‘Zeroing In’ on ‘Zero Emissions’

– Analysing the impact of electric vehicles on the United Nations Sustainable Development Goals (UNSDGs)

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Abstract

The United Nations launched the 2030 Agenda for Sustainable Development in 2015, to take action for the people, planet, and prosperity. This research paper aims to shed light on the impact of electric vehicles (EVs) on the 17 Sustainable Development Goals (SDGs) during various stages of its life cycle. Using the political ecology framework, the research paper maps key interactions of electric vehicles during the extraction and operations phase to relevant SDG targets using several national and local indicators from Chile, Indonesia, and the United States. The findings show that EVs have a negative and concentrated impact on most of the SDGs during their extraction phase, but the positive impacts of EVs during their operations phase are few and diffused across disparate locations. The findings of this research highlight the dangers of 'SDG tunnel vision' in the transition to electric mobility and provides recommendations for policy frameworks that take an integrated and holistic approach to achieve the SDGs using the Stockholm Resilience Centre's 'wedding cake' model.

Chapter 1: Introduction

“They are lying.” “Moral and economic madness.” “Turning a blind eye.” “Adding fuel to the fire.” “Vested interests.” “Dangerous radicals.” “Empty pledges.” “It is damning.” “A litany of broken climate promises.” “The results will be catastrophic.” These were the remarks made by Antonio Guterres, the United Nations Secretary General to describe governments and businesses while launching the Intergovernmental Panel on Climate Change (IPCC) report in April 2022 (*United Nations*, 2022). To date, global efforts have been insufficient to effect the necessary change, jeopardizing the 2030 Agenda's promise to current and future generations. Countries and corporations have followed the same economic development path for decades, albeit with new ‘prefixes’ such as ‘millennium’ and ‘sustainable’. Considering global pressure to act, several nations and corporations issued a joint declaration at COP 26 to accelerate the transition to zero-emission cars and vans. However, these electric vehicles' promise of ‘zero emissions’ was quickly followed by a footnote declaring that they only have zero greenhouse gas emissions ‘at the tailpipe’ (*COP26 declaration on zero emission cars and vans*, 2022). Though there are sufficient critical minerals for the transition to EVs, the demand for minerals placed by a typical electric car is nearly six times that of a conventional internal combustion engine (ICE) car (*International Energy Agency*, 2021). Extraction of these critical minerals in pursuit of a low-carbon future threatens the achievement of other sustainability and equality goals, necessitating a more comprehensive approach. While the 17 SDGs and their associated 169 targets may appear to be individual goals at first glance, pursuing certain goals/targets may have a ripple effect by influencing other goals.

Electric vehicles (EVs) claim to complement SDGs 7 and 13, which focus on developing clean energy and combating climate change (‘Sustainability Knowledge Group’, 2020). This research paper employs a political ecology framework as a guiding lens to examine the impact of EVs on the 17 SDGs during various life-cycle stages. Its primary objectives are twofold: to provide a comparative, comprehensive, and global review of the impact of electric vehicles on the SDGs that goes beyond single country cases, and to investigate how different life-cycle stages of electric vehicles have differential impacts on the SDGs in different regions of the world. The article's findings aid in visualizing the linkages between EVs and the socio-environmental impacts experienced by communities living in geographically disparate locations. Using the Stockholm Resilience Institute's ‘wedding cake model’ of SDGs, this research paper provides recommendations for the transition to electric mobility that will have a positive and enabling impact on all the SDGs. This research is significant because, it has the potential to reduce the conflicts associated with the transition to electric mobility and to complement the achievement of the 2030 Agenda.

Chapter 2: Theoretical framework and literature review

Political ecology combines the concerns of ecology and a broadly defined political economy according to Piers Blaikie and Harold Brookfield (Blaikie and Brookfield, 1987). Political ecology (PE) emerged from a desire to understand marginalization and exploitation from the perspective of the impoverished. Given the aforementioned considerations, political ecology can escape shallow explanations of the switch to electric vehicles, which is often projected as a ‘technological fix’ to combat global warming. Modern EVs, which were initially powered by lead acid batteries, have gradually been replaced by lithium-ion batteries (LIB) due to various benefits such as energy density, low maintenance, and longer life, among others. Furthermore, the World Bank predicts that LIBs will continue to dominate EV segment at least until 2030 (Hund *et al.*, 2020a). Most importantly, the cost of Li-ion batteries have plummeted from around $1,200 per kilowatt-hour (kWh) in 2010 to just $132/kWh in 2021 (Bhutada, 2022). Using the framework of political ecology, Benjamin Savacool's research, identifies the victims of low-carbon transition and outlines how renewable energy projects and a transition to electric mobility could perpetuate enclosure, exclusion, encroachment and entrenchment (Sovacool, 2021). The three common life cycle stages — extraction, operations, and end-of-life of an EV — are examined to better understand how they influence the SDGs.

Several studies have used the lens of political ecology to study the impact of extraction of various minerals such as lithium, copper, cobalt, and others in order to escape simplistic explanations of environmental degradation caused by extraction (Gooch, 2015; Mwansa, 2016; Sovacool, 2019; Dorn and Huber, 2020). In the countries where these extractions take place, these issues may become endemic as the push for electric vehicles grows stronger, preventing them from pursuing alternative futures in which extractivism plays a minor role. However, no studies have been conducted that take a truly multiscalar approach and examine all three lifecycle stages. Similarly, studies continue to focus on EVs' impact on a subset of the 17 SDGs and their interactions. As a result, while the impact of EVs on specific SDGs, such as SDGs 7, 11 and 13, is well-studied, a comprehensive integrated study that cover the impact of EVs on all 17 SDGs and their interactions are lacking (‘IISD’s SDG Knowledge’, 2017; Asekomeh, Gershon and Azubuike, 2021; Omahne, Knez and Obrecht, 2021). The gap identified from the literature has prompted this research to investigate how different life-cycle stages of electric vehicles have differential impacts on the SDGs in different regions of the world. It also grasps the potential for a cross-fertilization of political ecology with the SDGs.

