CHORD
CENTER FOR HUMANITARIAN LOGISTICS AND REGIONAL DEVELOPMENT

A DATA-DRIVEN STUDY OF

THE ENVIRONMENTAL PERFORMANCE OF EVs vs. ICEVs

WHAT ARE THE ENVIRONMENTAL TRADE-OFFS OF ELECTRIC VEHICLES (EVs) vs. INTERNAL COMBUSTION ENGINE VEHICLES (ICEVs) IN EAST AFRICA & THE MIDDLE EAST?

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OUR STUDY IN SHORT

Humanitarian organisations increasingly respond to disasters resulting from (or exacerbated by) global warming and environmental degradation. In addition to immediate aid, they also often take part in development programmes to support regions in need over a longer time period. These activities aren't without consequences, however, and the demand for life-saving humanitarian operations also contributes to climate change and environmental damage. Following the "do no harm" principle, humanitarian actors must take action to mitigate their environmental footprint in both aid and development efforts. In the commercial sector, the share of electric vehicles (EVs) is on the rise as a means to reduce greenhouse gas (GHG) emissions associated with transport. Yet, the potential for EVs to reduce the environmental impacts of humanitarian operations goes beyond carbon, and there are many other environmental dynamics at play. **Do EVs have a lower environmental impact than internal combustion engine vehicles (ICEVs)? Should humanitarian organisations increase the share of EVs used for operations? We address this question in the case study described in this report.**

Our case study compares the environmental impacts of the life cycle of a mid-size EV vs. two ICEVs (one mid-size, one large) based on various electricity and fuel scenarios. In collaboration with Fleet Forum, a membership organisation supporting aid and development organisations to improve their fleet management performance, we model scenarios for the use of the EV and ICEVs in East Africa and the Middle East by humanitarian aid workers (i.e., passenger cars). This includes comparing different electricity generation options (local grid, diesel generator, and solar panels) for the EV, while the mid-size and large ICEV are fuelled by petrol and diesel, respectively. The scenarios are based on a pilot study which is currently being run in Kenya, Jordan, and Lebanon.

MAIN TAKEAWAY

The EV often has a lower environmental impact than the ICEVs, especially in terms of GHG emissions. However, what matters most (for the environment) is the size and / or materials of the vehicle (i.e. the resources required to produce it) and the type of energy used to power it.

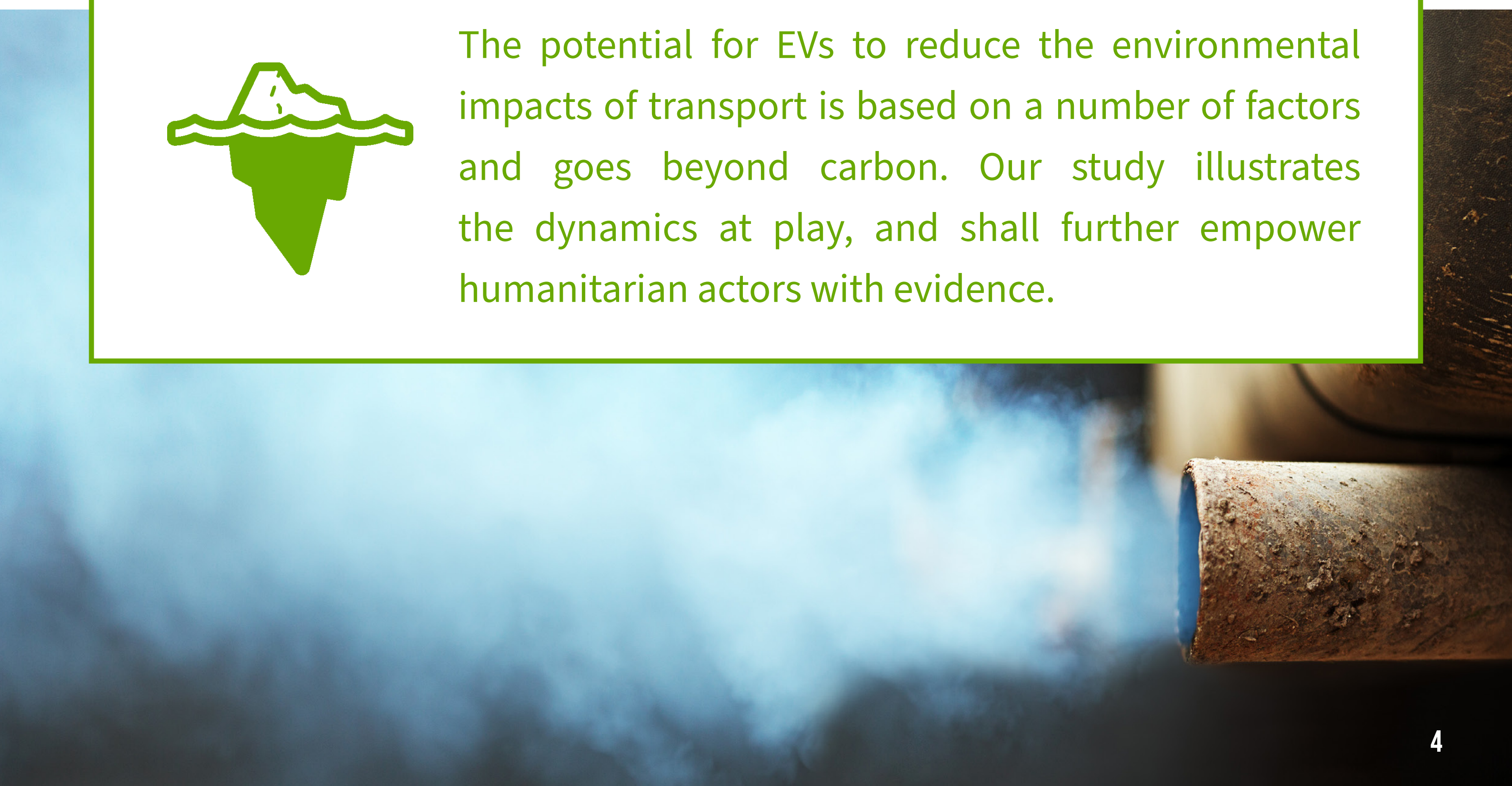
To evaluate which option is the most environmentally sustainable, we perform a life cycle assessment (LCA) to measure the environmental footprint of each vehicle throughout its full life cycle (production, use, and disposal) across multiple impact categories (GHG emissions, pollution, resource use, etc.).

The results of our study show that overall the EV is more environmentally friendly than the large ICEV, but this is not always the case in comparison to the mid-size ICEV. While the use phase (i.e., travelling in the car, including the production of electricity or fuel) typically ends in favour of the EV, the production of the vehicle plays a large role in the overall environmental impacts (as well as the disposal step, although to a lesser extent). This is especially relevant for the production and disposal of the battery of the EV.

Important to note here is that in terms of utility, the mid-size EV and mid-size ICEV are comparable. While the large ICEV is mostly used for passenger transport, it may be also used for further purposes, such as travelling on more challenging terrain. We include the large ICEV in this study because it was used in the pilot project and it may produce interesting insights when compared to the EV. Further research could also include modelling a large EV, though data would need to be collected through purely external sources.

The degree in which the EV comes out on top is also highly dependent on the source for electricity generation (with solar panels performing the best, and the local grid that is predominantly fossil-fuelled, the worst). Thus, drawing conclusions on which option (EV vs. ICEV) has lower environmental impacts is not always straightforward. There are a number of factors at play, illustrating the need to analyse environmental sustainability from a holistic perspective (i.e., full supply chain) across multiple impact categories.

