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The Impact of Electric Vehicles on the Demand for Natural Resources

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Abstract:

Advancements in electric vehicle technology are shifting demand for raw materials, including lithium, cobalt, and nickel, which are primarily used in the manufacture of EV parts, particularly batteries. The adoption of EVs is significantly changing the demand for resources. As a result, this shift in demand impacts the environment and the overall social wellbeing of the people. The most affected group are those in the localities where these minerals are mined. The economy is also significantly impacted because this shift carries with it a wide range of challenges associated with the mining processes of these minerals. This dissertation explores the sustainability of the current extraction to outline potential solutions to the problem of resource scarcity. This is essential in the sense that it ensures sustainability. The findings demonstrate that, whereas the use of EVS has environmental advantages, it is not devoid of challenges which arise from the over-reliance on critical mineral resources, thus affecting sustainability and supply chain stability.

Keywords: Electric vehicles, natural resources, lithium, cobalt, nickel, sustainability, supply chain, battery production

1. Introduction

1.1 Background and Rationale

The automotive industry worldwide is gradually transitioning towards electric vehicles (EVs). Sustainable solutions to address climate change-related challenges have become essential to both governments and public and private organizations as well as end customers. The Paris Accord serves as an international policy to limit global warming while reducing fossil energy use, as stated by Jackson et al. (2018) and Damian et al. (2015). The rise in the EV market and its use can be credited to advances in technology alongside government backing, together with growing awareness among consumers of environmental pollution. According to the latest IEA report, worldwide EV adoption rose to surpass 10 million units last year (IEA, 2021. Research indicates that EV demand will maintain its growing position in the global automobile market throughout the following years.

Electric Vehicles contribute to lower pollution because they do not have exhaust pipe emissions; however, their production processes and usage create

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economic, environmental, and geopolitical challenges. The production of EVs requires strategic metals for battery use since they depend on lithium cobalt and nickel resources (Liu et al., 2019). The growing EV market creates more demand for these mineral resources, which changes the way supply chains operate around the world. According to Sakunai et al. (2021), the growing market demand has strengthened the requirement for mineral mining to meet new market demands. Different geographical distributions of resources challenge the future sustainability of their usage while raising supply chain security concerns and social and environmental effect assessments for their mainly concentrated country sources.

Multiple mining operations are on the rise as critical mineral demand increases. This simultaneously creates environmental threats and social harm in resource-rich countries (Un-Noor et al., 2017). Cobalt extraction operations in the Democratic Republic of Congo (DRC) have been reported to create human rights violations (Baumann-Pauly, 2023). Child labour is a major human rights abuse in the Congo, as many children are employed in cobalt mines, where they work under hazardous working conditions (Umpula & Dummett, 2024). As for lithium extraction in the “Lithium Triangle” region of South America, including Argentina, Bolivia, and Chile, it raises concerns about water resources, land, and ecosystems (Carrasco, 2025). Nickel mining also has deep links to Indonesia and the Philippines, where deforestation, habitat destruction and pollution of the surrounding local communities have also been observed. These emerging issues show that while the use of EVS can have a relatively low impact on emissions, their production is not devoid of environmental and ethical issues.

Besides the environmental issues supply chain security is getting to be one of the most sensitive topic for governments as well as manufacturers. Currently, most EV manufacturing relies on a few countries that supply critical battery materials, exposing the EV industry to geopolitical risks and supply shocks (Ren et al., 2024). China has also strategically aligned itself as a major player in the battery supply chain. It is particularly involved in the refining and processing of battery metals such as lithium, cobalt, and nickel (Kalungi et al., 2024; Gulley, 2024). This has raised the probability of supply shocks and future stability of resources that are crucial in the extraction process.

Addressing these challenges require a holistic approach where resource security, ethical mining practice, and environmental sustainability are taken into consideration. According to Hou et al. (2024), new technologies in recycling batteries, development of new battery types that use new materials such as sodium and solid-state batteries, and the use of responsibly-sourced materials are some of the strategies that could help the battery industry to shift away from the exploitative extraction of fresh materials. Moreover, governments and international organizations must also continue to develop and implement favorable policies to support ethical mining practices. Supply chain traceability, and recycled and circular economy solutions are also essential to increase the lifespan of products made from such critical minerals.