Chapter 3: Research methodology

Introduction

The largest international body addressing climate change and sustainable development is the United Nations. The UN adopted the Sustainable Development Goals (SDGs) in 2016 to replace the Millennium Development Goals (MDGs). SDGs are more inclusive and target all countries while integrating environmental protection, social inclusion, and economic growth (*United Nations 2030 Agenda*, 2015). Different life cycle stages were identified in the literature review, but this study does not examine the effects of end-of-life/recycling, because very little recycling occurs today, with most estimates putting current recycling rates at less than 5% (Hund *et al.*, 2020b). Though hybrids and plug-in hybrids are sometimes referred to as 'electric vehicles,' this research paper considers only a 'battery electric vehicle' without an internal combustion engine to be an EV.

The seven-point typology

The Sustainable Development Goals (SDGs) continue to shape global policy-making and funding, despite criticism for a lack of transformative ambition (Gabay and Ilcan, 2017; Spangenberg, 2017). The impact of electric vehicles (EVs) on SDGs during various life cycle stages is analysed by mapping its interactions during the extraction and operations phase with several targets associated with the goals, using UN-specified indicators (*SDG Indicators*, 2022). Only direct impacts are considered in this paper, and they are classified as either positively or negatively affecting the goal based on the targets mapped. The number of interactions of EVs with the targets are categorized and scored as follows: indivisible (+3), reinforcing (+2), enabling (+1), no impact (0), constraining (-1), counteracting (-2), and cancelling (-3). This means that if EVs have three or more negative interactions with relevant indicators and can be mapped to three different targets of a goal, then the interaction is categorized as 'cancelling (-3)' a goal. However, the limitations of this approach have been discussed in a separate chapter.

The SDG 'Wedding Cake'

Figure 4.1: SDG 'wedding cake'

Source: (*The SDGs wedding cake*, 2016)

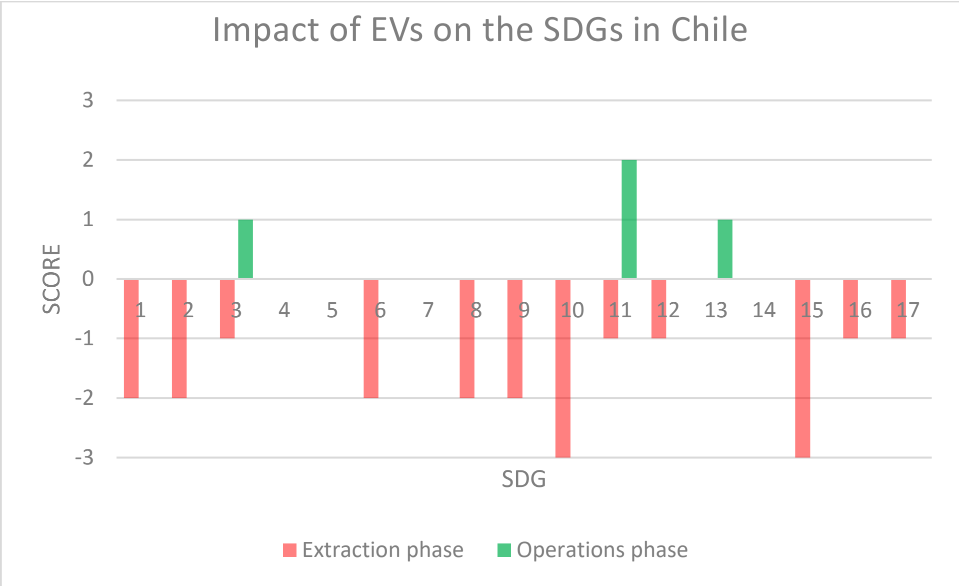
After evaluating the impact of EVs on SDGs in different countries, their impacts are grouped into three categories namely biosphere, society and economy, based on the Stockholm Resilience Centre's 'wedding cake model' (*The SDGs wedding cake*, 2016). The 'wedding cake model' also draws parallel with Kate Raworth's 'doughnut model' of social and planetary boundaries which addresses the problem of trade-offs between different sustainability goals. Raworth's model proposed that the economy should primarily fulfill the twelve social foundations without overshooting the nine planetary boundaries (Monbiot, 2017). Similarly, the 'Wedding Cake' model emphasizes the biosphere's health as a prerequisite for economic development and social well-being. The biosphere layer of the wedding cake paradigm has the SDGs no 6, 13,14 and 15 targeting water, climate action, life below water and life on land. Above this sits the social layer consisting of goals no 1,2,3,4,5,7,11 and 16 targeting poverty, hunger, education, gender equality, peace and justice among others. The economic layer that is above the social layer, consists of the goals targeting economic growth and inequalities, industrial production, infrastructure and innovation which are represented by the goals no 8,9,10 and 12. Finally the top layer consists of goal 17 regarding partnerships which transcends all the three layers of the cake. Thus, the wedding cake model of SDGs, is effectively used to analyze the impact of SDGs and formulate relevant policy solutions.

