

Environmental Repercussions of Gem Mining in Sri Lanka

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Abstract

As an industry, the gem industry has positive impacts on the economy and society while having severe negative impacts on the environment and health. Most of these impacts cannot be recovered for an extended period of time while causing the deaths of all living organisms on Earth. This study has portrayed the environmental repercussions of traditional and mechanical gem mining techniques practiced by the gem miners in Ratnapura while discussing the remedies that can be adapted to overcome those environmental. The population of the study consisted of gem mining lands in Ratnapura, and a sample of five tunnel gem mine lands, five backhoe gem mine lands, and five river gem mine lands was selected. Data was collected through observation and direct discussions with gem miners to identify the environmental repercussions of gem mining activities. The analysis was done using a narrative analysis of qualitative research. The study found that while gem mining contributes significantly to the economic development of the country, the techniques used, including tunnel gem mining, backhoe gem mining, and river gem mining, have several negative impacts on the environment, such as water contamination, soil erosion, deforestation, loss of biodiversity and animal habitats, and nutrient depletion. The study suggests that environmentally friendly methods for

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gem mining should be adopted, and government regulation is necessary to reduce the impact of mining activities on the environment. The study provides valuable insights into the environmental impact of gem mining in Ratnapura and highlights the need for sustainable practices in the gem industry.

Keywords: Environmental repercussions, gem mining techniques, remedial measures, gemming

INTRODUCTION

The Earth is the only planet in the solar system with an environment conducive to the existence of living organisms. Water, air, and land play a vital role in maintaining the lives of living beings. All things, whether they are natural or artificial, are tolerated by the land without expecting any gratitude from the user of it. People in the world have consumed the land in various forms to fulfil their needs. In this context, the underground mineral composition of the land has generated income for people. Regardless of the inherent risk, most people in countries that have benefited from mineral resources have made mining their primary occupation. In the Sri Lankan context, Sri Lanka has a significant gem industry, and various techniques have been used to extract gems from the land, including tunnel mining, open-pit shallow mining, riverbed mining, and backhoe mining.

In the colonial period, various valuable gem species were excavated by people, and those gems were asported by gem traders to their mother countries. Especially gems like Star Sapphire, Ruby, Garnet, Amethyst, Spinel, Rose, Quartz, Aquamarine, Tourmaline, Agate etc. asported (Ceylon Gem Hub, 2017). Even today, there is a huge demand for those types of Sri Lankan gems in the foreign market. Due to this nature, ancient Sri Lanka was called the "Land of Sapphire", "Gem Island". Even today, these terms are used by foreigners (Ceylon Digest, 2016).

The impact of gem mining can be viewed from different perspectives, including social, environmental, and health. Social tensions, income and security issues, employment and education, drug and alcohol abuse, and human rights are some of the social issues that arise due to gem mining. Environmental destruction of fauna and flora, loss of biodiversity,

deforestation, and soil erosion are some of the environmental impacts of gem mining. Health concerns include the risk of accidents and deaths in the pits, the deposition of toxic elements and air emissions, and hazardous acid and gas emissions.

In Sri Lanka, all gem mining techniques have generated significant impacts on the environment, including tunnel mining, open-pit shallow mining, riverbed mining, and backhoe mining. The environmental impacts are long-lasting and, in some cases, irreversible. Perhaps these impacts cannot be resolved due to their offensiveness. In the case study area, it is evident that there are huge natural hazards like landslides and floods faced by people who live in that area. This study has identified various environmental repercussions due to existing gem extraction techniques in Sri Lanka and possible solutions that can be adapted to avoid the obnoxious environmental repercussions of gem mining activities.

OBJECTIVES OF THE STUDY

This study mainly focused on identifying the environmental repercussions of gem mining activities in Sri Lanka. Accordingly, special adjectives have been formulated as,

1. To identify the traditional and mechanical gem mining techniques used by Sri Lankan gem miners.
2. To determine the environmental impacts associated with different gem mining techniques.
3. To identify possible solutions to avoid the environmental impacts of gem mining.