Environmental action calls for both vision and visibility. Humanitarian organisations need visibility to understand and decide on what to change and they need vision to plan (and implement) the change. The outcomes and learnings from visibility initiatives, like our EV vs. ICEV case study, must be shared across the sector — by both practitioners and academia — to accelerate the understanding of environmental challenges and lay the foundation for environmental action at appropriate scale.



The potential for EVs to reduce the environmental impacts of transport is based on a number of factors and goes beyond carbon. Our study illustrates the dynamics at play, and shall further empower humanitarian actors with evidence.

THE ROLE OF EVs TO REDUCE THE ENVIRONMENTAL IMPACT OF TRANSPORT LOCALLY & GLOBALLY

SECTION 1 IN SHORT

In an effort to decarbonize transport, the share of EVs has been steadily increasing in some regions of the world — yet they are widely unexplored in others. This is especially true for regions where humanitarian organisations are most active (e.g., East Africa and the Middle East). The environmental footprint of humanitarian operations can be largely associated with supply chain activities, and thus fostering a shift to sustainable transport modes plays a large role in reducing the sectors' contribution to climate change and environmental degradation. In this section, we briefly describe the links between humanitarian operations and the environment, as well as the development of EVs globally to contextualize the factors for increasing the share of EVs in humanitarian operations. This is specifically related to regions such as East Africa and the Middle East in which cleaner transport has the potential for exponential benefits.

Are EVs more environmentally sustainable than ICEVs? According to the International Energy Agency (IEA), transport alone accounted for 37% of global CO_2 emissions from end-use sectors in 2021[1]. Per kilometer, EVs emit less carbon than their ICEV counterpart, with the potential to reduce the transport sectors' contribution to climate change and overall impact of operations[2]. Decarbonizing transport is good for the globe, which becomes even more relevant as electricity grids increase the share of renewable energy sources, but EVs may also address common local challenges such as noise and air pollution. However, this is just one piece of the puzzle.

1 This figure also considers freight. International Energy Agency (IEA), 2022.Transport. https://www.iea.org/topics/transport

2 The World Bank , 2022. The economics of electric vehicles for passenger transportation. https://www.weforum.org/

EVs typically require more resources to produce, especially when considering the production of the battery. At the end of its life cycle, EV disposal may also pose more environmental challenges than the ICEV (again, due to the battery). This is especially challenging for areas of the world with limited sustainable waste management infrastructure. The consequences of the entire life cycle may also go well beyond carbon.

The use phase often ends in favor of EVs, especially considering GHG emissions, but what role do the other life cycle steps play in the overall environmental footprint? What other impact categories are relevant? Should humanitarian organizations aim to increase the share of EVs in operations?

Comprehensive visibility is key to seriously address this question. We provide an example of such visibility with the case study described in this report. The goal is to provide fact-based evidence on the environmental dynamics at play when considering the implementation of EVs, specifically in areas of the world in which ICEVs continue to dominate (e.g., Middle East and East Africa). This is especially relevant when considering the link between humanitarian aid and the environment (described in the next section).

This first section briefly describes the interplay between humanitarian operations and the environment, as well as the development of EVs globally. Here, we aim to contextualize the question of the potential for EVs to reduce environmental impacts of transport, specifically where humanitarian organisations are often most active. The second section provides insights into this topic through a case study with Fleet Forum. In this section, we provide evidence to support informed decision making when considering increasing the share of EVs. In the final section we summarize the lessons learned from the case study and conclude on the importance of environmental visibility (on top of vision) for the humanitarian sector to effectively reduce its environmental footprint.

HUMANITARIAN ASSISTANCE AND THE ENVIRONMENT

Humanitarian organisations are on the front line of climate and environmental crises (and some have a very long established presence). Each day, they witness and react to disasters resulting from (or exacerbated by) global warming, and both acute and chronic environmental degradation. Humanitarian organisations must adapt to these challenging yet glaring realities. On one hand, climate change is a main driver of humanitarian need[3], and they must scale up to face the increasing needs for humanitarian assistance. They must also help the communities they support become more resilient to future shocks triggered by climate change. On the other hand, humanitarian organisations must look inward and continuously work on reducing the negative impact that their operations have on the environment, as well as foster sustainable development efforts. Guided by the "do no harm" principle, they must ensure that their activities save and improve lives without harming the environment — in the short- and long-run. This requires visibility and vision.

3 OCHA, 2021. Humanitarian Action and Climate Change. https://www.unocha.org

Humanitarian organisations must think short-term because now is the time to act. They must also think long-term to define feasible but ambitious environmental targets as well as plans to effectively reach these.

Humanitarian operations contribute to environmental impacts in different ways across end-to-end logistics. As the supply chain forms the backbone of humanitarian operations — and because it typically represents around 60% to 80% of humanitarian expenses — the environmental footprint of humanitarian organisations can largely be associated with supply chain activities[4]. A key component of this is transport. Thus, reducing the environmental impacts of operations also requires shifting towards more sustainable transport modes. Understanding the role that EVs play in this transition is key in supporting humanitarian actors in adopting emissions reduction strategies. While in this study, we only model passenger transport, the results can be used as a foundation for further analyses which incorporate larger modes such as comparing electric trucks to their conventional fossil-fuelled counterparts.

THE TRADE-OFFS OF EVs: GLOBALLY AND LOCALLY

The widespread implementation of EVs varies greatly by geography — they are moving swiftly forward in some areas of the world (China, the United States, and Europe account for 90% of the world's EVs[5]) yet they are largely unexplored in others. This is especially true for developing countries, in which the switch to cleaner transport has the potential to provide exponential benefits.

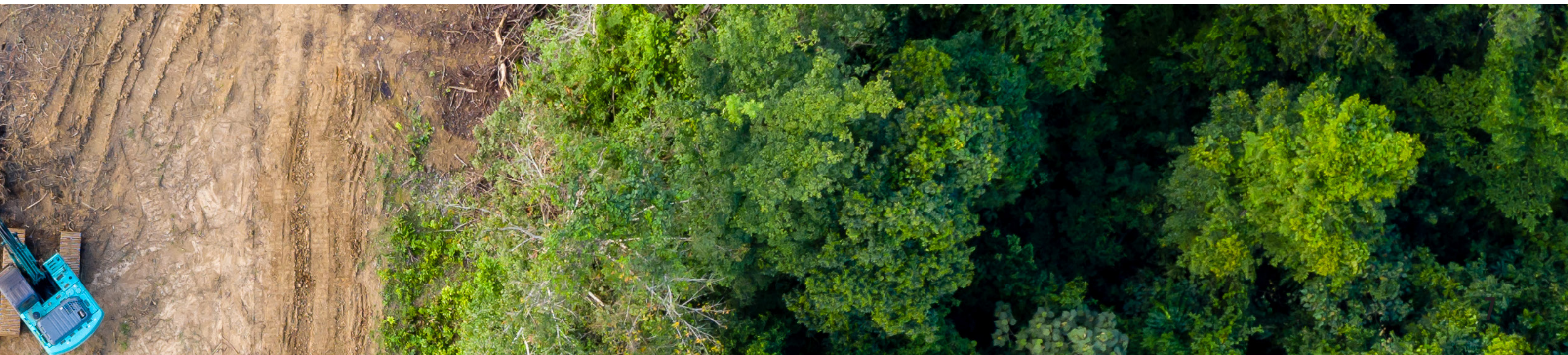
4 Stumpf, J., Besiou, M. and Wakolbinger, T. (2023), "Assessing the value of supply chain management in the humanitarian context – An evidence-based research approach", Journal of Humanitarian Logistics and Supply Chain Management, Vol. 13 No. 1, pp. 1-9. https://doi.org/10.1108/JHLSCM-03-2022-0039

5 The World Bank , 2022. The economics of electric vehicles for passenger transportation. https://www.weforum.org/

For example, in countries which have a low reliance on fossil fuels for local electricity generation, switching to EVs may provide significant air quality improvements — particularly relevant for growing urban populations. Despite this, the slow growth in developing markets is often financial and due to high start-up costs for both the public and private sector. Governments must invest in a seamless charging infrastructure and promote the use of EVs through leasing or financing schemes. For individuals or institutions, purchasing an EV typically implies a higher price tag than a comparable ICEV — which may not be a financial reality for the mass market.

