

COMPARATIVE STUDY OF GREEN MINING CONCEPTS: POLICIES, STRATEGIES AND INNOVATIONS IN SELECTED COUNTRIES

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ABSTRACT

Mining practices have been known as business activities, and deteriorate the environment. To overcome this, the concepts of Green Mining, Climate – Smart Mining, and Green – Climate Smart Mining were introduced to offer a more environmentally friendly way to carry out mining business practices properly. This paper is a systematic observation using Literature Review where selected papers are analyzed after going through a systematic search and selection procedure through nine stages. The results of this analysis showed that there are differences in policies, strategies, and innovations in implementing the concept. However, each country of Finland, Australia, Canada, and Indonesia, equally applies the concept of environmentally friendly green mining by referring to five pillars, namely (1) promoting material and energy efficiency, (2) ensuring the availability of mineral resources for future needs, (3) minimizing adverse environmental and social impacts, (4) improving work practices and organization, and (5) ensuring sustainable land use after mine closure. Various profiles are expressed in the conclusion.

Keywords: Sustainable mining, Green Mining, Climate-Smart Mining, Green Climate-Smart Mining

1.0 INTRODUCTION

Mining practices have been known to cause environmental damage. To overcome these impacts, the Green Mining (GM) concept was introduced to enable mining practices to be carried out in a more environmentally friendly manner (Nurmi, 2017). The GM concept has long been applied since the 19th century in many countries, such as France, Ireland, France, Spain, England, Canada, China, Finland, and the United States (Jiskani et al., 2021). Then in 2019, the World Bank introduced the Climate – Smart Mining (CSM) Initiative which supports the sustainable extraction and processing of minerals and metals. This is to secure supplies for clean energy technologies by minimizing carbon and material footprints throughout the value chain (Hund et al., 2020).

The CSM approach is the latest advancement in mining that aims to renovate traditional mining practices (Jiskani et al., 2021). Both the GM and CSM concepts are interrelated to ensure that mining is beneficial and the risks posed are minimal. Based on these two approaches, Jiskani introduced the Green Climate – Smart Mining (GCSM) concept which provides an opportunity to advance responsible/sustainable mining theory and practice. Additionally, the GCSM

concept is referenced for its significance in ensuring the mining sector is managed in a manner that greatly minimizes the environmental footprint.

To implement the GM/GSM/GCSM concept, many countries have created various policies, strategies, and innovations that support the implementation of these concepts (Jiskani et al., 2021). This paper focuses on how the government and mining industry in a country create policies, strategies, and innovations to implement the GM/CSM/GCSM concept. The breakthroughs made by both the government and mining companies in selected countries, such as Finland, Australia, Canada, and Indonesia, are interesting to analyse in this paper. The selection of these countries was based on previous literature studies which stated that the government/ mining industry in the selected countries had made several breakthroughs as a strategy and innovation in implementing the GM/CSM/GCSM concept. Then, in this paper, one could look at the differences and similarities in policies, strategies, or innovations carried out by both the government and mining companies.

2.0 METHOD

The method used in this paper is a systematic literature review. The review can be defined as a review of an existing body of literature that follows a transparent methodology in searching, assessing quality, and synthesizing it with a high degree of objectivity (Kraus et al., 2020). Systematic literature reviews are very useful for analysing large amounts of data because they make it possible to establish treatment patterns that allow the reduction and selection of the most significant references quickly and always based on criteria previously established by the researchers (Mangas-Vega et al., 2018). There are stages in conducting a systematic literature review. In writing this paper, nine steps for conducting a systematic literature review were carried out (Xiao & Watson, 2019), namely: (1) formulating the problem, (2) developing and validating a review protocol, (3) selecting a database as appropriate, (4) literature search, (5) screening for inclusion, (6) assessing quality, (7) data mining, (8) analysing and synthesizing data, and (9) reporting findings, A modified version of the systematic literature review process shown in Figure 1 (Pang et al., 2023):