LITERATURE REVIEW

Mineral exploration is one of the major economic activities that has had both positive and negative effects on the environment. A country like Sri Lanka, which is sustained by mineral resources like gems has obtained several economic benefits from gem mining and, on the other hand, has faced fatal environmental impacts due to these mining activities. Therefore, most researchers considered these positive and negative impacts of gem mining activities in local and global contexts in their research.

Mining Activities in the World

Most of the countries in the world have engaged in the exploitation of various minerals from the land. Those minerals may be valuable or less valuable, but the neediness may be ample. Generally, mining refers the extraction of the minerals or other geographical resources from the underground. Those minerals may in either metallic or non-metallic category. Metallic resources may be gold, gem, silver, diamond, platinum, tin, Zinc, Nickel etc. Non-metallic resources may Sand, Gravel, Gypsum, Uranium etc (Tulane University, 2012). The extraction of economically valuable resources and other geological minerals from the earth surface is known as mining. It may be in form of surface or underground mining (Balasubramanian, 2017). The Cambridge Dictionary defined mining as an industry which has engaged with removing the substances minerals from the ground by digging (Cambridge Dictionary, 2021).

The country China is the world largest country which consists of coal, gold and many other rare minerals. Apart from that, Tanzania, Argentina, Mongolia, Uganda have shown a dynamic development in their mining industry in past few years. Hence Russia, Botswana, Australia, Canada, Myanmar, Namibia, India, Belgium, Israel, South Africa, Thailand is some of the main countries which have sustained from valuable minerals in the world.

History of Gem Industry in Sri Lanka

Sri Lanka has a proud history of the gem industry since the ancient period of time. According to the Mahawanshaya, it has highlighted that Sri Lanka has become a colony as a result of the richness of minerals in the country. The Naga king's encrusted thrones were crafted by gems in 540 BC, proving that Sri Lanka has a gem industry with a history of around 2500 years (Ceylon Gem Hub, 2017). In the second century, the astronomer Ptolemy recorded that beryl and sapphire were the mainstay gems in Sri Lanka. Apart from that, the explorer Marco Polo recorded that ancient Ceylon was famous for gems such as sapphires, amethysts, topazes, and other gems found in Sri Lanka (Srigems, 2016). During the period of the 4th and 5th centuries, Sri Lanka was known as the "Jewels of Serendib" by the Persian

and Middle Eastern traders who crossed the Indian ocean to trade the gems from Sri Lanka and considering the availability of valuable gems in the country (Srigems, 2016). Therefore, it can be said the availability of valuable mineral resources in the country has become one of the major reasons for the concentration of the attraction to Ceylon by various countries in the world.

In the king's era, Sri Lankan kings sent many valuable gems and pearls to other countries with the purpose of establishing trade relationships with them. In 250 BC, the king at that time gifted three varied gems and eight pearls to the emperor in India (Ceylon Gem Hub, 2017). Furthermore, most recently, Sri Lankan blue sapphire gems have been used for the rings of the royal family for the engagement of Prince William and Kate Middleton and this was the original engagement ring of Prince Diana (Prestige Gems, 2019). Therefore, it is highlighted that Sri Lanka has a proud history of gems dating back to an ancient period of time. Apart from that, there is evidence that has been mentioned by several explorers and astronomers about the availability of gems in ancient Sri Lanka. The Roman emperor Claudius in 41 AD and 54 AD and the Greek astronomer Ptolemy in the 2nd century, Marco Polo in the 12th century, and Arab explorer Ibnu Batuta in the 14th century and Robert Knox, are some of those who have recorded the abundance of valuable gems like sapphire, Topaz, Beryl's, Garnet, Rubby, Amethyst etc (Ceylon Gem Hub, 2017). In this circumstance, it is highlighted that there is a long history of Sri Lankan gems and the celebrity of Ceylon gems and gem-related jewellery throughout the world.

Economic Benefits of Gem and Jewellery Industry

As an industry, Sri Lanka's gems have a higher demand in the foreign market. Usually, sapphire gems are demanded by most developed countries for jewellery making. Therefore, the gem and jewellery industry in Sri Lanka plays a central role in the country's exports and it directly contributes to the economic, cultural, and social development of the country. Because of this nature, Sri Lanka has become a top five gem trading country in the world (Sri Lanka Export Development Board, 2021). This contributed to generating an employment opportunity for people as miners, traders,

lapidarists, goldsmiths, retailers and jewellers. Thereby, the problem of the unemployment level in the country can be solved and most of the gem mining areas occupation of people have bounded with the gem and jewellery industry. On the other hand, this provides a solution for inequitable income distribution through generating employment opportunities for people in rural areas.

