

Environmental impact of open pit coal mining. case study: district of Moatize (2010 to 2023)

Abstract

The subject of this article is the environmental impact of open pit coal mining, with the general objective of evaluating the environmental impacts caused by open pit coal mining in the Moatize district. A qualitative approach was chosen, in an exploratory and descriptive research, regarding the technical procedures, consisting of a case study. It is concluded that residing in Moatize is not safe due to the harm that coal mining can bring to them. Dust was a much-mentioned element among respondents. Coal dust is referred to as causing health problems for those who live in the municipality of Moatize, especially in the neighborhoods close to the mine. The results of the study demonstrate that it is imperative that there must be an increase in the institutional responsibility of companies and government bodies, providing health care and promoting environmental interventions for the population of Moatize, directly affected by the precarious living and health conditions and by dust from charcoal, as well as a deeper re-discussion of the political and ethical aspects linked to the resettlement of more exposed population groups.

Keywords: mineral coal, exploration, environment, impacts and open pit

Volume 8 Issue 2 - 2024

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Received: April 05, 2024 | **Published:** April 25, 2024

Introduction

Contextualization

According to Goldemberg¹ the evolution of humanity, from the time of primitive man to contemporary society, is directly linked to energy consumption. With this we can say that energy is fundamental in the development of life.

In this way, the introduction of mineral coal marked the end of the era of renewable energies represented by wood and scarce hydro and wind energy, to begin the era of non-renewable energies – the era of fossil fuels.²

Mineral coal is, therefore, one of the most important resources to help the development of a nation, but obtaining it puts the characteristics of the nation's environment and nature at risk.

Nature has always provided forms of self-regeneration that adapt to the natural dynamics of the transformation of natural resources. However, this capacity has been surpassed by human activities which, given the growing need to increase the efficiency of the exploitation of natural resources and to overcome the limitations of these resources in the face of current demographic growth and mainly due to economic-financial imperatives, have been introducing variables foreign to natural dynamics. These changes have largely contributed to the deterioration of the natural environment.

However, for the rational use of coal, technical-scientific measures were developed that allow sustainable exploration, the correct interpretation of natural phenomena and their optimization.

Coal mining in Mozambique has increased rapidly in the last 10 years, due to the discovery of new coal deposits in Tete province. In 2008, it was discovered that one of the largest unexplored coal basins in the world, with an estimated capacity of around 23 billion tons of coal, was in the district of Moatize, in the province of Tete.

In 2010, multinational companies such as Vale Moçambique (from Brazil), Rio Tinto (Anglo-Australian), Jindal Steel and Power

(Indian), Coal and Beacon Hill (United Kingdom), Eurasian Natural Resources Corporation (Kazakhstan) and Minas de O Revubúé (Anglo-American) settled in Tete province to explore coal.³

Nature always has forms of self-regeneration that conform to the natural dynamics of transformation of natural resources. However, in the Mozambican reality, this capacity has been surpassed by human activities which, given the growing need to increase the efficiency of the exploitation of natural resources and to overcome the limitations of these resources in the face of current demographic growth and mainly due to economic-financial imperatives, has been introducing impacts on natural dynamics. These changes have largely contributed to the deterioration of the natural environment.

The choice of topic is justified by the authors following frequent complaints from residents of the Moatize region regarding the open-pit coal mining activities of Vulcan and ICVL, which are related to quality and non-compliance in the process, such as changes in ecosystem services, in particular changes in water and air quality.

The study of this topic is relevant not only for the professional and personal development of researchers, but it is also important for the social context, since each open pit coal extraction activity has an impact on citizens, thus becoming a mechanism of information to the public. Public interest that aims to improve knowledge about open pit coal extraction activities.

In 2017, the Moatize Coal Mine produced around 11 million tons of coal. As they are open-pit coal mines, their environmental impacts include air pollution, water pollution, soil degradation, social impacts and carbon emissions that contribute to climate change. On the other hand, communities complain about the negative impacts caused by open pit coal exploration in Moatize. It is in this sense that we intend to carry out a case study that allows us to understand this problem.