However, a recent study by the World Bank found that the lower operating costs (e.g. fuel, maintenance) associated with EVs often offset the higher start up costs over time[5]. In other countries, EVs became more economically attractive than ICEVs once the potential for reduction of environmental impacts were factored in. This refers to the reduction in costs associated with the environmental externalities typically associated with fossil-fuelled vehicles.

Identifying the environmental dynamics at play when considering the switch to EVs is key for evidence-based decision making, and a main objective of this study. This is especially relevant for areas of the world that are at higher risk for climate change consequences and environmental degradation — and often are in the highest need of humanitarian assistance. To successfully implement such holistic change, humanitarian organisations must adopt strategic short- and long-term vision, based on transparency and visibility in all echelons of operations.



COMPARING THE ENVIRONMENTAL IMPACTS OF EVs vs. ICEVs IN EAST AFRICA & THE MIDDLE EAST

SECTION 2 IN SHORT

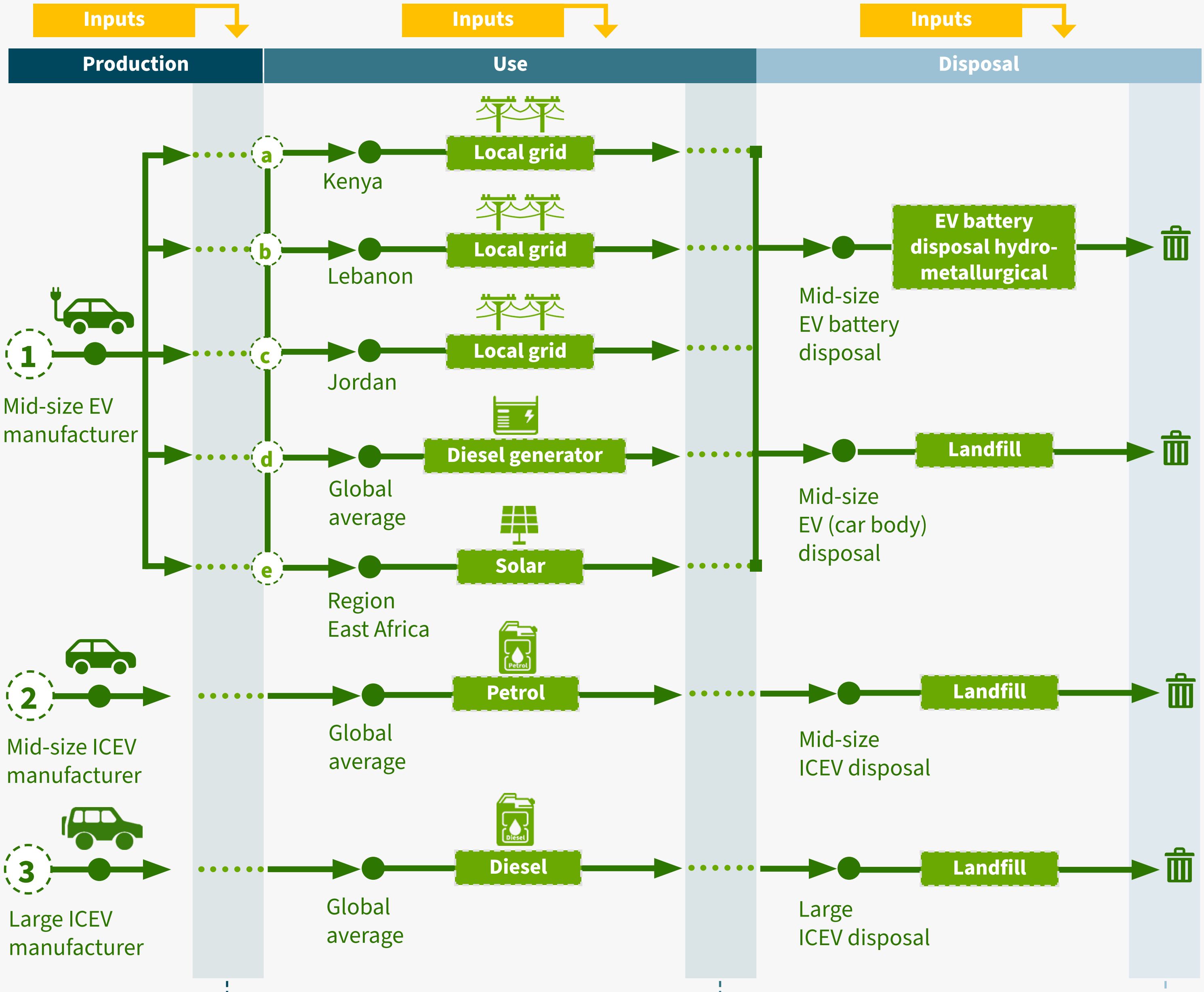
To evaluate the potential for more environmentally sustainable transport options, we measure the environmental footprint of a mid-size EV vs. both a mid-size and large ICEV — considering different electricity generation and fuel scenarios — based on the pilot study being carried out in East Africa and the Middle East. Our results indicate that the EV outperforms the large ICEV in terms of environmental impact, especially during the use phase. However, the production of the EV compared to the mid-size ICEV illustrates cases where the EV is less environmentally friendly. The disposal of the EV has a larger impact in some categories, although this is relatively small compared to production. Thus, the potential for EVs to improve environmental sustainability is based on a number of factors.

CASE STUDY DESCRIPTION

EVs are growing in popularity in many regions of the world. However, the environmental impacts of EVs vs. ICEVs, as well as the feasibility of their use, have been widely unexplored in the context of humanitarian operations. This also holds true for EV deployment in developing regions such as East Africa and the Middle East. Our study uses data from the Fleet Forum pilot project to model various scenarios considering transport behaviour of humanitarian aid workers in Kenya, Lebanon, and Jordan. In this phase of the project, data was modelled based on a number of factors, including location, model of vehicle, and energy source or fuel requirement per vehicle. The main users of the vehicles are the humanitarian aid workers (i.e., not for transporting goods), and the use phase models passenger transportation considering both urban areas and as a liaison between cites.

According to the project, three types of vehicles were modelled: mid-size EV *(Nissan Leaf 2019)*, mid-size ICEV *(Toyota Corolla 2019)*, and large ICEV *(Toyota Land Cruiser 2015)*. The production and manufacturing of the vehicles was modelled based on vehicle specifications and required raw material inputs (e.g., steel, aluminium, copper, rubber,

Figure 1: EV and ICEV scenarios for case study



Production is modelled to include the production of raw materials and manufacturing according to vehicle specifications. The finished vehicle is then delivered to the point of use.

Use is modelled based on different fuel scenarios. The EV is powered through either the local grid, diesel generator, or solar panel. The ICEV is fueled by either diesel or petrol.