This study reviewed the impact of EVs on the global demand for primary raw materials including lithium, cobalt, and nickel, and its associated effect on the economy and environment which arise from the extraction of more resources for the production of EVs. It also highlights on the dynamics of sourcing of minerals, the politics of distributing resources, and the possible ways of preventing adverse impacts to the environment and people. Identifying associated challenges is crucial in proposing policy implications and strategic directions for policy-makers, market players, as well as scholars to facilitate a responsible shift towards a more sustainable production of EV batteries to achieve sustainable electro-mobility.

2. Literature Review

2.1 The Rise of Electric Vehicles and Their Impact on Resource Demand

The adoption of electric vehicles is being propelled globally due to the desire to decrease the emission of green gases and curb impacts of climate change. The IEA reports that the transportation sector is responsible for approximately 24% of global CO2 emissions, which means that the reducing of carbon emissions is a priority (Sitati et al., 2022; IEA, 2020). Electric Vehicles (EVs) that emit no exhaust fumes are viewed as a key mitigation measure in the quest to address the adverse effects of vehicle emissions. However, electric vehicles depend on some vital materials, including lithium, cobalt, and nickel for battery production (Simon et al., 2015; Maisel et al., 2023). This has subsequently caused a steady rise in the usage of these resources, not without affecting the availability and sustainability of these resources in the global markets.

2.1.1 The Role of Lithium in EV Batteries

Lithium is a material used in the construction of Li-ion batteries, a popular type of batteries used in EVs. According to The Northern Miner Group (2022), the demand for lithium has since increased as evidenced the production by country which grew to 21% in 2024, as stated by the US Geological Survey (USGS), mainly due to the rising demand for electric cars (IRENA, 2024). Lithium resources are predominantly found in South America, and the

"Lithium Triangle" which includes Chile, Argentina, and Bolivia Ahmad, (2024). The extraction of lithium in this region has been associated with the risks such as water rationing and disruption of ecosystems. These sentiments are echoed by Mortensen (2019) and Greenfield (2022), who further stated that the process of mining for lithium in the Atacama Desert in Chile, has been linked to the drawing down of water from underground aquifers which are a valuable resource for people and animals in the area.

2.1.2 The Role of Cobalt in EV Batteries

Cobalt is another important mineral required in EV batteries, especially in the cathode portion of lithium-ion batteries. The Cobalt Institute estimates the global cobalt consumption to increase by 60 percent by 2025 mainly by EVs (Fu et al., 2020; Azevedo et al., 2018). Cobalt mining is primarily conducted in the democratic republic of Congo where it is estimated that 70% of the global output is sourced (Gulley, 2023). Still, the extraction of cobalt in the DRC has been linked with the violation of human rights particularly child labor (Moss, 2022). These children are exposed to hazardous working conditions which expose them not only to physical harm but also infection from communicable diseases. The sustainability of the current extraction practices has also been under criticism due to the negative effects of the process such as deforestation to access cobalt and water pollution.

2.1.3 The Role of Nickel in EV Batteries

Nickel is another important CM used in EV batteries, especially in high-nickel cathodes, which deliver more energy capacity and improved cycle life. The INSG report on global nickel supply and demand also reveals that nickel consumption is projected to rise by forty percent by the year 2030 with EV's being the key driver (Jennifer, 2024). Indonesia, the Philippines and Russia contain most of the global nickel resources. Nevertheless, the cycle has been characterized by social and environmental impacts such as destruction of the tropical forest, soil degradation, and water pollution due to nickel mining. However, the extraction of nickel from nickel ore to battery-grade nickel is a process that consumes a lot of energy and inevitably generates greenhouse emissions (Murdock et al., 2021), hence the concern over the environmental impacts of nickel production.

2.2 Environmental and Social Implications of Increased Resource Extraction

Lithium, cobalt and nickel, required in battery production, are increasingly mired in ecological and societal concerns. The exploitation and further treatment of these resources are accompanied by various environmental consequences including water deficit, disruption of ecosystems, and emissions of greenhouse gasses. Furthermore, there are social issues that are becoming increasingly sensitive such as the rights of individuals, especially indigenous people and other communities who are displaced by extractive industries.

