftment of schools and hospitals surrounding	Health care facilities to superspeciality ,regular medical checkup and safety wellness plan for schools within buffer.
Transportation	National waterway III for transport of heavy goods	Terminal development for export and import of products.
		Long term / Short term

Figure 8.11: The comparison of existing proposals with suggested proposals

Source: Author generated with reference to study 2023

8.5 Summary

1.The suggested strategies are long and short term to tackle the issues of study area and a spatial improvement plan for the area.

2.KMML can be facilitated through the provision of the basic infrastructure such as appropriately zoned and buffered land, efficient and scalable transport and corridors, utility provision designed to accommodate growth, etc. Governments can also ensure that their governance over the industry is of high quality.

3.The well planned KMML can maintains the strategic significance of the area for the State.

4.Development planning processes are efficient and as sensible as possible then the decisions should be made promptly.

CHAPTER 9 CONCLUSION

The study was conducted in Panmana and Chavara panchayats of Kollam district, where the public sector KMML is undertaking. From the respondents it helped to find out that almost all people residing in study area had a lot of health problems and various other problems from the polluted air and toxic effluents emitted because of mining activities and processing that have been going on there for some time since the KMML came into existence. The two-hour water supply that KMML provides and there is no other source of potable water and not all areas get a regular supply. The study found that the local environment was deteriorating.

Based on the summary of the study, strategies are suggested to tackle the existing issues in the study area due to industrial pollution. The best practices considered are international cases like the context to prepare strategic solutions. The phytoremediation process of Arkansas in the US is adopted to convert brownfield to greenfield surrounding industrial area and sustainable solutions of well-planned Kwinana industrial area is adopted for the enhancement of study area. The proposed remedial measures are both long-term and short-term. The Gantt chart is used to show how long each plan will take to complete.

The recommendations include innovative approaches like plantations that surround industrial and mining areas and act as a buffer to residential zones, such as green belts and green corridors., de-bottlenecking infrastructures such as Terminal facility utilising existing potential National Waterway III for heavy material transport. The integration of the latest innovations into the physical infrastructure, including monitored aquifer recharge, water reclamation and desalination facilities for managing wastewater and producing potable water. The utilization of iron oxide sludge of KMML for by products such as iron oxide bricks. The housing layout for rehabilitation and resettlement of affected people surrounding industrial area. Along these suggested strategies, measures such as coastal protection to prevent mining and regulations to improve the land use of study area.

The proposals promote a positive image to KMML in industrial area planning, the existing brownfield surrounding industrial area can be revived to greenfield through these strategies.

The provision of terminal facility in National waterway will connect the industrial and manufacturing centres, open new trade routes, and support the country's sustainable development. Effectively balancing the needs of the community such as clean water, waste management through innovative modern technologies, industry and the environment can make KMML unique in Kerala. For the benefits of industry to be retained, the industrial processes concerned must have a sustainable future. Such a future must allow for new investment to continue in the KMML so that industry can grow. At the same time, industry has a responsibility to the community to conserve the environment for current and future generations of study area.

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APPENDIX -A

Checklist for field study

Parameters	**Field study**	**Focus group discussion**	**Household survey**	**Industrial survey**
1.Buffer zone				
2.Agricultural land degradation				
3.Built ups				
4.Health facilities				
5.Air, water, noise, and groundwater quality				
6.Biodiversity degradation				
7.Hazardous waste management facilities				
8. Traffic due to industry				
9. Safety facilities				
10. Water scarcity				
11.Development community requires				

APPENDIX - B

DEPARTMENT OF ARCHITECTURE

TKM COLLEGE OF ENGINEERING

QUESTIONNAIRE FOR HOUSEHOLD SURVEY

SURVEY SHEET NO: _____

DATE:

1.Ward number:

2.Age:

3.Gender:

4.Occupation:

5.Residing since (year): -

6.Type of housing: - Concrete/Tiled/Asetose

7.Density of dwelling unit: - Dense/ spares

Physical infrastructure

8.Source of drinking water:

Govt water supply	Public tap	Bore well	Open well (own)	Water tank	River/canal/lake/pond	Others

9. Quality of water

Odour	Taste	Colour

10. Scarcity of water:

Yes	No	Reason

11. Quality of air: -

Yes	No	Respiratory diseases	Climate changes (Rainfall pattern / season changes)

12. If groundwater is polluted: -

Social Infrastructure

13. Health service nearby:

Government	Private	Distance

14. Affected by any diseases:

Name of disease	Since year

15.Any government support for health care for disease affected people:

16. Any disabilities:

17. Death or accidents occurred due to industry: -

18.Safety/Security of the place (Emergency facilities): -

19.Any support/help from the industry for the local community: -

Health care	Drinking water supply	Environmental protection

20. Any protest industry by the local community: -

21.Issues faced by the schools/colleges nearby due to industry: -

Spatial analysis

22.Loss of agriculture or property due to toxic effluents from industry: -

Yes	No	Land area (acres/cent /hectares)

21. Soil condition for agriculture: -

23.Major crop of area: -

24. Any environmental activities by local organisations:

25.Developments needed in area: -

Transportation

26.Difficulty due to heavy trucks: -

27. Traffic congestion due to industrial transportations: -

INDUSTRIAL SURVEY

1.How the hazardous waste is managed?

2.Mode of transportation of raw materials: -

3.Environmental measures of industry towards the community: -

4.If the industry following CPCB/SPCB guidelines: -

5.Effuent is treated before releasing to nearby waterbodies?

6. Loading and unloading of goods to the industry