Selection of critical minerals and countries of case study

According to the World Bank report 'Minerals for Climate Action,' the demand for two types of minerals will increase as the world transitions to renewable energy: concentrated minerals and cross-cutting minerals. This study does a case study of Chile, the leading producer of lithium (concentrate mineral) from brine, Indonesia, the leading producer of nickel (cross-cutting mineral), and the United States, which has the second highest number of EVs (Cabello, 2021; Lee, 2021; Gupta, 2022).

Chapter 4: Country level case studies

Chile:

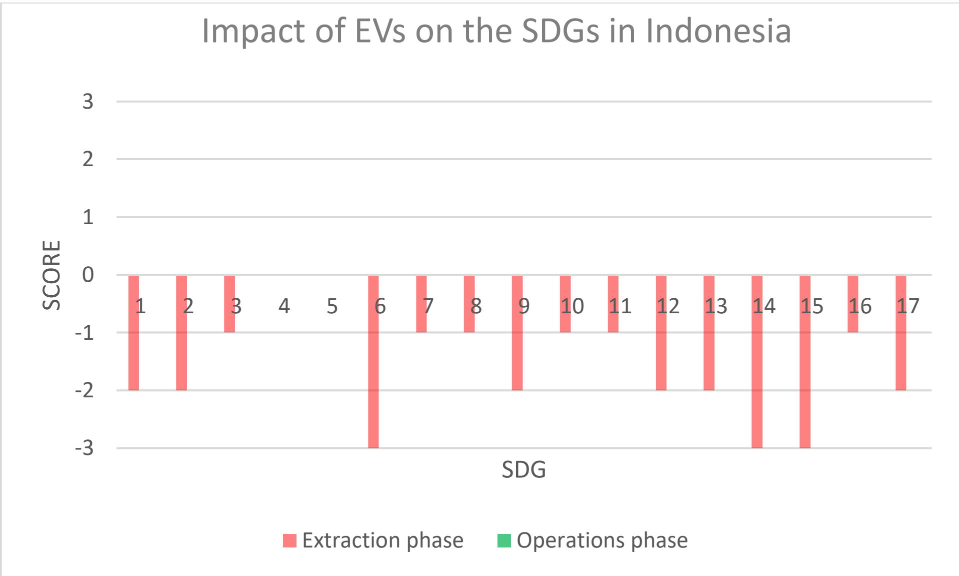


Salar de Atacama (SdA) or the salt pans of Atacama, Chile have the single largest reserve of lithium,(Marazuela *et al.*, 2020) which is considered as a strategically important mineral for a transition to 'zero emission' vehicles . In SdA, water has become the banner for the social, political and environmental struggle against lithium mining. This overexploitation of brine by lithium industries has led to a water deficit of about 15 m3/s in SdA causing ecological exhaustion in the Atacama (OECD, 2016). This has led to a decrease in agriculture, increased the inter-regional migration in the Atacama area and increased the social conflicts in the region (*Conflictos Mineros en Chile*, 2022). In this case study, indicators such as the largest nationwide protests against the privatization of lithium mines and the OECD reports are used as negative interactions and mapped to the targets 10.1, 10.2, 10.3, and 10.4, and thus have a 'cancelling' effect on SDG 10 (*OECD - Regions and Cities at a Glance*, 2018; Laing, Sherwood and Cambero, 2019). Similarly, the threat to the tentative UNESCO world heritage site due to lithium mining is used as a negative indicator and mapped to the target 11.4 and thus have a 'constraining' effect on SDG 11 (Marcos and Fernandes, 2021). Also, the corruption scam involving the mining company, SQM and Chile politicians violating the Foreign Corrupt Practices Act(FCPA) is used as a negative indicator and mapped to the target

16.5 and thus have a 'constraining' effect on SDG 16 (*US Securities and Exchange Commission*, 2017).

The transport sector in Chile is responsible for nearly 25% of the CO2 equivalent emissions of the country. The introduction of electric bus fleet in the region of Santiago, resulting in zero tailpipe emissions, is used as a positive indicator, and mapped to the target 3.9 and categorized as 'enabling' the SDG 3. Similarly, expansion of the electric public transport system resulting in reduced PM 2.5 and PM10 emissions is used as a positive indicator and mapped to the targets 11.2 and 11.6 and categorized as 'reinforcing' SDG 11. The detailed list of indicators used, targets mapped, and the resulting impact on the SDGs have been provided in the appendix 1. However, the SDGs that are unaffected by lithium extraction have not been included in the tabular column.

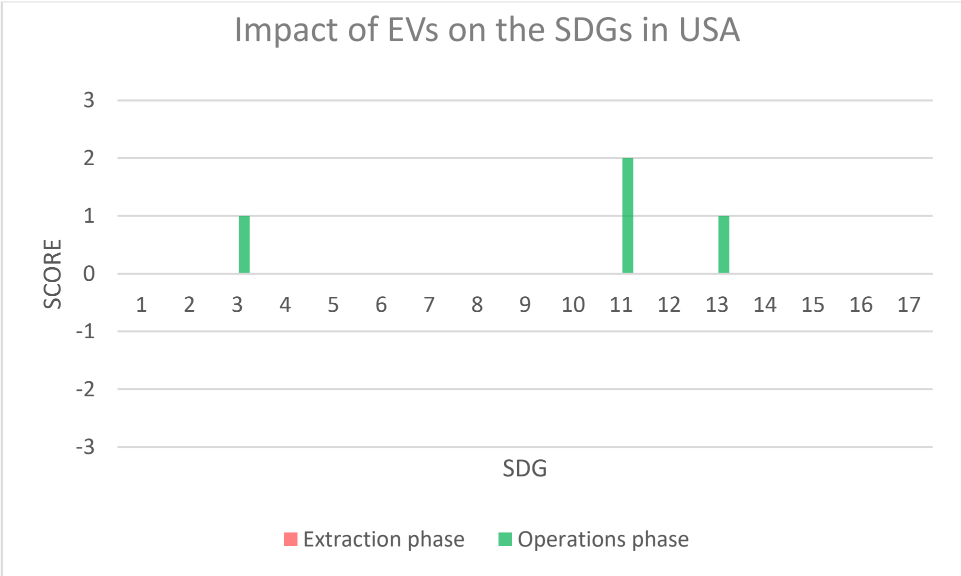
Indonesia:



According to the International Energy Agency, the supply of battery nickel would need to increase 19 times by 2040 in order to achieve the Paris Agreement's climate goals (*IEA*, 2022). In Indonesia, nickel mining corporations have been granted approximately 673,246 hectares (1,663,628 acres) of forest area, which could lead to a cocktail of issues (Fortuna, 2022). To encourage investment in manufacturing capacity along the EV supply chain, Indonesia prohibited the export of unprocessed nickel ore in 2014, relaxed the ban in 2016, and reinstated it again in 2019. From just 2 nickel smelters and a refined nickel production of 24,000 metric tons in 2014, its production exploded to 6,36,000 metric tons from 13 smelters in 2020 and most of its investment came from China. As of 2020, Indonesia had 292 nickel mining permits and most of them are concentrated in the provinces of Sulawesi and North Maluku. Analyzing the second goal on ‘zero hunger’, the injustices in the procurement of land for mining and construction of IWIP, Weda and land conversion are used as negative indicators and mapped to targets 2.3 and 2.4 (Rushdi *et al.*, 2021) and the interactions are categorized as ‘counteracting (-2)’ the SDG 2. Similarly, though the contribution of the manufacturing sector to Morowali’s GRDP (Gross Regional Domestic Product) rose sharply from 8.13% in 2014 to 36.17% in 2018 due to nickel mining, the contribution from agriculture dropped by almost half, which is used as a negative indicator and mapped to target 10.3(Prakoso and Agustina, 2022). Other issues caused by nickel mining relating to health, heavy metal contamination in fish leading to ‘bio-accumulation,’ deforestation, deep-rooted corruption, increasing conflicts with civil-society organizations, mismatch with global climate policies, and lowering of worker's rights and environmental protections under the contentious ‘Omnibus Law’ etc., have been used as indicators and mapped to several SDGs.

Indonesia has ambitious targets of having 2.2 million electric cars and 10,000 electric buses by the year 2030. However, Indonesia recorded only a measly 1,656 electric cars and 0 electric buses as of 2021 (Sufa, 2021; Taylor, 2021; Sofia, 2022). Also, scaling to this proportion needs to be backed by a sound strategy which seems to be missing in Indonesia which is engulfed in several dilemmas surrounding the battery swapping, recharging, standardization, and production etc. (Freischlad, 2022). When considering the increasing mix of coal as the primary source of electricity and with over 85% of the electricity generation coming from fossil fuels, the benefits of a transition to electric vehicles become hugely dwarfed in Indonesia (BP, 2021). However, despite being a country bestowed with several critical minerals required for manufacturing electric vehicles, Indonesia has not capitalized on its potential to transition towards electric mobility. Hence, currently EVs do not have any impact during its operations phase in Indonesia. Overall, EVs have a direct negative impact on 15 of the 17 SDGs in varying degrees during their extraction phase and do not have any impacts on the SDGs during their operations phase and detailed analysis is provided in appendix 2.

United States of America:



The USA has the second highest number of battery electric cars next only to China (*IEA*, 2021) and is among the top five countries with the highest lithium reserves, a key mineral for electric vehicles (Pettitt, 2022). Though USA has about 8 million tons of lithium in reserve, it currently accounts for just 1% of the global lithium mining and processing. In the quest to regain its lost glory as a leader in lithium production, the US has charted plans to mine lithium from Nevada, North Carolina, California, and Arkansas, etc using different technologies based on the type of reserve. For example, the lithium deposits in Nevada could provide 25% of the world's lithium and has a mine life of 46 years (Pettitt, 2022). Another project in Nevada's Thakar Pass might utilize sulphuric acid to leach lithium from clay and stone, occupy up to 17,000 acres of land, and pollute groundwater for more than 300 years, according to the US Environmental Protection Agency. Apart from this, the mine will also negatively impact biodiversity in area and the habitats of pronghorn antelope, golden eagles, and several plant species among others. Currently there is fierce opposition for the project which was 'fast tracked' during the Trump administration overlooking the concerns of the local communities (*Protect Thacker Pass*, 2022). However, since the United States does not mine any substantial amounts of lithium or other critical minerals currently, EVs have no impacts on the SDGs in their extraction phase in USA.

The EVs have a positive impact particularly because of zero tail pipe emissions. The reduction is PM2.5 and PM 10 levels and other gases such as NOx, SOx etc have a direct role in improving the health and wellbeing of the urban population, especially those in areas with dense vehicular population and heavy traffic (*IEA- Global EV Outlook*, 2022). This has been used as a positive indicator and mapped to the targets 3.9 and 11.6. Another impetus provided to boost EV sales in the US is the ‘Build Back Better’ agenda which positively affects the target 13.2 of SDG 13 in taking urgent action to combat climate change. Thus, EVs do not have any impact in the USA during their extraction phase and have positive impact on three SDGs during their operations phase. A detailed analysis of the same is attached in appendix 3.