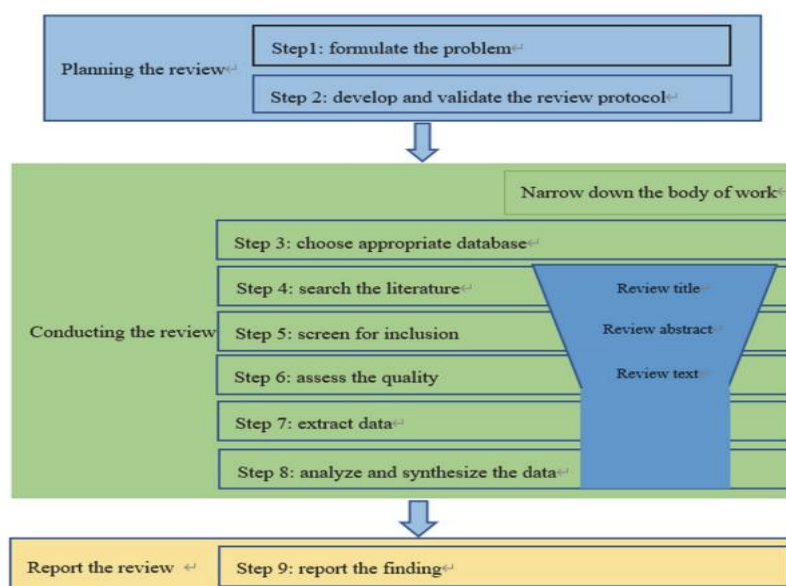


Figure 1 Systematic Literature Review Process

Source: Xiao & Watson, 2019 and Pang et al., 2023

Writing this paper follows the nine stages of the systematic literature review process as shown in Figure 1. To facilitate the literature search process, the author formulates the problem that will be the topic of writing the paper. Then the protocol for writing this paper includes selecting the most appropriate database. The four databases used by the author are Scopus, ScienceDirect, SpringerLink, and Google Scholar. After selecting four databases, the literature search continued. Search results from the four data sources used obtained a total of 475 articles, namely: 136 articles in the Scopus database, 122 in the ScienceDirect database, 115 in the SpringerLink database, and 102 in Google Scholar. After removing 45 duplicates, the author finally got a total of 430 articles.

Next, the authors screened the literature for inclusion. Each stage of the systematic literature review process is carried out based on the modified PRISMA (The Preferred Reporting Items for Systematics Review and Meta-Analysis) diagram, shown in Figure 2 (Mangas-Vega et al., 2018).

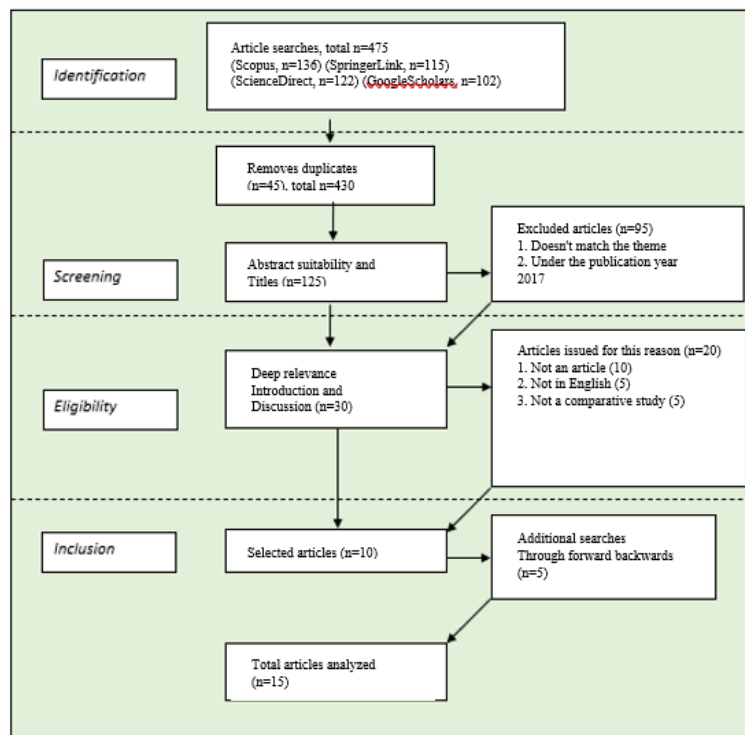


Figure 2 PRISMA Diagram for Reporting Literature Search for Inclusion

Source: (Mangas-Vega et al., 2018)