2.2.1 Environmental Impacts of Lithium Extraction.

Lithium extraction, especially in the so-called "Lithium Triangle" of South America, has been implicated in various environmental costs (Giglio, 2021). The extraction process involves the pumping of brine from the underground aquifers and then evaporation of the brine in a series of ponds to obtain lithium. This process involves using large volumes of water, which has caused the decline in the water table and reduced availability of ground water especially in areas like the Atacama Desert. Atacama Desert is the driest place in the world and lithium extraction has further contributed to water crises in the region, impacting communities and fauna. Farmers and indigenous communities share echo similar complaints about running lacking water, which make livestock farming unsustainable. The emission of hazardous wastes and harmful waste products receive inadequate regulation for disposal and produce lasting negative results for the environment. The environment suffers from two major problems so scientists research Direct Lithium Extraction (DLE) as a water-saving technology that produces lower waste. The local people and environment require better water management combined with enhanced environmental standards to minimize lithium extraction's adverse effects.

2.2.2 Environmental and Social Impacts of Cobalt Mining

The Democratic Republic of Congo (DRC) has consistently faced adverse consequences from cobalt mining. It has been found that the DRC miners extract the majority of its cobalt from ASM activities since ASM follows an informal process during which miners face various safety dangers by entering dangerous areas (Tsurukawa et al., 2011). Adults together with children undertake hazardous labor in unsafe mining conditions while earning minimal pay without receiving any protective safety equipment. The mining industry in cobalt mines employs children aged as young as six years to work with other workers. Children in these conditions encounter brutal working environments that include cave collapses that could bury them alive and toxic chemical exposure and lengthy manual labor duties. Also, cobalt mining leads to deforestation, soil erosion, and water pollution which are catastrophic to ecosystems or the inhabitants of these regions.

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This often entails deforestation, which entails the removal of trees in large areas and thus has a negative impact on the ecosystem. Whereas most mining operations are located close to water sources, the water in such areas is often laden with heavy metals and other chemicals. These social and environmental issues show that there is need for improved responsibility in cobalt mining as well as proper disclosure of supply chain. For example, the Responsible Cobalt Initiative (RCI) and the Cobalt Refinery Supply Chain Due Diligence Standard help to enhance working conditions and minimize the negative effects on the environment; however, it is crucial to continue to promote the idea of sustainable and ethical exploitation of cobalt.

2.2.3 Environmental Impacts of Nickel Mining

Nickel is primarily mined through open-cast mining method which causes deforestation, soil erosion and pollution of water sources (Asare & Darkoh, 2001; Bartzas et al., 2021). However, the extraction of nickel from nickel ore to battery-grade nickel is a process that consumes a lot of energy and inevitably generates greenhouse emissions hence the concern over the environmental impacts of nickel production. Currently in Indonesia, sulfide ores are mostly being processed using coal fired power plants, factors that causes air pollution and climate change. The effects of nickel mining and processing: Nickel mining and processing have adverse effects on the environment due to the use of fossil fuel and energy intensive methods and lack of strict environmental controls. Also, the reclamation of mined locations and reforestation can also serve to offset the long-term effects of nickel mining on the environment.

3. Discussion

3.1 Politics of Resource Distribution

The production of electric vehicles depends on minerals like cobalt, lithium, and nickel to make EV parts. These minerals are not evenly distributed on the surface of the earth which end up creating three main difficulties related to environmental destruction, geopolitical power dynamics and supply chain risks. The mining sector damages ecosystems because it requires destructive techniques including water pollution along with deforestation that particularly harms developing areas. These resources that exist unevenly across the globe enable resource-rich countries to gain political control thereby making their nations important for many global supply chains but also generating dependency issues. Cobalt extraction from the DRC represents more than 60% of the global supply. However, these operations exist within a region where unstable politics and unethical employee treatment practices endanger supply chain reliability. Evolved EV supply chains face instability because of the geopolitical conflict brought about the competition for resources by the two leading EV producers and world powers - the U.S. and China. These economic powerhouses consistently fight for rare earth elements resulting in political instability in the governments of the nation's producing these resources. The integration of global cooperation with ethical sourcing procedures together with investments in alternative materials and waste recycling solutions can serves to address the political along with environmental threats that arise from EV mineral extraction procedures.

3.2 Potential Solutions to Mitigate Resource Scarcity and Ensure Sustainability

The difficulty of extracting many of the critical minerals, lithium, cobalt, nickel, makes sustainability a big question in the economies where these mines exist. The reason being that the pursuit for income overrides safety, labor protections and sustainable mineral extraction in a manner that ensure current and future benefit from the resource. In an effort to overcome these difficulties, some solutions have been suggested as capable of mitigating these challenges include recycling batteries, developing new battery types and encouraging sustainable mining processes. These solutions are practical and provide effective means by which to minimize the negative effects that the extraction of materials has on the environment, politics and society while encouraging a sustainable extraction of the needed raw materials for EV batteries.