Chapter 5: Discussion and implications

The focus of this case study has been to examine and understand how EVs affect the UNSDGs and help in fulfilling the 2030 Agenda's plan of action for people, planet and prosperity. The findings of the case studies show that countries are not 'monoliths,' in addition to the fact that most of the SDGs are negatively impacted by EVs during their extraction phase and a very small number are positively impacted during their operations phase. Following a 'chain of causation' familiar from political ecology (Bridge, McCarthy and Perreault, 2015), the findings of the case study in Indonesia show how nickel mining causes respiratory illness and livelihood loss, which is accelerated by poorly enforced laws with lower environmental and labour standards, and propelled forward by global demand for nickel and electric vehicles, as well as an increase in foreign investment in Southeast Asia. At first sight, the sheer number of over 2 million electric cars sold in the USA during the period 2011-2021 might seem staggering but taking a closer look shows that about half of them are Plug in Hybrid Electric vehicles (PHEVs) and just 1% of the transportation fleet of the US has EVs. Another observation from the analysis by Reuters is regarding the disparity in EV adoption among the 50 states of USA and concentration of benefits in certain areas of the country. For example, the state of California alone accounts for about 50% of the EV sales and the vehicle fleet of USA (Cage, 2022).

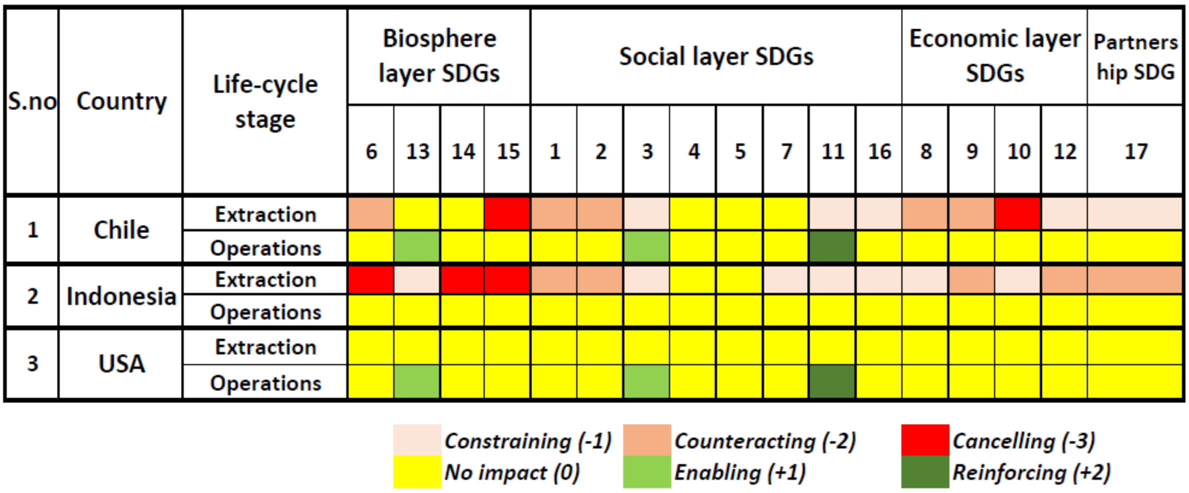


Figure 8.2: Classification of impact on SDGs based on 'wedding cake' model

Revisualizing the SDGs using the 'wedding cake' model and classifying the impacts of EVs into three broad themes on biosphere, society and economy helps us to identify the most potent levers to achieve sustainability (*The SDGs wedding cake*, 2016). According to the case study findings, EVs have the most cancelling impact (-3) on the biosphere layer of the SDGs during the extraction phase. In Chile, EVs have a negative impact on SDG 15, which is concerning life on land. SDG 15 appears to be particularly important based on the indicators used to map the targets because it has strong interactions with SDGs 1, 2, 3, 6, and 11. Again, this pattern can be seen in Indonesia, where the negative impact of EVs on SDGs 14 and 15 appears to be strongly linked to SDGs 1,2,3,6,7,9,12 and 17. The study further highlights the potential of SDGs 14 and 15 to be multipliers of co-benefits across all goals (Obrecht *et al.*, 2021). While positioning EVs as the prime solution to improve urban air quality, the transboundary nature of air pollution and various sources of air pollution other than vehicular emissions are largely overlooked. For example, California still has very poor urban air quality, though it has the second highest number of electric vehicles (Erickson *et al.*, 2020; Edelstein, 2021). This means that reduction in vehicular emissions has not led to improvement in urban air quality. This siloed and short-sighted implementation of electric mobility, concentrating only on a few of the social and economic dimensions of SDG is what this research paper defines as ‘SDG tunnel vision’.

EVs appear to be built on the myth that global warming is the only crisis confronting our planet today. The practice of providing misleading information about how EVs are more environmentally friendly may be defined as ‘greenwashing’ (Kenton, 2022). Companies and countries seem to be overtly relying on Environmental, Social and Governance (ESG) Index and studies have criticized ESG ratings for doing more harm than good (Taparia, 2021). The ‘2020 mining and SDGs’ report, noted how companies resort to ‘cosmetic’ reporting on SDGs by swapping it with ESG indicators, selective reporting, and usage of the SDG logos without any narratives (‘CCSI & RMF’, 2020). While the transition to electric mobility is a necessary goal, we must be careful how it is defined and implemented to avoid ‘greenwashing’. This research paper has highlighted how, in an increasingly globalized world, progress on one SDG in a specific part of the world is dependent on interventions made in other regions and sectors.