Disposal of the EV battery is modelled according to hydrometallurgical processes (shredder and chemical treatment). The EV body and both ICEVs are disposed of via landfill.

glass). The mid-size and large ICEV are fuelled with petrol and diesel, respectively. Various energy source scenarios were modelled for the EV: the local grid, diesel generator, and solar panels. Use of the local grid was also modelled for each country in the case study. Disposal of the EV was broken into two parts: disposal of the battery and disposal of the car body. Both ICEVs were disposed of without separating. Furthermore, disposal of the body of the EV and both ICEVS was modelled based on a landfill waste treatment process (recycling was not considered due to lack of data). Please see Figure 1. **Is it more environmentally sustainable to use EVs instead of ICEVs for humanitarian operations?** To answer this question, we perform a life cycle assessment of both EV and ICEV scenarios considering different vehicle and fuel / electricity generation options.

CASE STUDY APPROACH

Life cycle assessment (LCA) is a methodology used to measure the environmental footprint of products (or services) considering their entire life cycle — from raw materials extraction to the use and disposal of the product itself (see Figure 2) — across multiple environmental dimensions — e.g., global warming, land use, terrestrial acidification, freshwater eutrophication, et cetera. It is thus a comprehensive methodology.

Organisations typically perform LCAs to identify environmental "hotspots" in the life cycle of their products and act upon these, or to compare the environmental performance of similar products.

An LCA consists of four main steps: (1) goal and scope definition, (2) life cycle inventory, (3) life cycle impact assessment, and (4) results interpretation (see Figure 3). In the next subsections, we describe each step in theory and then apply it to our EV vs. ICEV case study.

Figure 2: Product life cycle steps that can be considered as part of an LCA

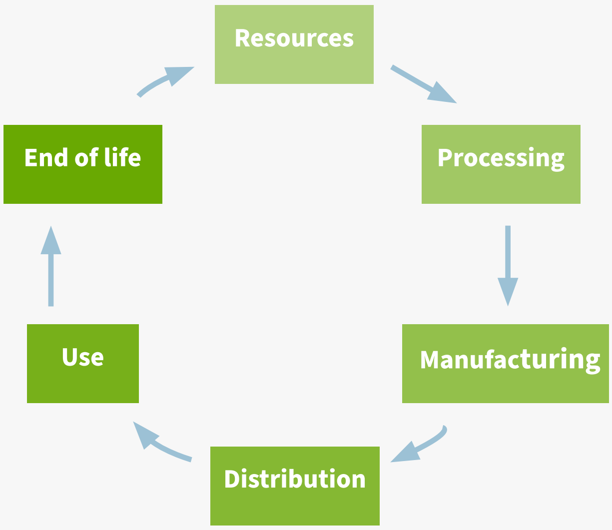
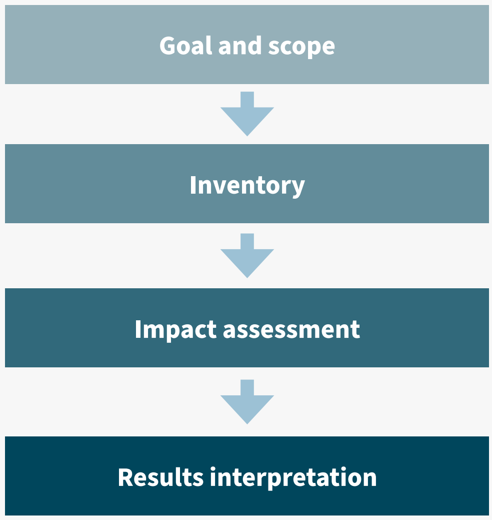


Figure 3: The four main steps of an LCA



LCA STEP 1: GOAL AND SCOPE DEFINITION

STEP 1 IN THEORY

The first step of an LCA is the definition of its goal and scope to create a model that mirrors reality as closely as possible. While the goal steers the entire study, the scope defines the LCA's functional unit and system boundaries. The functional unit describes the product and the function that it is to fulfil as part of the LCA (e.g., an LCA of milk could consider the life cycle of a litre of milk, as well as the intake of *x* grams of proteins and/or *x* kilocalories).

System boundaries define what product life cycle steps are considered as part of the LCA (e.g., the transportation of milk from the factory up to the selling point), and the required inputs for each step (e.g., the truck and fuel required to transport the milk). The difficulty for an LCA user is to create the model so that the distortions and simplifications do not significantly affect the outcomes.

System boundaries specify which product life cycle steps (e.g., the transportation of milk from the plant to the selling point) are included in the LCA and which inputs are necessary for each phase.

The most significant methodological decisions, presumptions, and restrictions as mentioned in the sections below are outlined in the scope of the study. Since an LCA is an iterative process, "initial" has been appended to most of the parts below.

Table 1: Vehicle specifications, fuel consumption, and lifespan of models in study

Specifications	Mid-size EV	Mid-size ICEV	Large ICEV
Model	Nissan Leaf (2019)	Toyota Corolla (2019)	Toyota Land Cruiser (2015)
Kerb weight (kg)	1322	1350	2182
Battery weight	286	*n.a.*	*n.a.*
Body style	Hatchback, 5-seater	Hatchback, 5-seater	SUV, 8-seater
Fuel source	Electricity	Petrol	Diesel
Consumption	0.138 kWh/km	.058 L/km	.158 L/km
Lifespan of EV/ICEV (km)	200000	200000	200000

As a result, one may begin with a set of needs and decisions that can later be modified as new information becomes available.

STEP 1 APPLIED TO EV vs. ICEV CASE STUDY

The goal of our EV vs. ICEV LCA is to understand the environmental trade-offs of EVs vs. ICEVs, especially considering countries where humanitarian organisations are often active. To do this, we developed scenarios for the life cycles of an EV and two ICEVs in Kenya, Lebanon, and Jordan to identify at which point (if ever) the EV is more environmentally friendly than ICEVs. Therefore, we defined the functional unit as a vehicle used for humanitarian aid workers in the respective countries — and consider in turn different types of vehicles (mid-size EV, mid-size ICEV, and large ICEV) under different fuel and disposal scenarios. This is described in Table 1. Important to note here is that the mid-size EV and ICEV are intended to fulfil similar requirements. Although the large ICEV has further capabilities (e.g., sedan vs. 4x4) it is included in this study because it was part of the pilot study and it provides a more holistic overview of the environmental impacts of various vehicle types. Though we do not analyse the impacts of a large EV (due to lack of data), this could be steps for a future study.

While the goal of our LCA is to compare the environmental footprint of EVs vs. ICEVs for humanitarian use in developing regions, our overall objective is to more generally understand the environmental dynamics considering multiple environmental impact categories and share these findings with relevant stakeholders.

Figure 1 illustrates the system boundaries of the study, which include:

- Production of vehicles including extraction and processing of raw materials (e.g., steel, aluminium, plastic, rubber, glass),
- Use of vehicles based on different energy source inputs (e.g., local electrical grid, diesel generator, solar, petrol, and diesel, as well as the production of panels, generator, et cetera),
- Disposal of vehicles considering different waste processes for battery and car body

The system boundaries of our LCA exclude the delivery of the vehicle to point of use.

Table 2: Breakdown of energy sources for local electricity grid of selected countries based on LCA background database (EcoInvent).

Energy source	Kenya	Lebanon	Jordan
Geothermal	38%		
Hydro	32%	2%	
Wind	2%		4%
Solar	1%		12%
Natural gas	1%		77%
Oil	16%	93%	3%
Other	10%	5%	4%

LCA STEP 2: INVENTORY

STEP 2 IN THEORY

The second step of an LCA is the modelling of the product life cycle steps with all its inputs and environmental outputs. Inputs enable a product life cycle step (e.g., a truck with fuel is required to transport milk up to its selling point). They can come from the technosphere (e.g., this is the case for the truck and the fuel) or from the biosphere (e.g., think about the land on which the cows live, or the water used to produce milk). Outputs are the direct environmental consequences of inputs — emissions to air, land, and water as well as the depletion of natural resources.