3.2.1 Recycling of EV Batteries

Recycling is regarded as one of the strategies that can address the challenges of resource scarcity and environmental degradation in the manufacturing of EV batteries. Recycling batteries can ensure that the constant demand for raw materials is controlled. Without recycling the demand will exceed supply and this can bring about increase in prices thus making the production of EV less motivating as customers can abandon them altogether. Besides, with uncontrolled demand, there is the likelihood of geopolitical tensions between countries as they compete for the scarce resources. The European Commission reported that recycling can potentially recover up to 95% of the critical minerals used in EV batteries or batteries in general, minimizing the demand for new mining operations (Antony Jose et al., 2024). Nevertheless, the current situation with the recycling of EV batteries is rather less developed and there are still many technological and logistical issues to solve. For instance, recycling involves the use of energy and can lead to the production of hazardous waste, which is contentious to the environment. Moreover, the collection and transportation of recycled wastes are sometimes complicated, especially in developing countries and areas with poor infrastructure. These too are potential causes of hazardous. Nevertheless, further investment in recycling facilities and creating innovative recycling technologies can be instrumental in addressing current technological challenges, material scarcity and effectively minimize the negative environmental effects of EV manufacturing. Below are some of the ways through which governments and industry stakeholders can support this vital industry. Funding, incentives, and regulatory support are key ways through which governments and other industry players can support the growth of the recycling industry to support the EVs industry.

3.2.2 Alternative Battery Technologies

The use of new types of batteries that may require fewer scarce metals like lithium, cobalt, or nickel can be a better way to reduce the demand for these critical raw materials. For instance, solid state batteries, batteries which utilize solid electrolytes rather than the liquid ones have better energy density and have longer battery life, meaning less reliance on critical minerals. They are also safer and more stable than the conventional lithium-ion batteries which also makes their use in EVs appealing (IEA, 2020; Hou et al., 2024). Furthermore, sodium-ion batteries such as batteries with sodium ions instead of lithium ions are more plentiful and less dangerous to the environment compared to lithium-ion batteries. It can be extracted from sea water making it easily available and not so much force is needed to mine it as in the case of other metals. Although these technologies are still under development, they can offer promising solutions for lowering the demand for critical minerals and enhancing the sustainability of batteries for EVs. Governments and industries can encourage the development of non-lithium batteries through promotion of research in the field as well as funding pilot projects.

3.2.3 Sustainable Mining Practices

Another solution to reducing the environmental and social effects of mining is sustainable mining. For instance, the American Initiative for Responsible Mining Assurance (IRMA) aims at lessening the environmental impacts of mining and enhancing the welfare of miners. IRMA's concepts are broad and affect areas such as environment, employee, and public relations (Greenfield, 2022). Moreover, the application of renewable energy in mines can mitigate the environmentally detrimental effects of greenhouse gas emissions in mining activities (IEA, 2020; Hou et al., 2024). For instance, mining firms can reduce electricity consumption from the grid and instead use solar or wind energy to perform their activities. There is also the aspect of policy that governments can use as well to ensure that mining is done in a way that will not harm the environment and the people in the long run (Greenfield, 2022; Hou et al., 2024). Thus, the industry can contribute more effectively to a paradigm shift in favor of electric vehicles and, consequently, the development of sustainable development goals on a global scale.

3.3 Sustainable Mining Practices to Address Economic and Environmental Challenges in the Electric Vehicle Supply Chain

The shift towards the use of electric vehicles is taking place across several countries. The production of EVs depends on crucial materials such as lithium, cobalt, and nickel, that are mined in environmentally, economically, and socially costly ways (IEA, 2020; Hou et al., 2024). To rectify these vices, sustainable mining practices have to be implemented to help realized net benefits and reduce supply risks, benefit local economies, and address environmental and social issues. Some of the sustainable mining practices that can aid in addressing the above weaknesses are as covered below.