In view of the arguments above, the need to answer the following questions arose: What is the environmental impact of open pit mineral coal exploration in the Moatize district? To provide more information, other questions arose: What are the potential ecosystem services

associated with the project coverage area? Are mitigation actions carried out by both companies, within the scope of their respective Environmental Management Plans?

To answer this question, the following general objective was outlined: Evaluate the environmental impacts caused by the exploration of mineral coal in the open air in the district of Moatize, being subcategorized into the following specific objectives of the study: Identify the potential ecosystem services associated with the area covered by the project; Describe how the effects of coal exploration interfere with the provision of identified ecosystem services and the well-being of the local population; Know the mitigation actions developed by both companies, within the scope of their respective Environmental Management Plans.

In addition to this brief introduction, this article is organized into five sections. The 2nd section presents the literature review, including empirical studies. The third describes the methodological considerations. The fourth highlights the results and discusses the study and, finally, in the fifth section, the final considerations are presented.

Theoretical foundation

Brief introduction

In this chapter referring to the literature review, in the first phase, concepts will be discussed according to various authors relating to: environment, mining, open pit mining, coal, as well as environmental impact followed by their theoretical foundation.

Presentation of basic concepts

Environmental impact

Coelho⁴ defines environmental impact as “any change in the physical, chemical and biological properties of the environment, caused by any form of matter or energy resulting from human activities that, directly or indirectly, affect: health, safety and good -being of the population.

Thus, environmental impact is understood as any change produced by man and his activities, in the constitutive relationships of the environment, which exceeds the absorption capacity of that environment.

Environment

For Marques⁵ environment is the sum total of the surrounding external conditions within an organism, there is a condition, a community or an object, adding that organisms can be part of the environment of other organisms. According to Mendonça⁶ the environment no longer receives that traditional descriptive or contemplative view of Geography as if it were a sanctuary that exists parallel to society.

Therefore, the environment, as it includes man and everything that surrounds him, constitutes a dynamic and constantly changing process, caused both by external factors, without the influence of man, flora or fauna, and caused by the actions of human beings. in the transformational processes of the raw materials they manipulate, as well as the cultural transformations caused by changes in values induced by man himself.

Mining

The mineral sector is quite diverse, both in the way resources are presented in nature, as well as in their volumes and characteristics,

which is why the description of the extraction process must be specific to each substance. According to Abrão et al.,⁷ mining is understood as an activity that involves mining and concentration of ores.

Mining is an extractive economic activity characterized by the use of natural resources, supplying humanity with mineral inputs in the form of raw materials, energy, fillers, noculants and other accessory substances in the most diverse industrial and construction processes, fundamental to the quality of life and socioeconomic development of modern society.⁸

Mining is the process of extracting minerals that are naturally concentrated on Earth. It is an economic and industrial activity that consists of research, exploration, mining (extraction) and processing of ores present underground.⁹

Therefore, mining is a term that encompasses industrial and industrial processes, activities whose objective is the extraction of mineral substances from proven mineral deposits in the soil or subsoil.

Open pit mining

Open pit mining is nothing more than extensive excavation of the surface of the land with the purpose of extracting metallic and non-metallic minerals, in any type of rock. Open pit mining can range from small manual scrapings on the surface of the land to gigantic excavations that reach hundreds of meters deep, and can occupy tens or even hundreds of square kilometers of surface.⁸ Open-pit mining is services performed by men equipped with shovels and pickaxes or by large mining equipment.¹⁰

Mineral coal

Mineral coal or stony coal is a dark-colored sedimentary rock, formed by a complex and varied mixture of organic components fossilized over millions of years, characteristic of fossil fuels. These components are remains of prehistoric vegetation that accumulated in swamps or muddy regions, under a sheet of water, over time, these deposits were covered by clays and sands (generating sedimentary basins), this gradual coverage led to an increase in temperature and pressure that expelled oxygen and hydrogen from the environment, concentrating carbon, a process called carbonization.¹¹

Mineral coal is composed of oxygen, hydrogen, sulfur, ash and, for the most part, carbon. The main constituent of mineral coal, which is wood, was mainly responsible for the percentage of carbon in its composition, with wood being composed of approximately 50% Carbon, 44% Oxygen, 5% Hydrogen and 1% other compounds.¹¹

The mineral can be defined as an inorganic crystalline solid that occurs in nature, with a well-defined chemical composition and characteristic physical properties.¹² According to Schumann¹¹ a crystal is a materially uniform body with a regular structure of its minimum particles (atoms, ions or molecules).