Input data must be gathered for each product life cycle step (in scope) — either as foreground or background data. Foreground data is specifically measured or collected against a product life cycle step. Background data is generic and comes from specialized databases (checked for quality and accuracy); it can be defined at different spatial aggregation levels (e.g., average energy required to produce milk in Belgium, or average energy required to produce milk in the world). Input data is entered in an LCA software which then "converts" it into output data[1].

STEP 2 APPLIED TO EV vs. ICEV CASE STUDY

We collected both foreground and background data for our EV vs. ICEV LCA through a collaboration with Fleet Forum, who collected data directly from the respondents. This includes data on:

- Model and year of vehicles used
- Country of use
- Types of energy sources used

Based on this information, we developed a number of scenarios and modelled them using the background database. This includes:

- Extraction of raw materials
- Manufacturing of vehicle
- Electricity generation / fuel production
- Vehicle use (i.e., including fuel and electricity production)
- Disposal processes

LCA STEP 3: IMPACT ASSESSMENT

STEP 3 IN THEORY

During the third step of an LCA, output data is translated into environmental impacts. The climate and environmental crises represent in fact many different environmental problems. An LCA can look at a multitude of these problems; the ones considered depend on the selected impact assessment methodology. The impact assessment methodology defines which environmental problems — referred to as impact categories — are considered as part of the LCA. It also defines which output element contributes to which impact category and to what extent (e.g., which emissions to air contribute to global warming and the extent of their contribution based on the global warming potential of each emission type).

[1] Output data could also directly be collected, but that is generally the case only with highly specialised LCAs.

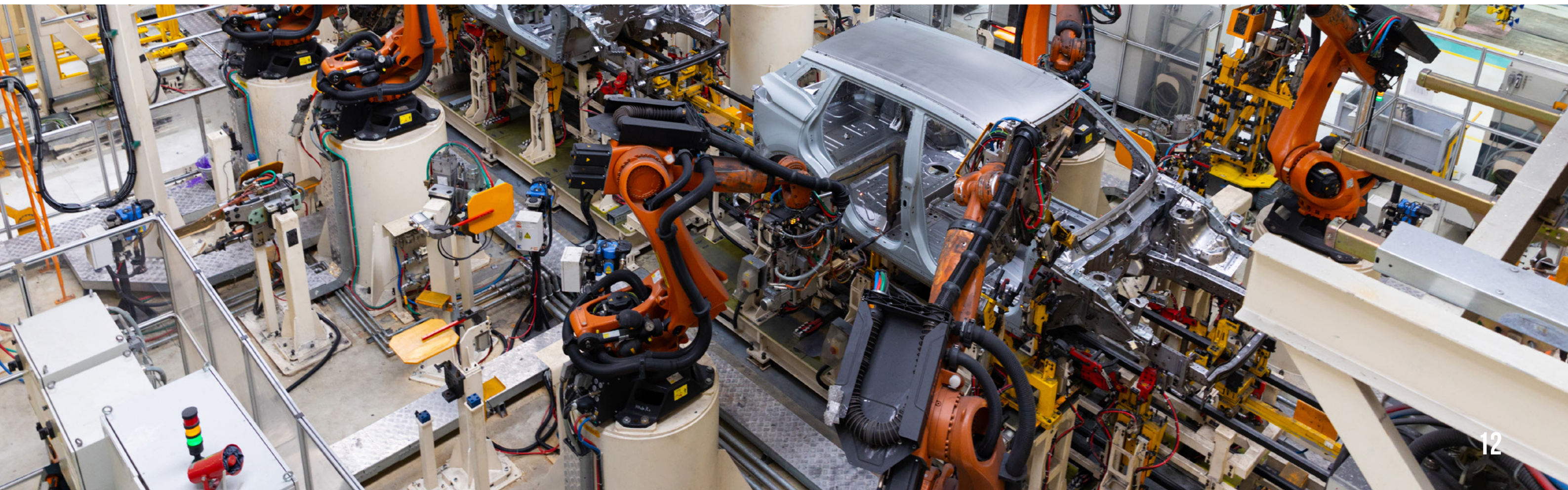
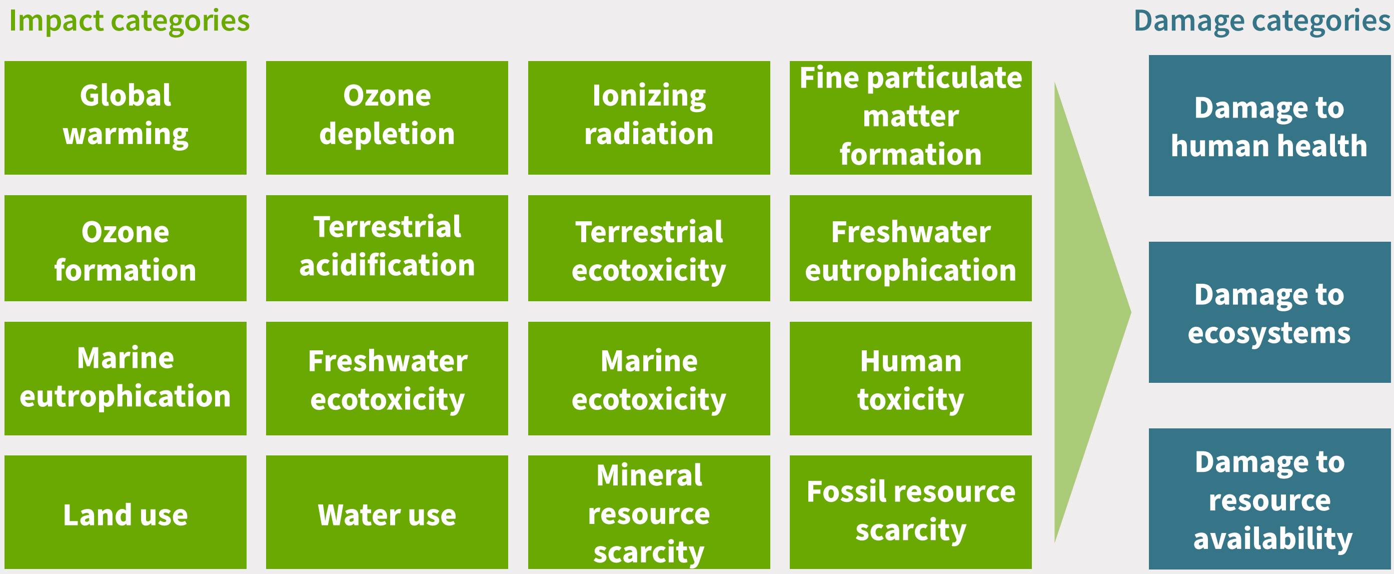


Figure 4: ReCiPe's midpoint and endpoint categories that can be considered as part of an LCA



In the graphs in the following section, the midpoint impact categories "ozone formation" and "human toxicity" are further split in two categories each: "ozone formation, human health" and "ozone formation, terrestrial ecosystems" for "ozone formation" and "human carcinogenic toxicity" and "human non-carcinogenic toxicity" for "human toxicity".

STEP 3 APPLIED TO EV vs. ICEV CASE STUDY

We selected ReCiPe 2016 as impact assessment methodology, and it is one of the most used impact assessment methodologies. Its strength lies in the fact that it considers 16 midpoint impact categories, which it then aggregates into three endpoint damage categories (see Figure 4). The midpoint impact categories present a detailed picture of the product's environmental footprint while the endpoint damage categories summarize these at aggregated level. The results are typically reported in two ways: (1) characterisation factor — a quantitative representative for the specific impact (e.g., kg CO_2 equivalent); (2) normalized results — relating the specific impact of the operation to a reference value (in our case the environmental impact of the average world citizen in 2010).