3.3.1 Diversification of Supply Chains

Countries and companies need to shift from a few suppliers by investing in mining projects in other parts of the world that offers unexplored reserves of minerals. For example, Australia, Canada, and Chile have good lithium and nickel resources that could be exploited to build the much needed robust supply chain. Another aspect of diversification is the promotion of artisan and small-scale mining and doing it right (Greenfield, 2022; Hou et al., 2024). Although most operations are informal and are subject to little or no supervision when using small-scale mining which has negatively impacted the environment and labor rights, through financial and technical assistance, governments and firms can enhance the working conditions, minimize the environmental cost, and mainstream these operations into supply chains.

3.3.2 Adoption of Circular Economy Principles

The linear model of mining involving extraction, usage, and disposal is quite unsustainable in the long run. Implementing circular economy, which implies recycling, reusing, and optimizing the use of resources, can significantly decrease the need for primary mining in the future. For instance, recycling of lithium-ion batteries can potentially reuse more than 95% of the strategic metals that are used in the batteries (Herrington, 2021). Tesla and Redwood Materials are among the companies that are developing battery recycling technologies for a closed-loop supply

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chain. They can help one shift towards a circular economy through incentives such as recycling and the extension of producer responsibility. EPR policies extend the legal responsibilities of manufacturers beyond the point of sale; they are also responsible for end-of-life disposal. This encourages firms to produced products with high levels of recyclable content and to support recycling systems.

3.3.3 Investment in Sustainable Mining Technologies

The technical know-how in the mining industry can decrease the impacts of mining in the environment and social aspects while increasing technical production rates. For instance, modern enhanced extraction technologies in lithium mining like direct lithium extraction or DLE, significantly lower the amount of water used in the lithium mining process. In South America's "Lithium Triangle," conventional lithium extraction techniques are associated with water deficit that impacts people and the environment (IEA, 2020; Hou et al., 2024). DLE technologies are more sustainable as they use chemical processes to extract lithium from brine without evaporating water. Digitalization and automation are also trends that are redefining the mining industry. Self-driving vehicles, unmanned aerial vehicles (UAVs), also known as drones, and AI can help optimize mining business processes, as well as enhance the safety and environmental aspect of the extraction and removal of valuable materials (IRENA, 2024). For instance, advancements in automated sorting technologies for ores enable miners to improve the extraction yield of the valuable metals, which means that they can minimize losses and, thus, require new mining sites. These technologies increase efficiency and decrease the social cost of mining.

3.3.4 Enhancing the Environmental and Social Governance (ESG)

Sustainability in mining operations needs environmental and social governance (ESG) because, if left unchecked, it results in massive negative externalities. Environmental standards need improvement, while EIAS requires extensive implementation to support adopting correct land reclamation methods and water resource management systems (IEA, 2020). Australian mining companies now need to develop comprehensive mine closure plans that will allow them to restore land areas concurrently with public community support measures. The system strives to guarantee the protection of the environment against negative impacts that could persist throughout the project's operation period.

Social governance is equally important. The practice of mining must respect both the native rights of local communities and indigenous people and provide them with advantages stemming from mining operations. This can be done by incorporating community development activities, paying employees fairly and implementing transparency in decision making. For example, the Initiative for Responsible Mining Assurance (IRMA) aims to offer accreditation of sustainable mining practices as well as social and environmental accountability (Greenfield, 2022; Hou et al., 2024). This way, the local communities will trust mining industries and, therefore, there will be less conflict of interest.

3.3.5 International Collaboration and Policy Frameworks

The research explains different challenges mining operations face while discussing sustainability approaches based on nation-state partnerships and policy unification. The development of worldwide sustainable mining standards falls as a core duty for both governments alongside industry and multinational organizations. The Climate Smart Mining MSG of the World Bank Group provides technical support and financial backing for climate-smart mining projects in developing countries as stated in IEA (2020). Governments along with businesses may establish effective policies for sustainable mining through trade agreements and cooperative agreements. The European Union established the Critical Raw Materials Act through which they achieve their goal of securing critical mineral supplies by establishing alliances with mineral resource countries while maintaining sustainable mining practices. This method would create sustainable global critical mineral supply chains which deliver advantages to all stakeholders.

4. Conclusion

The transition to electric vehicles is one of the defining moments in the fight against climate change, which presents a shift from internal combustion engine vehicles. Various difficulties accompany the shift to electric vehicles since natural resources face increased requirements. Manufacturing EV batteries for production requires only essential materials to succeed. The high utilization of resources leads to multiple severe impacts across supply chains. At the same time, it affects how resources can be accessed alongside issues of national interests, social fairness, and environmental stability. Manufacturing electric vehicles through mineral extraction causes sustainability problems, although their electrified system decreases emissions and air pollution.