Then this industry contributed to generating 350\$ million worth of foreign exchange on an annual basis, which is the seventh largest export contribution in Sri Lanka. In 2014, Sri Lanka exported coloured sapphire gemstones, which took a percentage of 70% by value (Shortell & E.Irwin, 2017). Therefore, Sri Lanka has benefited from access to the global hub of trading. Generally, Sri Lanka exports a great quantity of gems to Europe and the Middle East, where there is a higher demand for Sri Lankan gems (Sri Lanka Export Development Board, 2021). According to the Central Bank's annual report data the export composition of gems is showing an increasing trend in the export composition.

Impacts of Gem Mining Activities

Social Impacts

Mineral exploitation may cause displacement of human settlements. The 13th book chapter of an overview of mining and its impact describes how the displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development (The Environmental Law Alliance Worldwide, 2015). As a result of this, surrounding communities have settled where there are no adequate resources for living. Further, it may result in contaminating the existing living places of humans. Hence, the migration of people into a mining area and the immigration of people to the outside of the mines take place due to the pollution that exists in the area. Eventually, the social impact caused by the mining activities will threaten the livelihood of the people in the surrounding areas. According to the journal article "The Process of Land Use Change in Mining Region," mining's direct and indirect use of land has environmental and social consequences, some of which are not captured by

current management approaches (Productio, 2014). According to this article, most of the social impacts of mining are not captured by the existing management approach.

Health Impacts

The workers who are engaged in the mining industry face several health impacts during the working process. Most of the time, dangerous acid and gas emissions from the mine have become major causes of health impacts. Apart from that, the surrounding community has also become threatened due to the spread of diseases around the mining areas. The World Health Organization (WHO) defines health as a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity (World Health Organization, 2021). Therefore, the health of the workers and the surrounding community is a significant factor that should be given adequate consideration in mining activities.

The research conducted Review of Environmental and Health Impacts of Mining in Ghana has identified that mining continues to be among the most perilous professions globally, with risks ranging from immediate physical harm and fatalities to persistent health effects like respiratory disorders, cancers, silicosis, asbestosis, and pneumoconiosis (Emmanuel, et al., 2018). There is a high risk of deaths and accidents in the pits due to the lack of adequate air and ventilation. E.P Malisa and C.P Kinabo described how poor ventilation in deep underground pits leads to accidents due to a lack of adequate air circulation. Lack of oxygen under the mines and the generation of toxic air like carbon monoxide, hydrogen sulphide, and sulphur dioxide cause the accidents in the pits. Further, the researchers of this study have identified some reasons for health issues in mines by evaluating six years' worth of data from Merelani Mine. Those reasons are the suffocation, explosion, collapse of hanging walls, rock fragments flying from blasting, falling into shaft, break of hosting cables, flooding, mine waste heap failure or slide (Malisa & Kinabo, 2009).

Environmental Impacts

The magazine of Environmental Stewardship in Gemstone Mining by L. Cartier has investigated the identification of the impact of gem mining. This requires the identification of the factors that are affected by mining. He has identified the impacts on the environment in the form of water, soil, air, fauna and flora, humans and the landscape. From that, the impact on the land can be identified as a loss of fertility for agricultural activities, land use conflict, destruction of landscape, loss of soil and erosion of the soil, deforestation, destruction of fauna and flora. As a result of these impacts, the value of the land is reduced, or the land becomes useless. Moreover, (Cartier, 2010) has suggested some mitigation strategies for these impacts, such as replanting trees, limiting the damage to the topsoil, and closing pits and mines after mining. As a result of his study, his mitigation strategies are very practical even though people are not practiced. Further, in his study, he has identified the contamination of watercourses through mining activity can lead to deleterious environmental conditions.