Based on Figure 2, the inclusion criteria in this paper are (1) Green Mining, Climate Smart Mining, Green Climate – Smart Mining, Innovation/policy/award for sustainable/friendly

mining, (2) Article type only (3) Year of publication 2017 -2023, (4) Language limited to English, and (5) Comparative studies. To find out more about whether the articles were relevant to the needs of writing the paper, reading the titles and abstracts was carried out first, and 125 articles were obtained. Then 95 articles were excluded that did not match the theme and were under the publication year 2017. If the relevance cannot be identified through the title and abstract, then the introduction and discussion sections are read until it can be ascertained that the article meets the requirements for writing the paper, resulting in 30 articles. Then 20 articles were excluded (10 articles were not an article, 5 articles were not in English, and 5 articles were not comparative studies), so 10 articles were selected. Overall, there are a total of 15 articles that are considered to be the most relevant literature and were chosen as material for writing the review.

3.0 RESULTS AND DISCUSSION

The GM concept was introduced (Nurmi, 2020) to enable mining practices to be carried out in a more environmentally friendly manner. Implementing the GM concept will not only minimize environmental costs but also extend the use of mineral resources for future generations. Furthermore, Nurmi emphasized that long-term investment is needed in mineral exploration supported by geoscientific mapping, mineral systems research, and the development of exploration techniques. The GM concept aims to minimize adverse environmental and social impacts at all stages of operation and to maximize local benefits (Nurmi, 2017). This concept also promotes material, water, and energy efficiency to reduce the carbon footprint of the life cycle of mineral-based products, as well as enabling the recovery of all useful minerals and minimizing mining waste.

The GM concept also requires active participation from various stakeholders throughout the mining life cycle, from initial exploration to mine closure (Nurmi, 2017). According to employees, not dangerous for residents and the environment. Apart from that, Nurmi also emphasized that when mining activities have been completed/closed, GM also help restore the mining area so that it is safe and better so that it can be reused. One of the countries that is a pioneer in implementing the GM concept is Finland.

The GM concept in Finland was developed in 2011 as a key tool to make Finland a pioneer in sustainable mining (Nurmi, 2012). The GM concept is based on five pillars (Nurmi, 2017), namely (1) Promoting material and energy efficiency, (2) Ensuring the availability of mineral resources for future needs, (3) Minimizing adverse environmental and social impacts, (4) Improving work practices and organization, and (5) Ensuring sustainable land use after mine closure.

Apart from the five pillars that serve as Finland's reference in implementing the GM concept, the development of the Geological Survey of Finland (GTK) and the Finnish Funding Agency for Innovation (Tekes) also have an important role. In 2010, Finland was one of the first countries to implement a GTK strategy (Nurmi, 2020). GTK's role in Finland is very large, as a commission that helps the country assess geoscientific data and provide advice regarding safe mineral exploration processes. This is to support sustainable national economic growth, and prosperity, and ensure the availability of mineral reserves for future generations.

Currently, GTK is also continuing to be developed to provide 3D geological modelling data to determine the potential for new minerals to be explored by considering environmental risks. GTK's strategy in 2020 emphasizes more sustainable growth solutions and creating innovation for resource efficiency, circular economy, and solutions that lead to the application of low-carbon technology (Nurmi, 2020). Innovation in GTK was also carried out by adding the RDI (Research, Development and Innovation) program. One of the RDI programs is used by GTK to assist the government in making decisions involving companies and the community. GTK remains committed to continuing support to the Finnish government in its efforts to develop a sustainable mining industry. In addition, GTK also initiated a systematic development and skills program with various internal instruments and global recruitment of research professors, senior scientists, and post-doctoral researchers.