Chapter 6: Recommendations

Electric mobility will be powered by minerals, just as traditional ICE vehicles are powered by fossil fuels, and case studies in Chile and Indonesia have demonstrated how material extraction is severely undermining the UN Sustainable Development Goals. In response to growing criticism of offshoring extraction to the global south, the US and the EU are implementing the policy of critical minerals 'onshoring' to achieve 'energy security' and shorter supply chains. However, populations in the global north will not benefit equally from onshore extraction of these critical minerals, and studies on environmental racism have clearly highlighted that these countries are not 'monoliths' and that low-income, indigenous, or minority communities are disproportionately affected by environmental hazards (Riofrancos, 2022). Interactions between SDGs frequently involve trade-offs, but they could also generate co-benefits and have a significant potential for transformative change toward sustainable development. The following recommendations will have a significant positive impact on most of the SDGs during all the stages of an EV's lifecycle-

Increasing electric public transport and introducing FFPT –

According to a 2018 survey conducted by the United States Department of Transportation, approximately 60% of all vehicle trips were less than six miles in distance, and the average car occupancy was 1.5 people. This compares to the average bus occupancy in the United States, which is around 20.26 (*US department of energy*, 2018; *Center for Sustainable Systems*, 2021; *U.S Federal Highway Administration*, 2021). Another reason buses should be prioritized is that most of them are powered by diesel engines, which emit more GHG than gasoline engine cars (Roberts, 2017). The implementation of Free Fare Public Transportation (FFPT) could reimagine public transportation as a 'common good' rather than a commodity, and studies have shown that it pays for itself (Keblowski, 2018; Ünveren, 2022). Initiatives like the school bus electrification program in the US can have positive impact on urban air quality, improve children's health, create local employment opportunities and also bring savings to the management (Spengeman, 2022). Additionally, electrified public transportation and electrified FFPT can take pressure off finding minerals for privately owned cars and thus have no negative impact on the SDGs' biosphere layer. Similarly, public transportation has been lauded for directly addressing the issues of social exclusion, inequality, and transportation poverty which positively impacts the social layer of the SDGs (Keblowski, 2018). Finally, by creating new jobs and businesses, the economic layer of the SDGs is effectively addressed.

Using more abundant minerals for batteries -

Electric mobility primarily consists of cars, two-wheelers and buses which have different purposes. Without the stringent parameters that are required for a typical electric car such as high torque, density, range and acceleration, electric bus batteries could be made using more abundant minerals that have no or very little ecological impacts (*Global opportunity explorer*, 2018; Ali, 2019). Thus again, public transport powered by abundant minerals will have positive impacts on all the thematic areas of SDGs.

Community owned cooperatives for electric mobility –

Political ecologists have promoted community-based national resource management (CBNRM) as a more just alternative to an often oppressive systems of resource extraction (Benjaminsen, 2007). They have a significant advantage in their resistance to short-termism and think about future generations which are the core principles of the UN Sustainable Development Goals (Moxom *et al.*, 2021). El Hierro, a Spanish island, for example, is a vibrant community with many cooperatives such as those for electricity, fishing, transportation, agriculture etc, that work in a symbiotic relationship with one another to bring prosperity to all, while remaining within the planetary boundaries. It successfully recirculates €23 million in the local economy with an annual budget of nearly €29 million to build community wealth and ensure abundance for all (Driesenaar, 2020a, 2020b; *Community wealth building*, 2020). Cooperatives at all stages of the electric vehicle's life cycle can provide a sustainable path forward by building global partnerships (SDG 17), that addresses social inequality, alleviating poverty, and building resilient economies.

Apart from the above solutions, the urban air quality that electric cars claim to improve, could be significantly improved by adopting other measures such as traffic management systems, improving green infrastructure, urban planning, etc (Bigazzi and Rouleau, 2017; Hewitt, Ashworth and MacKenzie, 2020; Sofia *et al.*, 2020). Today, it is increasingly clear that deteriorating urban air quality is not due to a lack of policy recommendations but due to the lack of an honest understanding of the interconnectedness of today's global challenges.

Chapter 7: Limitations and further research

This case study has potential limitations, and hence should be interpreted with caution. However, these limitations could be addressed in future research.

(1) This research paper only measures direct impacts, but resource-rich countries such as Chile and Indonesia face numerous issues related to resource extraction of metals/minerals other than those studied. The sheer complexity of the interactions between different mineral extractions for various supply chains precluded this research paper from venturing into it.
(2) The SDGs themselves are not insulated from criticism. There is a particularly growing criticism of SDG 8 which is on promoting economic growth. Other limitations of the SDGs include conflicting goals, difficulty in measuring progress, disconnect from grassroots and cultural appropriateness, etc (Vandemoortele, 2018; Hickel, 2019).
(3) The seven-point typology used in the research, categorizes direct interactions into one of seven categories based on the number of targets mapped. However, this doesn't present the whole picture. Future research could use models such as the Principal Component Analysis (PCA) for the assessment of the SDGs with large datasets (Jolliffe and Cadima, 2016). This method helps to increase the interpretability while reducing information loss.

The present method can also be enriched to include elements of sustainability that are more culturally appropriate. For example, worldviews of indigenous people called 'ecocentrism', which considers all features of the natural world—including non-living things— to be of equal importance could be incorporated into the study to redefine, measure and implement sustainability (Mosquin, 2002; Washington *et al.*, 2017). Such research will shed further light on the power-laden negotiations and unequal impacts of the transition to electric vehicles.

Chapter 8: Conclusion

Electric mobility is, at its core, a political program and any discussion of its environmental character must put issues of power relations and uneven impacts at the forefront. When we hear the phrase ‘zero emission cars,’ we usually think of clean, green, and sustainable images of pollution-free cars. However, this research reveals, how the extraction required for electric vehicles comes at a very high ecological and social cost. Solutions to climate change cannot work on the back of injustices or poor environmental performance. The goal of global vehicle electrification to reduce greenhouse gas emissions should not create new injustices for other communities, as they will bear the brunt of the consequences of mining activities while being the least responsible for excessive global carbon emissions. Swapping oil with batteries will create newer problems and it is not enough to leave just the fossil fuels in the ground. Failing to understand these interconnected challenges will lead to ‘our common failure’.