LCA STEP 4: RESULTS INTERPRETATION

STEP 4 IN THEORY

The fourth step of an LCA is the interpretation of its results. It is the final step of an LCA, but it should be the start of targeted environmental action.

STEP 4 APPLIED TO EV vs. ICEV CASE STUDY

Figure 5 presents the results of our EV vs. ICEV LCA considering ReCiPe's 16 midpoint impact categories and Figure 6 presents the results considering ReCiPe's three endpoint damage categories. At midpoint level we illustrate three scenarios: EV using the Kenyan grid (Scenario 1a), mid-size ICEV (Scenario 2), and large ICEV (Scenario 3). Scenario 1a represents an average scenario for the EV in this case study (based on analysed results) and is used to reduce complexity in the graph. The results indicate that the large ICEV is the greatest contributor across the majority of the impact categories, including the largest — human carcinogenic toxicity (leading to damages to human health). However, the EV has a higher impact than both ICEVs considering both freshwater and marine ecotoxicity (leading to damages in ecosystem quality). In general, the production phase has the highest environmental impact across all vehicles for the majority of impact categories. These mixed results illustrate the complex dynamics behind environmental sustainability.

WHAT ARE THE ENVIRONMENTAL TRADE-OFFS OF EVs vs. ICEVs IN SELECTED COUNTRIES IN EAST AFRICA AND THE MIDDLE EAST?

Figure 5: LCA results at midpoint level (normalized to the average world citizen (2010))

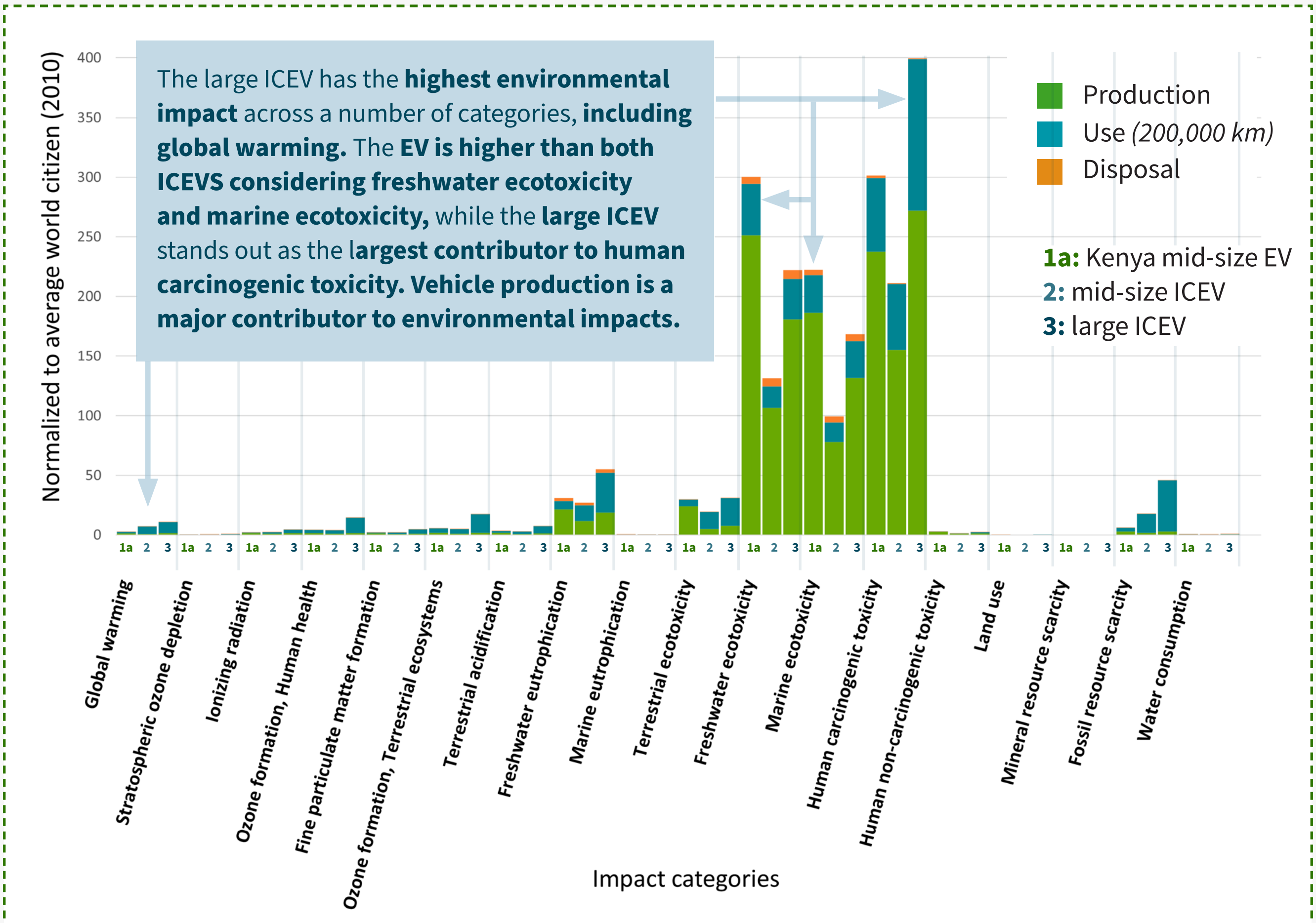
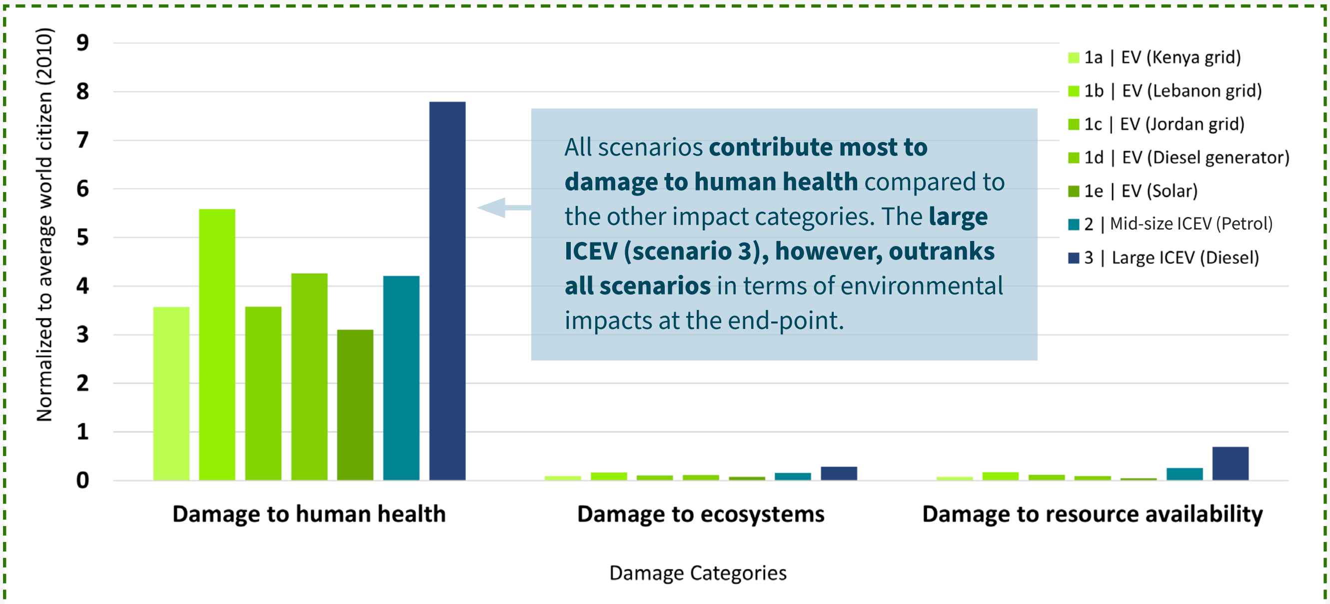


Figure 6: LCA results at endpoint level



The results are normalized to the yearly environmental footprint of an average world citizen in 2010 (e.g., 0.002 equals to 0.2% of the yearly footprint of an average world citizen in 2010). Normalization helps understand the relative weight of the impact categories based on a reference (in our case an average world citizen in 2010) and makes it possible to visualize the results of all impact categories with one same unit of measure. Source: Pré (2016). Introduction to LCA with SimaPro. Retrieved on 15.06.2022 from https://pre-sustainability.com/files/2014/05/SimaPro8IntroductionToLCA.pdf.

