Report on the results of the research

"Discovering feasible strategies reducing the environmental impact of International Humanitarian Organisations' transportation of personnel"

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August 2020

1. Introduction

The demand for humanitarian aid in developing countries has been rising annually for the last decade and is likely to continue increasing. Addressing the growing caseload, International Humanitarian Organisations (IHO-s) raise the number of humanitarian operations, which are performed via transportation of vital goods, equipment and aiding personnel to the hosting countries, resulting in growing number of road and air travels. Consequently, the IHO-s' consumption of fuel is increasing, leading to more emissions of the locally and globally damaging air pollutants, such as carbon dioxide (CO2). Apart from not complying with the internationally accepted Paris Agreements, seeking for the reduction of the carbon footprint of transport operations, this trend also contributes negatively to the climate change in the target areas of humanitarian aid. In fact, negative environmental impact of humanitarian fleet in the hosting countries increases the risks of emergence of a new local natural disaster, which can trigger socio-economic crises in the long-term perspective and thus, increase the demand for assistance in these areas even further. Research by Kelly (2013)[1] confirmed that "the failure to address environmental considerations within humanitarian interventions, can lead to a web of unintended adverse impacts on people and environment". These considerations unveil the cruciality of environmental dimension in the IHO-s' fleet management (*Figure 1*).

Figure 1. Importance of environmental dimension in humanitarian aid

[1] Kelly, C. (2013). Mainstreaming environment into humanitarian interventions – A synopsis of key organisations, literature and experience. *Evidence on Demand*, 3. https://doi.org/10.12774/eod_hd053.jul2013.kelly (p. iii)

Addressing the issues described above, this research aimed to build a System Dynamics model to identify cost-efficient strategies that can enable International Humanitarian Organisations to reduce the environmental impact of the transportation of their personnel, while providing the demanded level of aid (*Figure 2*). The methodology included quantitative analysis and System Dynamics modelling and simulation tools. The strategies tested were increasing loading of a car, delivering aid remotely, increasing the share of electric vehicles, making the fleet lighter or newer, etc. The research also tested the robustness of each strategy in a variety of plausible futures (scenarios). The results of the research can support IHO-s in decision-making regarding transportation of their personnel from the environmental perspective and systemic view.

- ***Research aim***: to build a System Dynamics model to identify cost-efficient strategies that can enable International Humanitarian Organisations to reduce the environmental impact of the transportation of their personnel, while providing the demanded level of aid
- ***Research question***: What are the cost-efficient strategies that can enable International Humanitarian Organisations to reduce the environmental impact of the transportation of their personnel, while providing the demanded level of aid?
- **Scope**: development programmes, transportation of aiding personnel

Figure 2. Research aim and research question of this research.

2. Methodology

System Dynamics

This study in its planning and research strategy followed the guidelines of policy analysis developed by Walker (2000)[2], while also applying System Dynamics modelling tool and data analysis. As this research aims to represent a holistic view on environmental impact of IHO-s' fleet, involved in the transportation of personnel, the range of relevant and most influential factors must be included under the focus of the study. To illustrate the systemic perspective, uniting environmental factors of the fleet with the costs and amount of performed personnel-trips, the System Dynamics modelling was applied, using Vensim software. This method allows to visualise main factors and cause-effect connections between them, quantify these relationships, and perform simulations for the future periods. Additionally, possession of an access to the fleet data enables

[2] Walker, W.E. (2000) Policy Analysis: A Systematic Approach to Supporting Policymaking in the Public Sector. *Journal of MCDA*, 9, 11-27

validation of the model developed in System Dynamics methodology, while reinforcing nature of the demand for aid growth in some future scenarios can be represented in this method by loop connection. The reasons supporting the choice of this method are summarized in *Figure 3*.