Apart from GTK, Tekes played an important role in Finland's success in implementing the GM concept. The word Tekes comes from the Finnish "Tekniikan Edistämiskeskus" or Centre for Advancement of Technology. Tekes is the Finnish technology and innovation funding agency of the Ministry of Employment and the Economy. The agency can provide funding to corporate projects to turn research-stage ideas into viable, environmentally friendly businesses. In the last five years, the Tekes program included more than 100 projects all covering the five GM pillars with a total budget of 116 million Euros and involving 185 partners ranging from industry to academia. The results of these projects continue to be used to help the mining industry improve its performance in all areas of environmentally friendly mining so that it has a social impact and is accepted in the future (Nurmi, 2020).

Apart from Finland, the country that has proven its success in implementing the GM concept is Australia. In contrast to Finland, Australia has had much success in implementing the GM concept in carrying out post-mining activities. The post-mining activities carried out are rehabilitation, namely activities to restore, maintain, and improve land function. In the mining industry, Australia is a leader in land rehabilitation with its theory, application, demonstration, and communication (Cummings, 2014). The Western Australian Mining Act 1978 stipulates that mining companies must rehabilitate mine sites after mining activities end (Burton et al., 2012). This policy is reinforced in most Australian states and territories through environmental bonds that provide incentives for companies to undertake rehabilitation (Burton et al., 2012; White et al., 2012). However, in terms of state law, regulators have certain latitude regarding the type of rehabilitation and the timing of its implementation (Burton et al., 2012).

Many mining companies in Australia have carried out high-quality land rehabilitation and brought socio-economic benefits to communities. For example, rehabilitation of sand mining in Newcastle, coal in the Hunter Valley, bauxite in western and northern Australia) (Cummings, 2014). The results of Cummings' research showed that the rehabilitation programs that have been carried out have returned the land to better conditions. In addition, the "Grassy Groundcover" and "Whole of Paddock Rehabilitation" programs have demonstrated efforts that can be made to restore rich native biodiversity (Cummings, 2014).

The rehabilitation program is a breakthrough in the Australian mining industry in efforts to repair former mines. One mining company that has exceeded its achievements in rehabilitation is the bauxite mining company Alcoa. Alcoa's success in restoring mining sites in the Jarrah-forest ecosystem, considers several criteria, namely the ecosystem which includes vegetation

structure, diversity of flora and fauna, and ecological processes including land functions such as nutrient cycles and water retention (Burton et al., 2012; Koch & Hobbs, 2007). Overall, it appears that the rehabilitation practices carried out by Alcoa have brought social benefits to society, which far exceed the costs incurred by the company for rehabilitation (Burton et al., 2012). In several literatures it is also stated that thanks to the rehabilitation efforts carried out, Alcoa was able to achieve 101% of its goals, namely reintroducing plants previously found in the area and introducing new plants that were more resilient and able to survive the dry season in the area. The same thing happened at the Wilkie Creek mine in Queensland, the Peabody coal company carried out a 395-acre rehabilitation project equivalent to almost two-thirds of the land used for the mining project. With even better results, much of the new land has been given over to cattle farming to continue to benefit the local economy.

Not only Finland and Australia have proven their success in implementing the GM concept. Many countries are also trying to realize the success of GM implementation and are also developing the GM concept itself. The World Bank introduced the Climate-Smart Mining (CSM) Initiative as part of the development of the GM concept. The CSM concept supports the sustainable extraction and processing of minerals and metals to secure supplies for clean energy technologies by minimizing carbon and material footprints across the value chain (Hund et al., 2020).