The main environmental problem stems from mining and processing strategic minerals. South American nations within the Lithium Triangle region practice their lithium extraction activities by converting water reservoir brines into shallow watering reservoirs for evaporation, affecting local water resources and endangering native ecosystems. Suspected environmental damages from cobalt mining in the Democratic Republic of Congo include deforestation and pollution of water resources and the push of labourers, including children, towards hazardous working conditions. Industrial nickel mining operations throughout Indonesia and the Philippines result in important environmental problems, including tree loss, topsoil degradation, and gaseous emissions produced during nickel ore refinement. Multiple factors indicate that better extraction and refining methods for these strategic minerals should become the standard practice because their current operations harm both the environment and society.

This has led to the increase in the advancement of EVs, which also comes with challenges such as resource constraints, politics of resource distributions and supply chain risks. With the growth of the EV market lithium, cobalt, and nickel demand is predicted to grow significantly leading to possible shortages and wide price fluctuation. This can affect the global supply chain of EV batteries, reduce the pace of new EV vehicles adoption and hinder global climate change mitigation efforts. That is why it is crucial to define new strategies and options that would help decrease the dependence on these materials and stabilize the supply chain.

One compelling option is the reuse of EV batteries. The recycling of batteries can reclaim 95% of the critical minerals, thus reducing the exploitation of new mines and their impacts. Recycling is still relatively in its infancy and there are still many technological and logistical considerations that have yet to be worked out. For instance, the process of recycling is very energy intensive and is often associated with the generation of toxic wastes, thus, questioning the environmental sustainability of recycling. Nevertheless, further investment in recycling facilities and creating innovative recycling technologies might also be instrumental in addressing current material scarcity and minimizing the negative environmental effects of EV manufacturing.

One potential solution is the emergence of advance battery technologies that will have reduced dependency on the critical minerals. For example, solid-state batteries replace liquid electrolytes with solid ones, which deliver more energy per weight, and last longer than conventional batteries without the use of lithium or cobalt. Sodium-ion batteries that use sodium as an electrode material instead of lithium are also another potential substitute because sodium is more abundant and less detrimental to the environment compared to lithium. Although these technologies are still under development, they can offer promising solutions for lowering the demand for critical minerals and enhancing the sustainability of batteries for EVs.

Sustainable mining also provides a way of minimizing the effects of the social costs and environmental risks resulting from mining. Some programs that have been developed in an effort to address some of these challenges include The Intervention Responsible Mining Assurance (IRMA) standards. Furthermore, using renewable energy systems in mining activities may lower greenhouse gas emissions and enhance the sustainability of the resources exploitation process. By implementing these practices, the mining industry can help take a more responsible position in supporting electric mobility.

In essence, policy-makers, industries and researchers must step in to help address these challenges. First, policy maker can encourage recycling and force companies to take back their products at the end of their lifecycle; Second, policy maker can promote research and development of more sustainable battery technologies; Third, policy maker can encourage sustainable mining practices. Manufacturers and other industry players can also focus on research and development to enhance batteries' capacity to support clean energy without heavily depending on critical minerals. These findings therefore suggest that researchers can go further and apply new knowledge to solve scarcity of resources.

Review

In this dissertation I have highlighted the implications of electric vehicles (EVs) on demand for natural resources highlighting the issues that arise from the increasing demand for three primary minerals - lithium, cobalt, and nickel. From this research, I was able to increase my understanding of the social and environmental impacts that arise from higher demand for the ores and metals used in EVs and associated challenges. The major limitation that I faced was the availability of data on extraction and recycling of resources. In collecting the data, I used both primary and secondary research resources and in particular, academic articles, industry reports and case studies.

Despite the challenges I faced when researching this subject matter, this project study has helped improved my research skill, analytical skill and synthesizing skill. I was able to searched for information from different sources, which made me realized the significance of sustainable approach towards the extraction of raw materials and the increasing concern of developing new strategies to meet the increasing demand for electric vehicles. As for the future, I would like to use the knowledge and skills that I have acquired through the course of this project and in further research and practice.