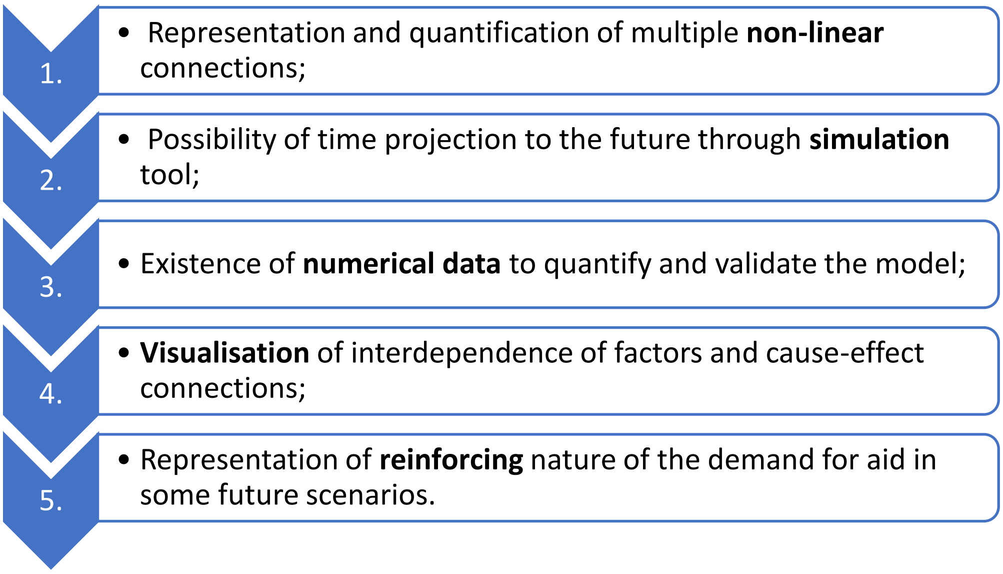

Figure 3. Arguments supporting methodological choice of System Dynamics tool and Vensim software

Fleet data

The fleet data used to verify the model belongs to *Organisation A* (name was changed due to anonymity request). This IHO has over 10 000 employees worldwide, delivering humanitarian aid to around 80 countries, majority of which are African and Middle Eastern. The IHO possesses over 3000 light vehicles, enabling the transportation of aiding personnel. *Organisation A* delivers assistance to the target areas to bring relief to local healthcare systems after natural or socio-economic disasters. The dataset has the recordings of over 3000 vehicles, declaring their type, procurement costs, country of operation, maintenance and fuel costs, litres of fuel consumed, number of kilometres driven and the year of purchase, reported for the whole period from the date of procurement of a vehicle until October 2018. For the purposes of model validation, the data of 9 countries was used. To test the strategies, settings for Jordan were used (feasibility of all strategic alternatives was considered).

Scenario analysis

Another technique, applied in this research, was scenario analysis. The mobility of the staff of IHO is influenced by numerous factors, that are, in fact, outside of the system of control for an organisation. These factors are the local aspects, such as driving conditions and infrastructure or traffic, amount of funding by donors and the demand for aid in the target areas. As these factors cannot be set by IHO, there are multiple combination of the assessments of these factors, forming the scenarios of the future and defining the characteristics of external environment for an IHO.

Later, by testing each alternative strategy within the context of each scenario, the criteria of policy robustness will be assessed. The source of the scenarios was a report by Inter-Agency Research and Analysis Network (2017), which addresses mainly the conditions, within which humanitarian aid will be performed, the different possible future caseloads of an IHO, and donors' funding (*Figure 4*). The key scenarios were illustrated and explained via the framework of the developed and previously validated System Dynamics model by defining variables influenced by them and linking mathematical equations.

