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Environmental Repercussions of Gem Mining in Sri Lanka

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Abstract

As an industry, gem mining has both negative and positive impacts on economic and social perspectives. But this has generated a severe negative impact on the environment and health perspectives. 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 impacts with the objective of identifying the environmental repercussion of gem industry in Ratnapura district. The population of this study consisted of the gem mining lands in Ratnapura and out of that selected the five of tunnel gem mine land, backhoe gem mine land and river gem mines land as the sample of this study. Collection of the data was done through the observation and discussions conducted with the gem miners to identify the environmental repercussions of gem mining activities. The analysis of the data was done as a narrative analysis of qualitative research. As a major gem mining country Sri Lanka practiced three techniques for gem mining as tunnel gem mining, backhoe gem mining and river gem mining. Although there is a huge contribution to the economic development of the country, these techniques have several impacts on the environment and many other sources. As an environmental impact there are the contamination of water, erosion of soil, deforestation, losing the nutrients of the soil, loss of animal habitats, loss of biodiversity and many more. To avoid these impacts miners can adapt environmentally friendly methods for gem mining and it is necessary to regulate the mining activities by the government to reduce the impact of mining activities.

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 the 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. The country, Sri Lanka has played a vital role in the gem industry in the global market since the ancient period. In the colonial period, various valuable gem species were excavated by people and those gems were exported by gem traders to their mother countries. Especially gems like Star Sapphire, Ruby, Garnet, Amethyst, Spinel, Rose, Quartz, Aquamarine, Tourmaline, Agate etc exported (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).

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The final output of burnished gemstone is obtained as a result of the huge endeavour of gem miners. As per the normal procedure, gem miners excavated land for six months to two years. Anyhow, this circumstance changes depending on the environmental condition and the gem miners' level of effort. In Sri Lanka, gem miners practiced several methods of gem mining to extract gems from the land. There, tunnel mining, open-pit shallow mining, and riverbed mining have existed since an ancient period. Apart from that, the use of modern techniques for gem mining has become a new trend in the Sri Lankan gem industry. Thereby, the new method of gem mining which is backhoe gem mining has come into the consideration of gem miners as a cost-effective and efficient method of abstracting the gems from the land. As a developing country, this is a forward step for the gem industry compared with the modern world's mining techniques. However, these techniques have their own impacts on different sides which were experienced today.

The impact of gem mining can be explained from different viewpoints as social, environmental and health. In the concern of social, social tension, income and security issues, employment and education, drug and alcohol acceptability abuses, demography and human right and in environmental perspective, destruction of fauna and flora, loss of biodiversity, deforestation, loss of soil and erosion of the soil can be identified. in the health concern risk of deaths and accidents in the pits, collapse of hanging walls, deposition of toxic element and air emission, hazardous acid and gas emission under the mine are some impacts that can identified related to the mines. Most probably, environmental repercussions of the gem industry have generated fatal impacts for a long period of time. In Sri Lanka, all the gem mining techniques which are tunnel mining, open pit shallow mining, riverbed mining and backhoe mining have generated insufferable influences on the environment. Perhaps these impacts cannot be resolved due to their offensiveness. However, most miners today are making efforts to mitigate the environmental effects of their activities.

In this study, it has identified various environmental repercussions occurred due to existing gem extraction techniques in Sri Lanka and the possible solutions that can be adapted to avoid obnoxious environmental repercussions of gem mining activities. In the case study area, it is evident that there is a huge natural hazards like land slide, flood faced by people who live in that area. As per the disaster management centres, they have identified the major reason for occurred this kind of hazards are the gem mining practices in the case study area. The observations done in the case study area also evident those scenarios. Therefore, this study has focused to identify major environmental repercussions in Rathnapura occurred due to the gem mining activities. Especially, the land gem mining techniques, river gem mining techniques as a major way that impacted to the environment.