Apart from that the impact of gem mining on the environment largely depends on the method of gem mining and the geological context that governs how easily the minerals can be separated from the ore material. Apart from above mentioned impacts, the flood impact has been cited as a potential impact of gem mining (Gemstone and Sustainable Development Knowledge Hub, 2021). Further, artisanal and small-scale mining is known to have several negative impacts, including the loss of mineral revenue due to smuggling, food insecurity, and damage to surface and underground water caused by toxic contamination and pollution from mud and sediments. Additionally, air and noise pollution and the destruction of biodiversity, including natural flora and fauna and aquatic species, are other significant challenges associated with this type of mining (Suglo, et al., 2021). In the river gem mining the impact of water is huge and this directly cause for the health impact. The research of assessing the social and environmental impacts of illegal mining operations in river bonsa prepared by pure fm-tarkwa, for the busac project (Kusi-Ampofo, et al., 2012) has demonstrated that the mining activities conducted in and near the Bonsa River have significantly altered its natural course. Furthermore, the quality

of the water has been greatly impacted and degraded. In this concerns people considers the various mitigation methods of above impacts in both local and global context. The study conducted by (Greentumble, 2017) introduced thatn conscious consumerism can play a crucial role in mitigating the high stakes that illegal mining poses to both humanity and the environment. The introduction of the Kimberley Process in 2003, which was heavily campaigned around the conflict mining trade, has had a significant impact in reducing the illegal mining industry over the last decade. While the process has not completely eliminated the problem, it has substantially reduced it.

METHODOLOGY

This study was conducted related to the gem mining lands in the Ratnapura divisional secretariat area, which is a major gem mining area in Sri Lanka. This study has mainly focused on the environmental repercussions of gem mining activities in the case study area and both land gem mining and river gem mining have been considered as the population of this study. Among them, ten land gem mining lands and five river gem mining lands have been selected as the sample by considering the convenience to reach sample. The sample has been selected by using the cluster sampling method based on the Grama Niladhari divisions of Ratnapura divisional secretariat that have engaged in gem mining activities.

The collection of data for this research was done through both primary data collection and secondary data collection methods. The primary data for this research was collected using a observation, which was conducted among all selected gem mining lands for this research. In the meantime, focus group discussions were arranged with the landowners and miners of all selected gem mines to clarify the investigated data of observations The secondary data for this study was collected through the journals, reports, books, websites and other relevant materials that were written based on the mining activities and their impacts from different perspectives. Then the analysis of the data was done in narrative analysis of qualitative data and photographs that were collected during the observation were attached to the better clarification of the collected data.

RESULT AND DISCUSSION

Mineral exploration is an industry that gives a remarkable benefit to a country and its miners toward the development of its economy. However, all the countries in the world are not rich with mineral resources which are valuable in a global context and the availability of the mineral resources may be more or less depending on the soil composition of a particular country. In this context, Sri Lanka has preserved a reputation for the gem industry over a thousand years ago and has become one of the major gem exporters in the global market. Recently, Sri Lanka has risen to the top five gem exporters among gem exporting countries in the world. However, the exploration process of the gems is slightly different from country to country depending on the available technology.

Techniques that are used for extracting gemstones from the lands have invariably impacted to the environment without any diffidence. Especially, in Ratnapura out of the main gem mining techniques of tunnel gem mining, backhoe gem mining, open pit shallow mining and river mining, tunnel mining, backhoe mining, and river mining have seriously impacted to the environment. The observation conducted in the case study area of Ratnapura divisional secretariat area proved that those techniques have generated a plumbless impact on the environment that cannot be revised for a long period of time. The extraction of gems from the land takes a long period of time with the involvement of human power. The observations made in the case study area and the data obtained from the respondents have purported that some mines have been continued for 1-2 years or even more. In this circumstance, it is highlighted that most of the miners excavate the underground land until they quarry a gemstone. There are very rare situations where miners leave mines without finding a gemstone. As a result of excavating the land, it damaged the underground soil of the land. Eventually, this resulted in various environmental impacts.