Mozambican mining legislation

According to Matos and Medeiro¹³ Legislative revolutions, mainly in land and mining laws, which began in the late 1980s and consolidated in the late 1990s and early years of the new millennium, favored the unbridled exploitation of mineral resources and spoliation. of native territories.

The revolutions in land and mining legislation have had significant impacts on the territories of native communities, where they are plundered due to the interests of international capital, shadowed by supposed national development.

The Mining Law privileges mining exploration in the forms of mining concession and mining certificate. Its holders have the right to use and occupy the land and carry out activities on an exclusive basis. Also, they are the only forms that have the right to benefit from the provisions of article 43 of the Land Law, that is, priority use for mining activities is only applicable to these forms of mining exploration.

With regard to the duties of mining concession holders (article 50), they must: a) Carry out reconnaissance in the respective area; b) Submit information and periodic reports in accordance with legal requirements; c) Compensate land users for damage caused to land or properties resulting from reconnaissance activities in the area; d) Carry out the activity in accordance with good mining practices and restore the land in case of any damage resulting from reconnaissance activities, in accordance with environmental quality standards.

The holder of the reconnaissance license can only carry out drilling and excavations in accordance with the regulations. Failure to comply

with the provisions of paragraphs c) and d) of paragraph 1 of this article and non-payment of surface tax are grounds for revocation of the reconnaissance license.

The new regulation adds the need for the holder to carry insurance against all risks, taking into account the installed capacity in the mine or the volume of the investment. Insurance must include (a) damage to mining facilities, (b) liability to third parties and, (c) work accidents of personnel involved in mining operations.

Methodological procedures

Location of the study area

The study area refers to the district of Moatize, province of Tete (15° 37' and 16° 38' South Latitude, 32° 22' and 34° 28' East Longitude), located east of the province of Tete, central region of Mozambique (Figure 1), with an area of 381,887 ha.