With the rise of new distractions such as ‘Net-Zero’ clubs, we must question whether our optimism is justified. None of this is to say that we shouldn’t pursue a rapid transition to electric mobility. We absolutely must and urgently. But this research paper highlights that, if the transition is to be technically feasible, ecologically coherent, and socially just, then the transition cannot be from an ‘ICE’ car to an ‘electric’ car. We live in a ‘finite planet’ and need to remove cars from our streets. No new roads or tunnels can fix it. We must take a different approach. We will have to break down silos, work across disciplines and change our perspectives. The research paper also presents several policy recommendations guided by political ecology and the SDG ‘wedding cake’ paradigm, to make the transition to electric mobility inclusive, reduce inequalities and build community wealth. While highlighting the perils of a ‘SDG tunnel vison’, the research paper identifies how SDG targets influence one another as part of a system, indicating where policy intervention would be most strategic to generate overall progress. Pro-active engagement and enhanced partnership across government departments, ministries at local, national, and international levels will be required for this to happen effectively.

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Appendix 1:

Impact of EVs on SDGs during resource extraction in Chile-

SDG no	SDG	Impact	Reason	Targets mapped	Indicators used
1	No poverty	-2 Counteracting	Hindering land-based livelihoods through high water footprint of mining operations leading to increase in poverty. (Water deficit of 15m3/sec)	1.4 and 1.5	OECD Environmental Performance Reviews (OECD, 2016).
2	Zero hunger	-2 Counteracting	Decline in agriculture due to labor outflow	2.3 and 2.4	Chilean Internal Migration Database/CHIM database (Rowe, 2017).
3	Good health and well-being	-1 Constraining	The scale and intensity of local social activism increased, putting human rights defenders at risk. Children and women face health and safety risks because of mine-related labor migration.	3.9	Mineral Extraction Conflict database (*Conflictos Mineros en Chile*, 2022). Chilean Internal Migration Database/CHIM database (Rowe, 2017).
6	Clean water and sanitation	-3 Cancelling	Excessive water consumption by Lithium mining	6.4, 6.5 and 6.6	Report by Natural Resources

			Shrinking of wetlands and threat to bio-diversity		Defense Council/NRDC (Blair *et al.*, 2022). CORFO, Chile's Development Agency (Sherwood, 2018).
8	Decent work and economic growth	-2 Counteracting	High material footprint per capita Significant decrease in share of local labor in mining	8.4, 8.9	Material flow data portal (‘Materials flow’, 2018). Chilean Internal Migration Database/CHIM (Rowe, 2017).
9	Industry innovation and infrastructure	-2 Counteracting	Employing primitive technology resulting in poor lithium recovery (30%) to save costs. Low spending on R&D as a percentage of GDP	9.4, 9.5	Evaporation process efficiency (Liu, Zhao and Ghahreman, 2019; Fawthrop, 2020). OECD indicators (*R&D - OECD Data*, 2020).

10	Reduced inequalities	-3 Cancelling	Massive countrywide protest against inequality in 2019 and demanding lithium mining nationalization. High unemployment rate in Atacama region	10.1,10.2, 10.3 & 10.4	Media reports (Laing, Sherwood and Cambero, 2019). OECD indicators (*OECD - Regions and Cities at a Glance*, 2018).
11	Sustainable cities and communities	-1 Constraining	Chile has proposed the Atacama Desert to UNESCO as a world heritage site, but it is threatened by lithium mining.	11.4	Tentative list for nomination UNESCO (Marcos and Fernandes, 2021).
12	Responsible consumption and production	-1 Constraining	High material footprint per capita	12.2	Material flow data portal (‘Materials flow’, 2018).
15	Life on land	-3 Cancelling	Decline of Andean Flamingo because of Lithium mining site overlapping with important breeding sites of the species.	15.1, 15.4, 15.5	Andean Flamingo under IUCN Red list category (*Andean Flamingo - BirdLife species factsheet*, 2022). Report by NRDC and

			Shrinking of Ramsar site- Laguna Santa Rosa wetland		published journal article (Alam and Sepúlveda, 2022; Blair *et al.*, 2022).
16	Peace, justice and strong institutions	-1 Constraining	SQM agreed to pay $30 million to resolve parallel civil and criminal cases for violating the Foreign Corrupt Practices Act (FCPA).	16.5	The United States Securities and Exchange commission press release (*US Securities and Exchange Commission*, 2017).
17	Partnerships for the goals	-1 Constraining	The scale and intensity of local social activism increased, putting civil society organizations at risk.	17.17	Mineral Extraction Conflict database (*Conflictos Mineros en Chile*, 2022).

Impact of EVs on SDGs during operations/use in Chile-

SDG no	SDG	Impact	Reason	Targets mapped	Indicators used
3	Good health and well-being	+1 Enabling	Zero tail pipe emissions	3.9	World bank report on Chile (World Bank, 2020).

11	Sustainable cities and communities	+2 Reinforcing	Expansion of electric public transport system Decrease in levels of PM2.5 and PM 10	11.2, 11.6	World bank on Chile (World Bank, 2020).
13	Climate action	+1 Enabling	100% urban public transportation buses in Chile by 2040	13.2	Chile's NDC submitted at UNFCCC (*Chile NDC*, 2020).