The CSM framework is based on four building blocks known as four building blocks (Phadke, 2019). The first is climate change mitigation, which consists of the use of renewable energy, innovation in extractive practices, and energy efficiency. The second is climate change adaptation, which involves environmentally friendly mining, resource efficiency, and innovative mine waste solutions. Third is reducing material impacts which focuses on implementing a circular economy, recycling materials/using low-carbon minerals, and managing low-carbon mineral supply chains. Fourth is creating marketing opportunities, which consist of reducing investment risks (prioritizing low-carbon minerals), the benefits of carbon financing instruments, and strong geological data management (Hund et al., 2020).

One country that is currently trying to implement the CSM concept is Canada. The Government of Canada is committed to advancing climate-smart mining and providing raw materials for clean technologies worldwide. The Government of Canada's support for sustainable mining was conveyed at several international conferences, especially to advance the extraction and sustainable management of metallic minerals as per the CSM framework which is a World Bank initiative. One of the innovations carried out by the Canadian Government was to create an Action Plan which was released in 2020 and is known as The Canadian Minerals and Metals Plan (CMMP). This Action Plan is the responsibility and priority of the Canadian federal, provincial, and territorial governments. CMMP activities and programs are developed in collaboration with the government, indigenous communities, industry, and civil society. The vision that will be realized is reducing the environmental footprint of mining, managing mining waste into useful products, better planning for mine closure, reclamation of mine sites, and systematic climate change adaptation planning. To accelerate the achievement of this vision, the Canadian government collaborates with the World Bank and other international partners. This is to operationalize climate-smart mining and support sustainable economic growth in the transition to a low-carbon economy.

Another interesting thing about implementing the GM/CSM concept in Canada is the active community involvement in environmental assessments (EA) in the mining industry which is supervised by the Nunavut Impact Review Board (NIRB). EA is one of the most influential aspects of environmental regulation and policy in North America. EA activities include analysis of the environmental and socio-economic impacts of mining industry plans, steps to mitigate or eliminate negative impacts while providing benefits, identification of impacts that will be left behind and the significance of handling them, as well as follow-up plans and monitoring of activities (Prno et al., 2021).

One example is The Back River Project, a gold mine owned by Sabina Gold & Silver Corp. The mining industry operation has received NIRB approval by developing a comprehensive community engagement program during the EA phase. The industry shares information receives and addresses feedback, addresses local community concerns, and develops productive relationships to support industry progress (Prno et al., 2021). Sabina Gold & Silver Corp's experience in expressing the importance of early community involvement is an important lesson for other mining companies. The approach used is a context-specific approach consisting of (1) comprehensive recording and reporting, (2) meaningful integration of community perspectives and traditional knowledge, and (3) a focus on long-term relationships, partnerships, and local benefits.

The application of the GM/CSM concept as carried out by Finland, Australia, and Canada apart from inspiring other countries, such as Indonesia, also inspired research development. For example, in research conducted by Jiskani et al. (2021), the concept developed is known as Green Climate – Smart Mining (GCSM). In assessing mining business practices, the GCSM concept uses six main indicators, namely (1) environmental production, (2) pollution control, (3) waste management, (4) energy and resource efficiency, (5) technology empowerment and implementation, (6) sectoral and managerial efficiency.

The implementation of the GM/CSM/GCSM concept in Indonesia is carried out through collaboration between the government, mining companies, investors/mining entrepreneurs, and researchers which are referred to as green policy, green management, green investment, and technology. green (green technology) (Saepudin et al., 2022). To support the implementation of the GM/CSM/GCSM concept in Indonesia, various regulations have been made by the Indonesian Government, for example, Law Number 3 of 2020 concerning Amendments to Law Number 4 of 2019 concerning Mineral and Coal Mining (UU Minerba) along with derivative regulations and other related. The mineral and coal law regulates mining practices starting from the stages of applying for permits to carry out mining businesses, and mining activities, to closing mining areas. For each of these stages, the Indonesian government makes derivative regulations as a reference for technical implementation.

The Indonesian government is also making innovations through the Company Performance Rating Assessment Program in Environmental Management, or known as Proper. This program is regulated in Minister of Environment and Forestry Regulation Number 1 of 2021 where Article 1 states that Proper is an evaluation of the performance of the person responsible for business and/or activities in the field of environmental management. Proper was developed by the Indonesian Government as a measure of a company's ability to implement pro-

environmental policies. It also encourages the business world to continue to improve environmental management performance and make continuous improvements.