Objectives of the study

This study mainly focused on identifying the environmental repercussions of gem mining activities in Sri Lanka with the sub objectives of analysing techniques used by Sri Lanka gem miners, to determine the environmental impacts of gem mining and to find solutions to avoid the environmental impacts of gem mining. As a major economic activity, gem mining has been regarded as a blatant activity that has had a wide-ranging impact on the environment. Therefore, this has become a major focus area for environmental specialists and researchers today.

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.

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, Amathyst 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 jewelleries 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 (Shotter & 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 (Production, 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 dieses 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.

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, L. Cartier 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 (Cartier, 2010).

One of the internet sources indicates 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).

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 an observation, which was conducted among all selected gem mining lands for this research. In the meantime, discussions were arranged with the landowners 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

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 01: Stem of the Trees Use for Construction of Tunnel

Source: Photograph by Author (2021)

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 pomp 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.

Figure 02: Backhoe Mining Land

Source: Photograph by Author (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, scrabs, 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.

Figure 03 Contamination of Water due to the River Gem Mining

Source: Photograph by Author (2021)

Table 01: Environmental Impacts 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: Jayawardhana (2022)

Conclusions and Recommendations

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.

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.

As a common environmental impact, these three mining techniques can be identified: deforestation. In tunnel gem mining and river gem mining, the construction of tunnels and scaffolds is done by using timber or stems of trees. This directly contributed to increasing the deforestation rate of Ratnapura. On the other hand, most of the illegal mines are located near the forest edge or in the forest. This also leads to deforestation. Similarly, deforestation impacts the other environmental impacts of loss of biodiversity, loss of habitats and many other issues. Consequently, the land gem mining techniques of tunnel gem mining and backhoe gem mining, there are a huge force for soil erosion. When the mining pits and tunnels excavate using human power and machines, the soil becomes eroded due to the movement of the machines, humans and non-closure of the mines and other natural reasons like wind and rain. Once the soil becomes eroded, that soil automatically becomes infertile. Ultimately, this caused a reduction in the agriculture sector's production in the case study area. In the case study area, there can be seen a number of vacant lands that have not been utilized in any agricultural or any other uses due to the mining activities. Furthermore, land gem mining has an impact on soil stability due to the non-closure of mining pits. Since most of the miners leave the mines without closing them, the baring capacity of the soil is lost when the load is applied to the land. With the passage of time, those lands are subject to natural descending.

The contamination of the underground and surface water is a common environmental impact of these three gem mining techniques. In the land gem mining techniques of tunnel gem mining and backhoe gem mining, the escape water from the mines is mixed with the acids and chemicals extracted in the excavation. River gem mining has a large-scale impact on the contamination of water compared with the other two techniques. Since the river gem mining proceeds, the river's flowing water becomes polluted and that water is not suitable for usage, especially for drinking. Ultimately, this leads to a higher rate of health issues for all living beings who consume that polluted water. Anyhow, miners can overcome these environmental impacts by adapting ethical and environmentally sensitive remedies for these identified impacts.

Miners can follow a replanting strategy to reduce the impacts of deforestation as a remedial measure. But it is necessary to regulate this policy by the respective organization or government body. On the other hand, the government can impose some penalties for overuse of trees for mining activities or can provide some incentives for replanting trees. To reduce soil pollution, miners can adapt a manageable policy to discharge the leaked water from the tunnel and pit. Furthermore, to reduce the impact of contamination of water due to the mixing of water with chemicals and acids extracted during the mining process. For that, miners can discharge water into a particular area by constructing ponds. Therefore, it facilitates reducing the mixture of

polluted water with non-polluted water. Further, to protect the animals' habitats in the mining areas and the lives of those animals, can restrict hunting and impose a penalty for that. Apart from that, the respective government institutions can follow an ecosystem management program and provide the knowledge to the miners indicating the importance of protecting the environment and future generations. But the most important thing is the necessity of government involvement for regulation of the gem industry to reduce the adverse impacts of mining activities. If not, there may be a negative impact of gem mining rather than the positive impacts. Furthermore, all living organisms may have to face huge environmental hazards in the near future and future generations may have to bear the adverse impacts of mining activities because of current unethical gem mining practices.

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