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In my future research I would like to explore such areas as novel technologies like solid-state batteries and sodium-ion batteries that can help lessen the need for strategic metals. I would also want to explore the effects of recycling on resource availability and circular economy possibilities in the EV market. These topics may be of interest to policymakers and industry players to facilitate the shift to EVs and to researchers who seek to design effective policies and systems. Lastly, I would like to express the gratitude my tutor, mentor, and academic tutor, without whose help, I could not have complete the entire project.

References

Ahmad, S. (2024). The Lithium Triangle: Where Chile, Argentina and Bolivia Meet. Harvard International Review. Retrieved from https://hir.harvard.edu/lithium-triangle/

Antony Jose, S., Dworkin, L., Montano, S., Noack, W. C., Rusche, N., Williams, D., & Menezes, P. L. (2024). Pathways to Circular Economy for Electric Vehicle Batteries. *Recycling*, *9*(5), 76. https://doi.org/10.3390/recycling9050076

Asare, B. K., & Darkoh, M. B. K. (2001). Socio-economic and environmental impacts of mining in Botswana: a case Study of the Selebi-Phikwe Copper-Nickel Mine. *Eastern Africa social science research review*, *17*(2), 1-42.

Azevedo, M., Campagnol, N., Hagenbruch, T., Hoffman, K., Lala, A., & Ramsbottom, O. (2018). Lithium and cobalt. *A Tale of Two Commodities*. 1-20.

Bartzas, G., Tsakiridis, P. E., & Komnitsas, K. (2021). Nickel industry: Heavy metal (loid) s contamination-sources, environmental impacts and recent advances on waste valorization. *Current Opinion in Environmental Science & Health*, *21*, 1-12.

Baumann-Pauly, D. (2023). Cobalt mining in the Democratic Republic of the Congo: Addressing root causes of human rights abuses. *White Paper, NYU Stern Center for Business and Human*.1-16.

Carrasco, S. (2025). Closing the Lithium Triangle: Public Policies in Argentina and Bolivia. *From (De) regulation to Industrialization? Chilean Lithium Policy in Comparative Perspective*. Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-77130-9_7

Damian, M., Abbas, M., & Berthaud, P. (2015). The main directions of the 2015 Paris climate agreement. *Natures Sciences Societies*. 19-28.

Fu, X., Beatty, D. N., Gaustad, G. G., Ceder, G., Roth, R., Kirchain, R. E., ... & Olivetti, E. A. (2020). Perspectives on cobalt supply through 2030 in the face of changing demand. *Environmental science & technology*, *54*(5), 2985-2993.

Giglio, E. (2021). Extractivism and its socio-environmental impact in South America. Overview of the “lithium triangle”. *América Crítica*, *5*(1), 47-53. https://doi.org/10.13125/americacritica/4926

Greenfield, N. (2022). Lithium Mining Is Leaving Chile’s Indigenous Communities High and Dry (Literally). NRDC. Retrieved from https://www.nrdc.org/stories/lithium-mining-leaving-chiles-indigenous-communities-high-and-dry-literally

Gulley, A. L. (2023). China, the Democratic Republic of the Congo, and artisanal cobalt mining from 2000 through 2020. *Proceedings of the National Academy of Sciences*, *120*(26), 1-20. https://doi.org/10.1073/pnas.2212037120

Gulley, A. L. (2024). The development of China’s monopoly over cobalt battery materials. *Mineral Economics*, *37*(3), 619-631. https://doi.org/10.1007/s13563-024-00447-w

Hou, H., Du, B., Guo, D., Xu, H., & Fan, Y. (2024). Path to the sustainable development of China’s secondary lead industry: An overview of the current status of waste lead-acid battery recycling. *Environmental Impact Assessment Review*, *105*, 1-12. https://doi.org/10.1016/j.eiar.2023.107389

IEA (2021), Global EV Outlook 2021, IEA, Paris Retrieved from https://www.iea.org/reports/global-ev-outlook-2021,

IEA. (2020) *Tracking Transport 2020*. Available at: https://www.iea.org/reports/world-energy-outlook-2020

IRENA (2024), Critical materials: Batteries for electric vehicles, International Renewable Energy Agency, Abu Dhabi. https://www.irena.org//media/Files/IRENA/Agency/Publication/2024/Sep/IRENA_Critical_materials_Batteries_for_EVs_2024.pdf

Jackson, L.P., Grinsted, A., & Jevrejeva, S. (2018). 21st Century sea-level rise in line with the Paris agreement. *Earth’s Future*, *6* (2), 213-229.