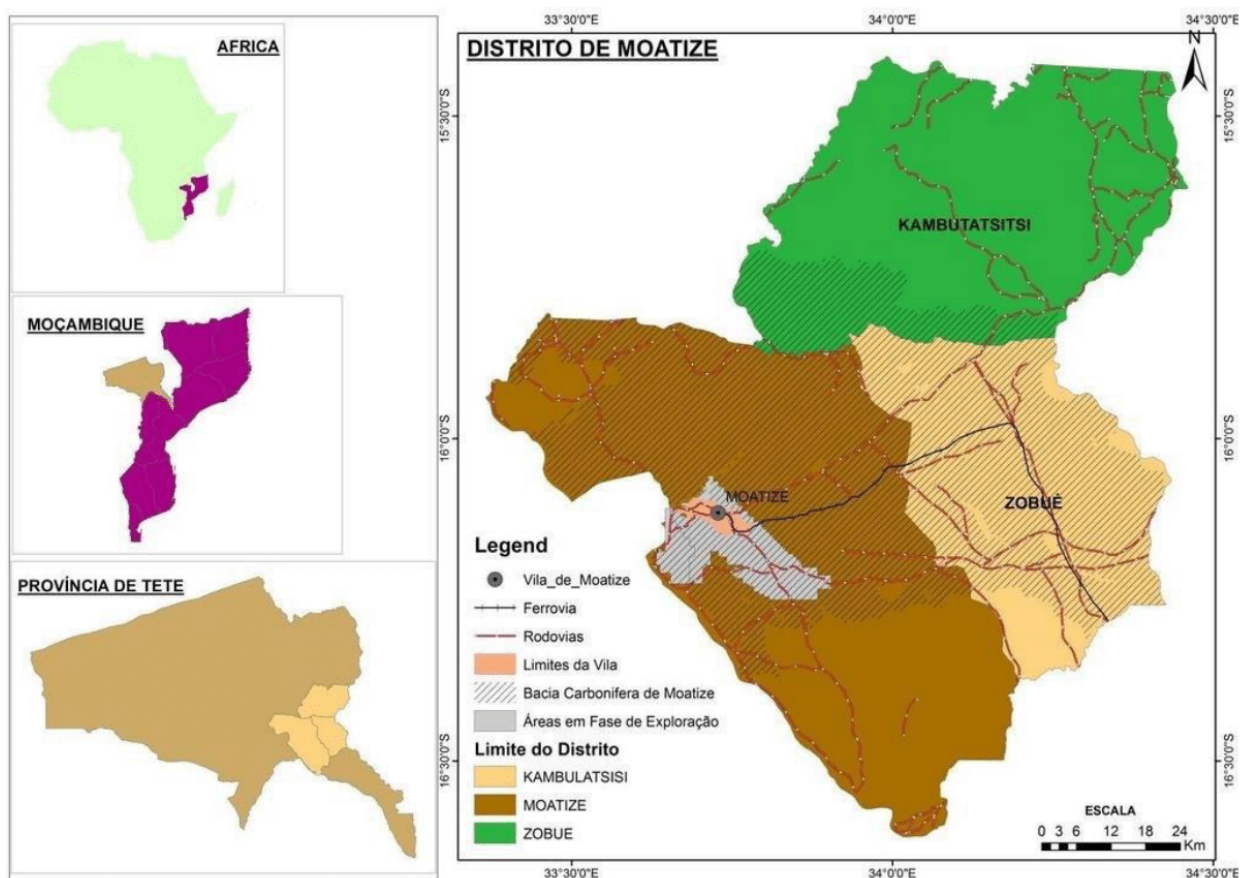


Figure 1 Location of the study area.

Source: Authors (2024).

Type of search

Freitas and Prodanov¹⁴ applied research aims to generate knowledge for practical application aimed at solving specific problems. It involves local truths and interests.” The research followed a qualitative approach. As for the objectives, the research is exploratory and descriptive. Descriptive research is seen as “that which aims to find the existence of relationships between variables (Gil, 1994). As for the procedures, it is a case study and bibliographical research.

For this study, residents of the Moatize district were involved as the research universe. The inclusion criterion was that they were directly involved in the internal communication process.

However, for this research, it focused on collecting information from twenty-two (22) participants (residents) living in the district of Moatize, using the non-probability sampling type, but quite simple and for convenience. For this research, the data collection techniques used were the questionnaire and observation. For this study, it was

necessary to use a questionnaire survey, as it is one of the most reliable techniques for this type of research. All questionnaires were semi-structured with mixed questions characterized by open, closed and multiple-choice questions. The respondents to this questionnaire were residents and, due to the simplicity of the author of the work, they were free to freely express and justify their opinions on the subject addressed when answering the open questions in the questionnaire. The questionnaire was addressed to the neighborhood chief and residents of the Moatize district.

The study results from extensive direct observation. This technique allowed the researcher to get closer to the subject's perspective, following the daily experiences of the individuals included in the research. For Lakatos & Marconi,¹⁵ extensive direct observation uses the senses to obtain certain realities, it does not only consist of seeing and hearing, but also of examining the facts and phenomena that one wishes to study.

In this case, through observation, the author experienced the reality that exists in the Moatize district, seeking to identify potentially affected ecosystem services and find elements that support the environmental impact of open-pit coal mining in the Moatize district.

And through this, the researcher, without needing to contact the stakeholders, verified whether or not they fulfilled their obligations in terms of reducing environmental impact and improving the quality of ecosystem services. In this work, the data were processed and analyzed through descriptive content analysis, as Gil (2002) says that the techniques "are operational procedures that serve as practical measurement or collection and analysis of data to carry out research (p. 26).

Bardin¹⁶ refers to this technique because it is very didactic and facilitates the sequence of tasks and activities to be followed for qualitative data analysis (p. 15).

Presentation, analysis and discussion of the results of the case under study

In this chapter, research data is presented and analyzed in a qualitative way. As a methodology to facilitate the work of comparing results, they are presented in percentages.