Tunnel Mining

The vertical tunnel starts from the ground level and excavated tier by tier. For the first step, four bamboo or betel-nut stems are dipped into four sides

of a selected area. Then each tier of the tunnel is constructed by using stems and laths of the jaggery palm, coconut trees, and betel-nut trees. Sometimes rubber and other trees are used depending on the availability. The most important thing is the robustness of the tunnel. For that, miners used bracken leaves and interleaved the laths with bracken leaves. Most tunnel mines in the Ratnapura area are normally excavated up to 30 ft.-40 ft. But there can also be seen vertical tunnels that have a depth of around 55 ft. to 60 ft. After excavating the vertical tunnel, they started to excavate the horizontal tunnel of the mine. The horizontal tunnel can be excavated in any direction according to the miner's perception. Moreover, there is more than one horizontal tunnel attached to a vertical tunnel. Construction of the horizontal tunnel is also proceeding as per vertical tunnel construction material.

The leakage of the water during the excavation is the major environmental impact of tunnel mining. In general, the trickled water is mixed with the toxic chemicals that are produced underground. Thereby, the PH value of the water is changed to the contrary value and the water becomes unhealthy for human use. Once the vertical tunnel is excavated, the soil becomes eroded. Soil erosion is a certain impact of land gem mining. This occurred due to the rain. During the rainy period, the excavated soil and topsoil around the mine move from one place to another. Apart from that, when the leaked water is pumping out from the tunnel, the topsoil becomes eroded. Further, there is an impact of losing the soil's nutrients. This automatically converted the fertile soil into infertile soil. Since Ratnapura is already famous for agricultural activities, the loss of the fertility of the soil has highly impacted the agricultural sector activities. Furthermore, mining activities impact the stability of the soil. This is mainly caused by the vibrations that occur during the mining process and excessive usage of explosives. Also, at the closure stage of mines, miners do not attempt to close horizontal mines. As a result of this, after some certain period, the soil on the horizontal tunnel starts sinking down to the tunnel and the load-bearing capacity of the topsoil gets lost. Consequently, this has limited the available land for the development activities in the case study area.

The construction of the vertical and horizontal tunnels cannot be continued without the stems of the trees. For the robustness of the tunnel, they also used the leaves of bracken. For that, miners must cut a number of trees in the forest areas. It also cannot be used on previously stemmed or tumbled-down trees. Because of that, the cutting down of mature trees is essential. As a result, the tunnel mining summons to a huge environmental destruction which cannot be reinstated for a long period of time. Indirectly, this also impacted photosynthesis, biodiversity, deforestation, and other natural resources.

Figure 1: Stem of the Trees Use for Construction of Tunnel



Source: Photograph by Author (2021 /Date: 20.07.2021)

The above photographs show the stems that were used for the construction of the tunnel mine. Most of the stems in the photographs have been rejected for use, and the soil around the mine has been eroded due to the moving of huge stems around the tunnel. Therefore, it directly involves environmental repercussion in the way of deforestation, soil erosion, and biodiversity loss.

Backhoe Mining

The technological development of the world has been facilitated to simplify the human activities. As a result of that, the traditional mining techniques have been changed into mechanical mining techniques. Most probably in

the mining industry, modernized excavating and lixiviation methods have been recently introduced to the gem industry. In this circumstance, most miners change their traditional mining techniques to the mechanical mining technique of backhoe mining.

The excavation of mines is done by using a backhoe and those mines are excavated up to a depth of 55 ft. to 60 ft. The leakage water of the backhoe mine pump out by using a sucker machine. Here the use of human power for mining activities is limited and only used for operating the backhoe. The lixiviation of excavated soil (lode soil) is done by using buggies, which consist of mesh. There, high pressure water is supplied to the buggy and a huller machine is facilitated to sieve the gemstones layer by layer. The upper layer of the buggy consists of large and weighted gemstones and gems remain from the upper layer to the lower layer depending on the extent and weight of the gemstone. Most of the time, there are three layers in the huller machine. The excess water is flowing out of the machine at the lower layer of the huller machine.

The environmental impacts of backhoe mining mainly occur on the soil because backhoe mining consumes a larger area than tunnel mining. On the other hand, bringing the backhoe machine to the mining area is done through the surrounding land. Therefore, not only that particular area but also the surrounding lands are impacted by this. In backhoe mining, the flora and fauna are destroyed from the first stage to the final stage of backhoe mining. Since the backhoe mining is concentrated on the forest areas, this has largely impacted the biodiversity of the forest area. In the case study area of Ratnapura, which has lost its forest cover day by day due to the illegal mining activities in the forest area.