Jennifer, L. (2024). Nickel Power: Will Demand for EVs Drive Supply to New Heights by 2030? Carbon Credit. Retrieved from, https://carboncredits.com/nickel-power-will-demand-for-evs-drive-supply-to-new-heights-by-2030/

Kalungi, P., Yao, Z., & Huang, H. (2024). Aspects of nickel, cobalt and lithium, the three key elements for Li-ion batteries: an overview on resources, demands, and production. *Materials*, *17*(17), 1-14. https://doi.org/10.3390/ma17174389

Liu, D., Gao, X., An, H., Qi, Y., Sun, X., Wang, Z., ... & Jia, N. (2019). Supply and demand response trends of lithium resources driven by the demand of emerging renewable energy technologies in China. *Resources, Conservation and Recycling*, *145*, 311-321.

Maisel, F., Neef, C., Marscheider-Weidemann, F., & Nissen, N. F. (2023). A forecast on future raw material demand and recycling potential of lithium-ion batteries in electric vehicles. *Resources, Conservation and Recycling*, *192*, 1-12. https://doi.org/10.1016/j.resconrec.2023.106920

Mortensen, N.H. (2019). Our demand for electric cars and smartphones is drying up the most arid place in the world. DANSK. Retrieved from https://danwatch.dk/en/our-demand-for-electric-cars-and-smartphones-is-drying-up-the-most-arid-place-in-the-world

Moss, N. A. F. (2022). *Child Labour in the Democratic Republic* *of Congo's Cobalt Mines: The United Nations and the European Union as Providers of Human Security (2016-2022)* (Master›s thesis, Universidade do Minho (Portugal).

Murdock, B. E., Toghill, K. E., & Tapia-Ruiz, N. (2021). A perspective on the sustainability of cathode materials used in lithium-ion batteries. *Advanced Energy Materials*, *11*(39), 1-11.

Ren, H., Mu, D., Wang, C., Yue, X., Li, Z., Du, J., & Lim, M. K. (2024). Vulnerability to geopolitical disruptions of the global electric vehicle lithium-ion battery supply chain network. *Computers & Industrial Engineering*, *188*, 1-12. https://doi.org/10.1016/j.cie.2024.109919

Sakunai, T., Ito, L., & Tokai, A. (2021). Environmental impact assessment on production and material supply stages of lithium-ion batteries with increasing demands for electric vehicles. *Journal of material cycles and waste management*, *23*, 470-479.

Simon, B., Ziemann, S., & Weil, M. (2015). Potential metal requirement of active materials in lithium-ion battery cells of electric vehicles and its impact on reserves: Focus on Europe. *Resources, conservation and recycling*, *104*, 300-310. https://doi.org/10.1016/j.resconrec.2015.07.01

Sitati, C. N., Oludhe, C., Oyake, L., & Mbandi, A. M. (2022). A street-level assessment of greenhouse gas emissions associated with traffic congestion in the city of Nairobi, Kenya. *Clean Air Journal*, *32*(1), 1-12. https://doi.org/10.17159/caj/2022/32/1.12546

The Northern Miner Group (2022). Global lithium production hits record high on electric vehicle demand. Retrieved from https://www.mining.com/global-lithium-production-hits-record-high-on-electric-vehicle-demand/

Tsurukawa, N., Prakash, S., & Manhart, A. (2011). Social impacts of artisanal cobalt mining in Katanga, Democratic Republic of Congo. *Öko-Institut eV, Freiburg*, 1-65.

Umpula, E., & Dummett, M. (2024). The blood cobalt narrative: Addressing human rights concerns or scaremongering? *Business and Human Rights Journal*, *9*(2), 308-314. https://doi.org/10.1017/bhj.2024.4

Un-Noor, F., Padmanaban, S., Mihet-Popa, L., Mollah, M. N., & Hossain, E. (2017). A comprehensive study of key electric vehicle (EV) components, technologies, challenges, impacts, and future direction of development. *Energies*, *10*(8), 1-10.

Yong, J. Y., Ramachandaramurthy, V. K., Tan, K. M., & Mithulananthan, N. (2015). A review on the state-of-the-art technologies of electric vehicle, its impacts and prospects. *Renewable and sustainable energy reviews*, *49*, 365-385.

Appendix - Gantt chart