Perception of environmental risks

Environmental risks were identified based on field observations and responses to changes that have occurred over the last five years in the neighborhood's environment. Thus, the main environmental risk mentioned by interviewees was air contamination by dust.

Presentation of data relating to environmental quality

Of the 22 interviewees, only 3% did not mention the occurrence of environmental changes in the Municipality of Moatize. The majority of respondents (97%, 43% women and 54% men) responded that environmental changes had occurred in the neighborhood where they live and that there had been improvements in some aspects of the neighborhood's environment: 94% reported that the improvements were due to good water quality , (3%) to the quality of the soil and (3%) to the slightest dirt.

Regarding changes for the worse in the neighborhood's environment, 93% of respondents indicated that air quality has worsened; (4%) soil quality and 3% did not answer the question.

Analysis of the score, on a scale of 0 to 20 points, attributed to the neighborhood's environment indicates an average of 8.24 points

and ranks third in the score of the worst changes occurring in the Municipality of Moatize. However, 59% of respondents said the neighborhood environment was good, 12% said the environment was bad and 18% said it was worse because of dust.

Presentation of data regarding water quality

In relation to the environmental component water, the average score was 16.83 points and is the first environmental aspect that has improved, according to 94% of those interviewed (43% of women and 51% of men), in the last five years in the Municipality of Moatize . However, some women surveyed (3%) expressed concern about facing difficulties in accessing water.

In general, respondents do not seem to have a perception of the impact of coal dust on water quality, as their assessment is associated with access and supply of water and not the quality of the water itself.

Respondents reported that the improvement in the water quality component is due to the fact that they have water every day (30%), which is better (60%) and normal (3%). Despite this, the vast majority of those interviewed reported that the quality of the water is good, as it is treated and even those in rural areas seem to be satisfied with the water deposited in their reservoirs.

Presentation of data regarding soil quality

With regard to soil quality, the majority (64%) of respondents responded that the land does not allow for good agricultural production, some (15%) stated that it is good, while others indicated that the soil is impermeable. Furthermore, 9% of respondents reported that the low score was due to the fact that there was "trash".

Therefore, the interviewees' perception of soil quality does not establish a direct relationship with soil contamination by coal dust. However, the soil quality index ranks second as one of the aspects that has worsened the most in the municipality of Moatize in the last five years, after air quality.

Presentation of air quality data

In the air quality component, the average score was 3.82 points, being the lowest of the evaluations. Air was the most prominent environmental element in terms of the worst environmental changes, according to 83% of those interviewed (42% women and 51% men), which occurred in the municipality of Moatize.

The change for the worse is due to pollution caused by coal dust from coal extraction in Vale Moçambique projects. The perception of air quality ranged from extreme positions, from clean air (3% of respondents) to polluted air (53% of respondents). Respondents reported that the air was good (3%), that there is no good air in Moatize and that the air contains coal (6%), that the air causes coughing (7%), that the air is dusty (53%) , and which caused respiratory problems (18%).

Dust was an element frequently mentioned among interviewees. It is often referred to as a popular form of coal dust, as it causes health problems for those who live in the municipality of Moatize, especially in the neighborhoods close to the mine.

As Moniz (2010) mentions (Porto and Freitas, 1997; Brillhante and Caldas, 1999; Marandola Jr. and Hogan, 2004), the individual and social perception of environmental impacts and the actions to mitigate them (adaptations and adjustments) present losses and gains on different scales, especially when the causes of risks are industrial technological processes.

Perceptions of health risks

Coal dust data presentation

In parallel to the environmental problems mentioned, coal dust was perceived, by the majority of interviewees, as an environmental factor that puts human health and the environment at risk in the Municipality of Moatize. Regarding the negative impacts of coal dust on the environment, 93% of respondents demonstrated that they had a perception about the negative impacts of coal dust.

Presentation of data about living in Moatize

According to Moniz (2010), citing Oliveira and Zambrone (2006), the territory and the social, environmental and personal factors that contribute to the structuring of social life have a direct influence on the degree of vulnerability in relation to a given health problem, depending on the individual and collective control over the risk of acquiring a disease.