The erosion of the soil is the foremost environmental impact of backhoe mining. In backhoe mining, the mining pits are excavated to a 55ft–60ft depth with a width of 50ft–60ft. These ranges differ from mine to mine due to the availability of the resources. According to the regulatory framework of mechanical mining, there should be land with an extent of one acre or more. Ultimately, at the end of the mining process, the soil on the subject

land becomes eroded due to the movement of the backhoe machine on the land. As a result, rather than tunnel mining, backhoe mining causes large and rapid erosion of the soil. In the below photographs, it is evident where the soil erosion is occurring at large in the case study area. Exactly, the use of the backhoe machine exacerbates this issue in the backhoe mine land.

Figure 2: Backhoe Mining Land



Source: Photograph by Author (2021 /Date: 10.09.2021)

In this phenomenon, the erosion of the soil causes the fertile soil to be converted into infertile soil. The removal of the topsoil due to the moving of backhoe machines and the changing of the soil layer at the time of excavating mining pits rendered infertile soil for agricultural activities. Nevertheless, most of the landowners argue that once the mining pit is closed after the mining activities, that land is suitable for agriculture activities. But the issue is that most of the miners do not attempt to close the mining pits after the completion of mining activities. On the other hand, it

is necessary to adapt soil rehabilitation before utilizing that land for agricultural activities.

Backhoe mining causes significant loss of wildlife habitat and life. In the excavation process, the underground worms, insects, scabs, rats and other small creatures lose their lives and habitats. Sometimes, due to the unethical behaviour of the miners' animals like pigs, deer, porcupines, bulls, and barking deer lose their lives. Miners hunt these kinds of animals for their food during the mining activities since they guard the mines and equipment until the mining activities are finished. Apart from these impacts, there are the impacts of contamination of ground water and surface water due to the discharge of sedimentary materials like acids, chemicals, and explosive materials during the mining process. This directly impacted the health issues of both humans and animals.

River Mining

River gem mining is a novel method of gem mining that was introduced a hundred years ago after discovering that the valuable minerals were lying on the bed of the river. As per the land gem mining, miners need to obtain a license from the National Gem and Jewellery Authority to proceed gem mining activities in the river. Typically, miners will hold an auction and bargain to obtain a portion of the river for mining purposes. However, most of the mines in the river lack a license and therefore those mines are illegal. For the first stage after selection of the appropriate portion of the river construct a scaffold across the river by the miners. The construction of scaffold done by using the stem of trees which keep the robustness of the scaffold. The miners stand on these stems and unearth minerals from the riverbed to the surface of the river. For that miners use the hoe which has a long holder with a length of 10ft. But this length may differ according to the depth of the ore. The person who step-down to the ore obtain oxygen from the machine which is fixed outside of the surface of the river where the surface is in the upper level than the riverbed. Nevertheless, the river gem mining has legally prohibited due to the huge environmental impact of it.

The major impact of river gemming is the contamination of water resources that are available for drinking, agriculture, and other uses of humans and animals. During the gemming process, the portion which is blocked by the scaffold becomes muddy and mixed with the chemicals produced in the ore. Therefore, the flowing water from this level gets polluted and it is not suitable for use. Ultimately, this causes health issues for humans and animals.

On the other hand, river gem mining causes alteration in the water flow of the river. The scaffold being constructed across the river and the inside mining activities change the normal water flow of the river into an irregular flow. Perhaps at the end of the mine, the removal of the scaffold changes the normal flow of the water, and it directly influences to fall down the polder areas of the river.

River gem mining is proceeding on the river. Since river gem mining directly influence to the depletion of the riverbed. Once the mine is started, miners dig the riverbed and bring the ore to the surface. Through that, the riverbed gets depleted, and the surface of the river also gets depleted when the water flashes with the riverbank. This resulted to number of natural hazards like floods, landslides, etc. As per the Department of Disaster Management, they have identified that one of the main reasons for floods occurring in Ratnapura is river gem mining. This has resulted in an increase in the flood level in Ratnapura. The areas around the Kalu river probably faced this incident because miners continually used the Kalu river for river gem mining.