Aggregated at endpoint level, the results are more conclusive: the large ICEV has the most significant contribution to all damage categories (human health, ecosystems, and resource availability). Damage to human health has the highest normalized impact, and within this category, the results are less clear. The EV performs better than the mid-size ICEV under some use conditions, but not all. Scenario 1b (EV with Lebanon grid) has the highest impact. The local grid is comprised of 93% oil, which plays a key role here.

It is clear the large ICEV is the least environmentally friendly option considering most impact categories. However, how does the EV compare to the mid-size ICEV? Figure 7 illustrates the two categories (freshwater and marine ecotoxicity) in which the EV has a greater environmental impact than both ICEVs, while Figure 8 illustrates an impact category (human carcinogenic toxicity) in which the EV outperforms the large ICEV, but not the mid-size. In Figure 7, the production phase of all vehicles stands out, however the EV contributes significantly more than both ICEVs. In Figure 8, production is also the largest contributor to the impact category. Here, it is clear that the increase in materials needed for the EV compared to the mid-size ICEV plays a role.

These results indicate that there are cases in which the EV is less environmentally friendly than the mid-size ICEV, yet overall (considering the endpoint indicators), the EV has lower environmental impacts than both ICEVs — but this is dependent on the source of electricity.

Figure 7: LCA results for freshwater and marine ecotoxicity

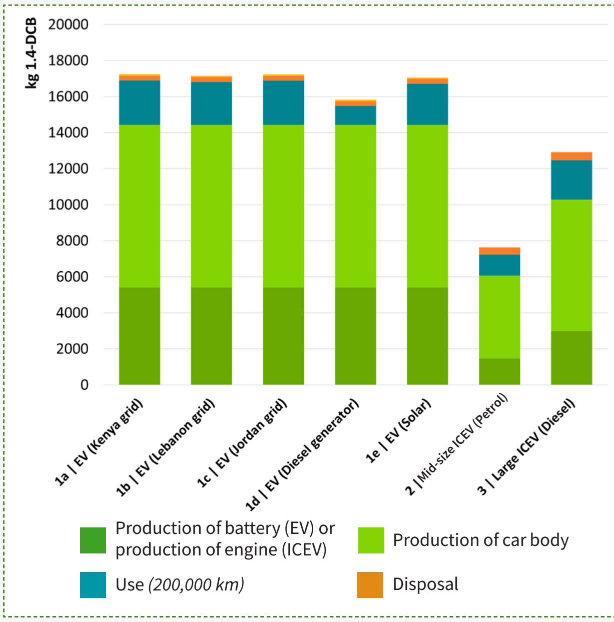
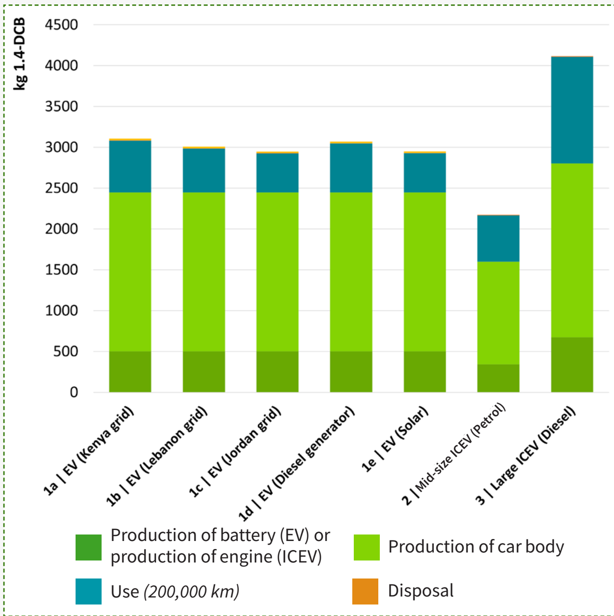


Figure 8: LCA results for human carcinogenic toxicity



WHAT MATTERS (FOR THE ENVIRONMENT) IS THE SIZE AND/OR MATERIALS OF THE VEHICLE (I.E. THE RESOURCES REQUIRED TO PRODUCE IT) AND THE TYPE OF ENERGY USED TO POWER IT.

Figure 9: LCA results for global warming for vehicle production

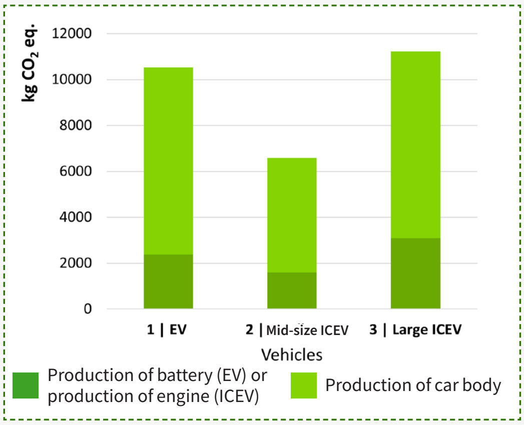


Figure 11: LCA results for global warming for production, use (200,000 km), and disposal

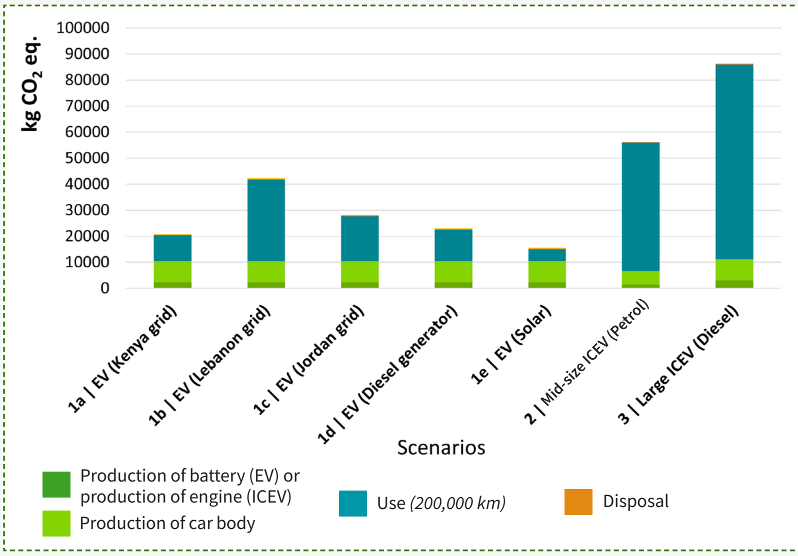


Figure 10: LCA results for global warming for use (200, 000 km)

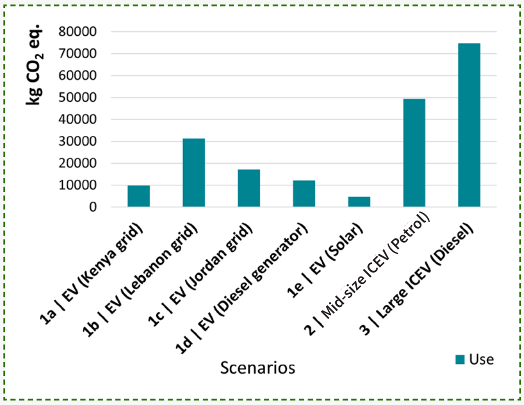


Table 3: Carbon emissions associated with the production and disposal of each vehicle (kg CO_2 eq.)