Thus, the place of work and the place of residence can constitute contexts for the occurrence of health problems for the individuals who work there. In accordance with this understanding, the results of the questionnaire show that the residents of Moatize established a relationship between the place where they work and/or live and the development of events that put their health at risk.

Respondents were asked whether they considered it safe to live in the Municipality of Moatize or in the community of Benga. Of the 22 respondents, 81% responded that living in Moatize is not safe because there is a greater possibility of having a disease compared to other places.

It was observed that a greater number (47%) of the residents surveyed perceive that living in Moatize is not safe. This may be related to the life experience of some individuals regarding the impacts that coal mining can have on themselves, friends or family, even if the mine is not their place of work and regardless of their level of education.

According to Moniz (2010) citing Freitas et al., (2003) and Freitas (2000), other “reasons may have contributed to individuals’ judgments about the relationship between risks and local security, among which situations of inseparable socio-environmental vulnerabilities stood out, such as population and institutional vulnerabilities”.^{17–23}

Final considerations

It was noticed by those interviewed that the environmental impacts generated by mining companies on the population’s routine are accentuated on windy days, making it practically impossible to stay outside or even inside homes because of the coal dust expelled from the mines. Houses, plants and animals are covered in coal dust, impacting crop productivity and disrupting local cultural dynamics, as it is unfeasible to put flour and clothes out to dry.

It was observed that a large number (47%) of those interviewed realize that living in Moatize is not safe due to the damage that coal mining can bring to them. Dust was an element frequently mentioned among interviewees. It is often referred to as a popular form of coal dust, as it causes health problems for those who live in the municipality of Moatize, especially in the neighborhoods close to the mine.

In general, respondents do not seem to have a perception of the impact of coal dust on water quality, as their assessment is associated with access and supply of water and not the quality of the water itself.

The perception of the environmental impact and the magnitude of health risks among Moatize residents affected by open-pit coal mining does not appear to be as heterogeneous as one might expect due to the influence of the socioeconomic characteristics of the interviewees. Data analysis showed that the majority of residents surveyed do not seem to realize that environmental exposure to coal dust occurs practically throughout the municipality of Moatize due to the dispersion of coal particles, although the mines themselves are the biggest threat, due to explosions. and accumulation of “piles” of mineral coal waste generated during the manufacturing process and deposited in this physical space.

Throughout this study, we sought to introduce a communicative element of reflection and awareness about the impact of open-pit coal mining to a small portion of the population environmentally exposed to coal dust, faced only with their questions. With the aim of promoting transformations in the individual and collective attitudes of risk groups, risk perception studies often serve to support risk communication projects and strategies. However, it is imperative to investigate whether education and information can overcome residents’ misconceptions about the risks they face due to exposure, as even well-structured information measures may not be able to change some people’s risk behaviors.

At the same time, the results of the study demonstrate that it is imperative that there is an increase in the institutional responsibility of companies and government bodies, providing health care and promoting environmental interventions for the population of Moatize, directly affected by the precariousness of life and health, conditions environmental issues and coal dust, as well as a more in-depth re-discussion of the political and ethical aspects linked to the resettlement of more exposed population groups.

Suggestions

Based on what was mentioned here, the authors believe it is pertinent to make some considerations and propose the following recommendations:

- I. Conduct sustained research: Research must be conducted in a sustained manner to assess and mitigate all negative environmental impacts associated with coal extraction and exposure to coal dust.
- II. Institutionalize notification of exposure to coal dust: There is a need to study different ways of dealing with different social groups living in regions affected by coal extraction to carry out prevention and clarification campaigns about the potential impacts of coal extraction on the environment and in human life.
- III. Apply the concept of ecosystem services in Environmental Impact Assessment (EIA): Recognize the importance of incorporating the concept of ecosystem services in EIA.
- IV. Promote the institutionalization of complaints and conflict management mechanisms between affected communities and mining companies: The complaints presented in a generalized manner by communities in the areas covered by the study reveal the lack of or lack of knowledge about the existence of institutionalized mechanisms for dialogue between communities in the area and mining companies.

Acknowledgments

None.

Conflicts of interest

The authors declares there is no conflict of interest.

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