As per the tunnel gem mining, the riverbed mining also has an impact on the environment for deforestation. The construction of the scaffold proceeds using the stems of trees like tropical almond, coconut, rubber, beetle nut and other valuable trees. Since the scaffold must be stronger to block the water, miners cut the mature trees from the forest. Therefore, the use of trees for mining activities causes deforestation and indirectly, this generates environmental impacts like loss of biodiversity, loss of habitats, erosion and land converted to arid land. In this way, river mining has more impact on

the water while other two methods of mining impacted to the soil or else land. In the given photograph, it can be seen that part of the water is brown. The reason for that is the mining of the soil in the riverbed by the miners. On the other hand, the miners have blocked the water from flowing by constructing a scaffold. As a result of that, the contamination of the water is high, and people who are in the lower part of the river experience health issues.

Figure 3:Contemination of Water due to the River Gem Mining



Source: Photograph by Author (2021 /Date: 20.07.2021)

Gem mining techniques such as tunnel mining, backhoe mining, and river mining have various environmental impacts, including erosion of soil, deforestation, loss of biodiversity, and contamination of water. These impacts can be mitigated by implementing remedial measures such as proper closure of mining pits, adaptation of rehabilitation measures, replanting trees, and regulation of excavation activities. Apart from that, ecosystem management programs and penalties for illegal activities can also help prevent environmental damage caused by gem mining. In the Sri Lankan context, since the environmental repercussions are highly recognized, the following remedial measures can be suggested for the identified environmental repercussions:

Table 1: Environmental Impact and Suggested Remedial Measures

| Gem Mining Technique | Environmental Impacts | Remedial Measures |
|-----------------------------|---|---|
| Tunnel Gem Mining | Contamination of ground water and surface water | Discharge of the water to separate place |
| | Erosion of the soil | Improve the extraction technology of soil |
| | Soil become infertile for agricultural activities | Rehabilitation of soil |
| | Deforestation | Replanting trees |
| | Loss of bearing capacity | Proper closure of tunnel pit |
| | Loss of animal habitats | Impose penalty for hunting animals |
| Backhoe Gem Mining | Erosion of soil | Proper closure of the mining pits. Regulation of the backhoe mining activities |
| | Land become useless | Adaptation of rehabilitation measures |
| | Loss of biodiversity | Replanting trees Regulate illegal mine |
| | Threat to the underground living organism | Regulation of excavation activities Introduce ecosystem management programs |
| | Loss of stability of the soil | Proper closure of mining pits |
| River Mining | Contamination of water | Separation of contaminated water much as possible |
| | Deforestation | Replanting trees |

Source: Compiled by Author Data obtained from Observations (2021)

CONCLUSION

Sri Lanka, as a developing country, used human-based techniques for gem exploration. But most recently, these traditional gem mining techniques have been changed to mechanical gem mining techniques with the introduction of backhoe machines to the Sri Lankan gem industry. As a result, aside from tunnel and river gem mining, most miners who have the resources have focused on backhoe gem mining as an effective and efficient method of gem mining. But these three gem mining techniques have their

own impacts on different perspectives on social, environmental, health etc. This study has focused on the environmental impacts of these three gem mining techniques practiced by miners in Ratnapura.

Gem mining in Sri Lanka has significant environmental repercussions, including contamination of water, erosion of soil, deforestation, and loss of biodiversity. These impacts are primarily caused by the tunnel, backhoe, and river mining techniques used in the industry. To mitigate these environmental impacts, it is necessary to implement remedial measures such as the proper closure of mining pits, replanting trees, and regulating excavation activities. Additionally, ecosystem management programs and penalties for illegal mining activities can also help prevent further environmental damage. It is crucial to address these environmental repercussions of gem mining in Sri Lanka to ensure the sustainable development of the industry and protect the country's natural resources for future generations.

Future research studies could explore the feasibility of introducing new and innovative mining techniques that are less harmful to the environment, such as eco-friendly gem mining methods. Furthermore, future research could explore the social and economic impacts of gem mining, including the effects on local communities and the workforce. It is important that future research studies continue to address the environmental and social impacts of gem mining in Sri Lanka to promote the sustainable development of the industry while protecting the country's natural resources.

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