Vehicle	Production	Disposal	Production & disposal
mid-size EV	10,530	444	10,974
mid-size ICEV	6,589	287	6,876
large ICEV	11,231	320	11,551

When considering GHG emissions, the EV outperforms both ICEVs considering the full life cycle. Figure 9 illustrates the GHG emissions (kg CO_2 eq.) associated with the production of each vehicle. The EV has higher emissions than the mid-size ICEV, but less than the large ICEV. Considering the use phase (Figure 10), the EV outperforms both ICEVs based on all scenarios for electricity generation source. Figure 11 illustrates the entire life cycle of all scenarios, in which it's clear that the lower emissions associated with the EV use phase make it the best option compared to both ICEVS. However, it is clear from Table 10 and 11 that the composition of the local grid plays a large role. The Lebanon grid is powered mostly with oil, while Kenya and Jordan also incorporate renewable energy sources. Table 3 illustrates the "fixed' emissions of all vehicle (the GHG emissions associated with the production and disposal of the vehicles). From the start, the large ICEV has higher GHG emissions than the EV.

Figure 12: Break-even point for GHG emissions associated with mid-size EV vs. mid-size ICEV

At what point does the EV have lower carbon emissions than the mid-size ICEV?

The "EV Solar (1e)" refers to the scenario in which the EV has the lowest GHG (Scenario 1e), with solar power. The "EV Lebanon (1b)" refers to the scenario which the EV has the highest GHG (Scenario 1b). This illustrates that when considering the emissions associated with production, use, and disposal, the mid-size EV outperforms the mid-size ICEV after 18,305 km when electricity is produced via solar, and 45,300 km when electricity is produced according to the Lebanon grid (i.e., predominantly oil).

SO WHAT?

What do the results of the LCA mean for humanitarian actors? Transport is a key component of operations, and thus reducing its environmental impact requires first understanding the relevant trade-offs of EVs and ICEVs. To reduce the environmental impact of aid and development efforts, humanitarian organisations should consider a number of factors in regards to increasing the share of EVs in operations.

A main challenge for overall impacts was production of the vehicle, namely the increase in resources required (smaller vehicles have a lower footprint). However, improving material technology has the potential to play a large role. While the battery and car production technology is steadily developing, in the short-term humanitarian organisations should aim to increase the share of EVs if they can also ensure a clean source of energy.

In terms of carbon emissions, the main consideration is the source of electricity. In cases where the local grid is mainly comprised of renewable energies (e.g., geothermal, solar, wind, hydro), switching from the ICEV to the EV may already provide environmental benefits. However, if the local grid is predominantly fossil-fuelled (e.g., oil) then the switch to the EV is more complicated, and may not offer lower environmental impacts. In these cases, humanitarian organisation could consider charging vehicles through decentralized renewable energy sources (e.g., solar, which typically had the lowest impact across the majority of impact categories).

Furthermore, humanitarian organisations may consider engaging with local actors to improve infrastructure and potential to charge EVs with sustainable energy sources from the grid. This may be with local planning agencies to improve charging options, or government agencies to generate sustainable energy policies.

ENVIRONMENTAL VISIBILITY TO DRIVE CHANGE TOWARDS SUSTAINABLE TRANSPORT

SECTION 3 IN SHORT

Environmental action calls for short-term visibility and long-term vision. Humanitarian organisations need comprehensive quantitative analysis to support evidence-based decisions on what needs to change and which direction they want to go. The outcomes and learnings from visibility initiatives must be shared across the sector — by both practitioners and academia — to speed up the understanding of environmental challenges and lay the foundation for environmental action at scale.

Reducing the environmental impact of transportation — both passenger and freight — is a main priority of many humanitarian organisations. However, this objective requires a comprehensive analysis comparing more sustainable options across multiple relevant impact factors (i.e., not only carbon). Overall, the results of this study indicate that the EV outperforms the ICEV in many cases (especially GHG emissions) but falls short in others. This is due to the larger resource requirements for the production of the vehicle and battery, especially compared to the mid-size ICEV. Shifting towards sustainable electricity generation to power the EV plays — and will continue to play — a significant role, especially as the share of EVs globally continues to rise.

In the short-term, humanitarian organisations should aim to increase the share of EVs if they can also ensure a clean source of energy. This is highly dependent on the local grid, as well as the potential for decentralized electricity production. In the long-term, humanitarian organisations could also aim to support the regions in which they operate transition to more environmentally sustainable electricity generation for the local grid.

While the technology for cleaner transport is still in a development and transition phase, increasing the share of EVs implies a greater demand for electricity overall. Without a clean source to supply electricity, the potential to reduce environmental impacts may be minimal. This is also relevant beyond passenger transport. While not explored explicitly in the study, the results indicate that the larger the vehicle, the greater the reduction in GHG emissions when switching to EV. However, this also implies an increase in resources needed to produce the vehicles, as well as energy required to power them. Using the same logic, some other insights can be drawn. Namely, regardless of EV or ICEV, larger vehicles imply greater environmental impacts than smaller ones — thus if a larger vehicle is not necessary (for utility reasons), organisations should opt for a smaller one to reduce impacts.

In the first section of this report, we mentioned that to mitigate their environmental footprint, humanitarian organisations must develop a short- and long-term vision. Vision is indeed important, but it requires visibility. Humanitarian organisations need visibility to understand how and to what extent their operations are harming the environment and to subsequently define a vision and road map to mitigate their environmental footprint. Environmental visibility is increasing in the humanitarian sector, with the volume of studies and number of tools steadily on the rise. A growing number of organisations are enacting initiatives to provide a more transparent overview of the environmental impacts of operations, such as through carbon accounting. To increase the strength of these initiatives, humanitarian organisations should share their results and collaborate with other practitioners to accelerate knowledge sharing and change.

While the EV market may be driven by the commercial sector in a select number of countries, the potential for EVs to reduce the impact of operations — especially as grids become greener and battery technology better — should be explored further in the context of developing regions to not only reduce the GHG emissions of operations, but also to promote environmental sustainability at a local level across multiple environmental sustainability dimensions.

Furthermore, there is also a need for visibility considering costs and environmental trade-offs. For example, it may be interesting to look at the extra cost of the EV for the gain from an environmental point of view — versus other green solutions (not necessarily transport related). A big challenge for organisations is to know what green initiatives to prioritise considering limited funds, however this may become less difficult as donors continue to acknowledge the extra costs that may be associated with green solutions (which reduce the environmental externalities associated with operations, and may save costs in the long-run).

In the next phase of the analysis, we aim to use data from the respondents to enrich our model. This includes actual data for vehicle efficiency and charging source (e.g., grid, generator, solar), as well as costs associated with the use of the vehicle. Our goal is to further empower humanitarian organisations with evidence to make informed decisions that support short- and long-term sustainable development.

360° VISIBILITY TO FEED SUSTAINABLE CHANGE

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> *"Running a comparative life cycle assessment (of vehicles, in our case) is easier said than done. We are grateful that CHORD, its students, and management team is managing that very complex work with and for us."*
>
> *- Fleet Forum*

A DATA-DRIVEN STUDY OF
THE ENVIRONMENTAL PERFORMANCE OF EVs vs. ICEVs

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