According to the 2022 annual report of the Ministry of Environment, Proper has been running for 25 years and has developed into a platform for the business world to carry out sustainable business practices by applying green economy principles. Criteria for environmental management and community empowerment contained in Proper include environmental management systems, energy efficiency, reducing emissions and greenhouse gases, water efficiency, reducing and utilizing hazardous and toxic waste (B3), 3R waste management (Reduce, Reuse, and Recycling), protecting biodiversity, community development, implementing Life Cycle Assessment, Social Return on Investment, and Green Leadership.

For mining companies that receive the Proper award, the Indonesian government will provide incentives or facilities such as tax exemptions on imports of mining equipment and recommendations to banks to obtain financial loans to support the management of the company's mining activities. For example, PT Adaro was the first mining company to receive Proper gold. This award is an important recognition for company management, placing energy and environmental issues as an important part of the company's management and continuing to make improvements in running the mining business (Saepudin et al., 2022). Several innovations have been made by PT Adaro, namely (1) the use of new and renewable energy (2) environmentally friendly green energy initiatives (developing electrical energy from waste), and (3) creating nurseries and nurseries for plants and trees with the best quality to support the Net Zero Emission program.

Apart from the Proper award, the Ministry of Energy and Mineral Resources (ESDM) also gave awards to several mineral and coal mining companies, which were deemed to have implemented good Mineral and Coal mining engineering principles. The implementation of good mining principles is regulated in the Minister of Energy and Mineral Resources Regulation Number 26 of 2018. Activities carried out routinely by the Directorate General of Mineral and Coal are an appreciation from the Indonesian government to mining companies in their efforts to comply with technical regulations, implement resource and reserve conservation, create safe working conditions, and protection of the environment. All of these activities are carried out to realize good mining practices or Good Mining Practices.

An example of an award given by the Ministry of Energy and Mineral Resources is the Good Mining Practices Award. In 2022, PT Trimegah Bangun Persada (PT TBP) received this award because of its achievements in mining management. Several innovations were carried out by PT TBP, namely (1) Environmental Impact Analysis which can mitigate potential negative impacts on the environment, waste management, water management and conservation, and biodiversity, and (2) the use of Limoite nickel smelter with High Pressure Acid Leach technology which is claimed has a lower carbon footprint.

4.0 CONCLUSION

There are differences and similarities in policies, strategies, and innovations carried out by both the government and mining companies in Finland, Australia, Canada, and Indonesia in implementing GM/CSM/CCSM. The differences are caused by the characteristics of each country. Finland, with its high commitment to being a pioneer in implementing GM in the

world, adheres to the five pillars that were built. The five pillars include: (1) promoting material and energy efficiency, (2) ensuring the availability of mineral resources for future needs, (3) minimizing adverse environmental and social impacts, (4) improving work practices and organizations, and (5) ensure sustainable land use after mine closure. Meanwhile, Australia has been successful in carrying out post-mining activities, which are supported by strong policies that regulate mining companies' obligations to carry out rehabilitation and provide incentives.

Canada, which plays an active role in supporting the CSM concept, innovated by creating an Action Plan known as The Canadian Minerals and Metals Plan (CMMP) and supporting the active involvement of the community in environmental assessments (EA). In contrast to Finland, Australia, and Canada, Indonesia is innovating with award programs carried out by the government for mining companies and providing incentives. This can be a stimulant for mining companies to carry out environmentally friendly and sustainable mining practices.

Even though there are differences in policies, strategies and innovations in implementing the concept, each country (Finland, Australia, Canada and Indonesia) equally applies the concept of environmentally friendly green mining by referring to the five pillars. The goals to be achieved are the same, namely supporting sustainable development, prosperity, ensuring the availability of mineral reserves for the needs of future generations, and minimizing waste and environmental footprint.

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