Appendix 2:

Impact of EVs on SDGs during resource extraction in Indonesia-

SDG no	**SDG**	**Impact**	**Reason**	**Targets mapped**	**Indicators used**
1	No poverty	-2 counteracting	Decrease in fish population leading to decrease in income for fishing community in Obi islands.	1.4 and 1.5	The Environmental Justice Atlas (Sawal, 2022).
2	Zero hunger	-2 counteracting	Threatening land rights of indigenous people through unfair land procurement against their Free, Prior and Informed Consent (FPIC) Reduction in contribution of agriculture to regional economy because of land conversion to mining	2.3 and 2.4	Report by the Rosa-Luxemburg-Stiftung foundation (Rushdi *et al.*, 2021).
3	Good health and well-being	-1 Constraining	High occurrence of Acute Respiratory Illness (ARI) in the Nickel mining village of Kawasi (20%) which is more than twice the national average of Indonesia. Presence of unsafe levels of carcinogenic hexavalent chromium (Cr6) in drinking levels	3.9	Investigation report by 'The Guardian' (Firdaus and Levitt, 2022).

			contaminated by Nickel mining. Pollution due to Coal dust. Contamination of fishes in lake Matano by Nickel and Iron and potential of human toxicity.		Documentation by Action for Ecology and People Emancipation (AEER) (Rushdi *et al.*, 2021) Study published in International scientific research journal IOPscience (Fahmi *et al.*, 2019).
6	Clean water and sanitation	-3 Cancelling	Presence of unsafe levels of carcinogenic hexavalent chromium (Cr6) in drinking water contaminated by Nickel mining. Damage of freshwater ecosystems and presence of heavy metals (nickel) in fishes in lake Matano.	6.1, 6.3 and 6.6	Investigation report by 'The Guardian' (Firdaus and Levitt, 2022). Study published in International scientific research journal IOPscience (Fahmi *et al.*, 2019).

7	Affordable and clean energy	-1 Constraining	More than 50% increase in the use of coal in national electricity generation with significant increase in coal fired captive power plants for nickel mining industrial complex.	7.2	Statistical review of world energy – 2021 (*BP*, 2021). Coal power plants in nickel industrial parks (Morse, 2022).
8	Decent work and economic growth	-1 Constraining	Instances of pay discrimination based on race and unsafe working environments	8.8	Road to ruin report (Sangadji, Ngoyo and Ginting, 2019).
9	Industry innovation and infrastructure	-2 counteracting	Using captive coal fired power plants instead of renewable sources for electricity Employing poor mining waste management practices	9.4, 9.5	Coal power plants in nickel industrial parks (Morse, 2022). The Washington Post report (Morse, 2019).
10	Reduced inequalities	-1 Constraining	Very high poverty rate (above national average) and income distribution inequality in Central Sulawesi.	10.3	Study published in international journal (Prakoso and Agustina, 2022).
11	Sustainable cities and communities	-1 Constraining	Severe air pollution and high instances of Acute Respiratory Illness especially among	11.4	Investigation report by 'The Guardian' (Firdaus and Levitt, 2022).

			infants/newborns aged less than 5 years.		
12	Responsible consumption and production	-2 counteracting	Presence of unsafe levels of carcinogenic hexavalent chromium (Cr6) in drinking water contaminated by Nickel mining.	12.4, 12.6	Investigation report by 'The Guardian' (Firdaus and Levitt, 2022).
13	Climate action	-1 Constraining	Contribution to increase in GHG emissions due to massive deforestation and captive coal power plants for nickel mining industrial complex.	13.2	Coal power plants in nickel industrial parks (Morse, 2022). From Nickel to deforestation (Hidayat *et al.*, 2022).
14	Life below water	-3 cancelling	Marine ecosystems damaged by high nickel content in the sea (20 times the government's limit) and loss of livelihoods for artisanal fishers.	14.1, 14.2, 14.b	Published Scientific research study (Zakir, Abdul and Emiyarti, 2019). The Washington Post report (Morse, 2019).
15	Life on land	-3 Cancelling	Nickel mining is a driver of deforestation	15.1, 15.2, 15.4	Investigation by Pulitzer Center (Hidayat *et al.*, 2022).

			Biodiversity loss and destruction of endemic primate habitats in Sulawesi region.		Study report (Pratama and Widjaja, 2013; Supriatna, 2020).
16	Peace, justice and strong institutions	-1 Constraining	High instances of corruption to get mining permits and low environmental compliance	16.5	Investigation by Pulitzer Center (Hidayat *et al.*, 2022).
17	Partnerships for the goals	-2 counteracting	Poor policy coherence leading to the extraction of climate-saving minerals powered by coal. Increased conflict of mining companies with civil societies in nickel mining areas	17.14, 17.17	Statistical review of world energy – 2021 (*BP*, 2021). Introduction of 'Omnibus law' (Castello Sant, 2020). Investigation by Pulitzer Center (Hidayat *et al.*, 2022).

Appendix 3:

Impact of EVs on SDGs during operations/use in USA-

SDG no	SDG	IMPACT	REASON	Targets mapped	Indicators used
3	Good health and well-being	+1 Enabling	Zero tail pipe emissions	3.9	IEA report (*IEA-Global EV Outlook 2022*, 2022).
11	Sustainable cities and communities	+2 Reinforcing	Expansion of electric public transport system Decrease in levels of PM2.5 and PM 10	11.2, 11.6	IEA report (*IEA-Global EV Outlook*, 2022).
13	Climate action	+1 Enabling	50% electric vehicle sales share by 2030 under 'Build Back Better' agenda	13.2	The White House statement (*The White House*, 2021).