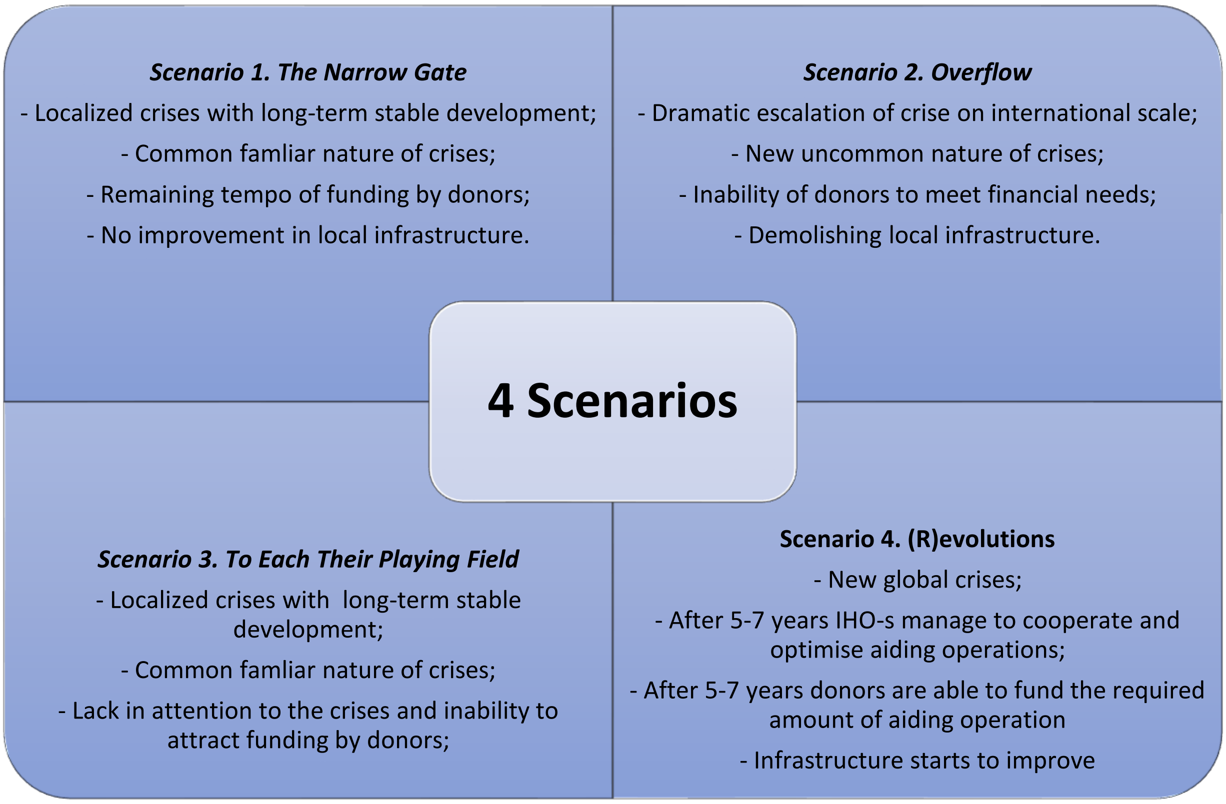

Figure 4. Description of scenarios developed by (IARAN, 2017)

Finally, validated with one IHO's fleet data System Dynamics model was used to test various strategies for the period from 2020 until 2030, while controlling for their robustness on the range of plausible futures (scenarios).

3. Research results

Analysis of strategies was conducted by comparing the environmental and financial outcomes of each corresponding simulation. The operational objective (regarding the number of transported personnel) in the model was met by all strategies and defined the costs of aid delivery. These costs were controlled for being within the budgetary constraints (checking 'Accumulated deficit' variable). However, testing one strategy the setting of 4 various scenarios, it might meet the limits of budget in one plausible future, while not in another. Therefore, such estimator as 'Robustness' of a strategy was implemented. It can be also considered a measurement of risk of a strategy, where high robustness is linked to the low risks. If a strategy can be performed within the budget limits in 3 or 4 scenarios, it is labelled as 'HIGH' in robustness (low in risk). If a strategy is cost-efficient within 2 scenarios, it was categorized as 'MEDIUM' robust (medium risks), if in 1 or 0 scenario(s), then 'LOW' robust (high risks). Improvement in resulting from transportation of personnel CO2 emissions as an outcome of different strategies can be compared in two ways. First, we try to adjust the key parameter of each strategy (such as loading of a car, trip distance, weight of a vehicle, age of the fleet, share of electric vehicles, or share of remote aid) by around the same scale (changing it by 20-25% comparing to the initial base case) and compare the improvement in accumulated CO2 emissions during next 10 years (measured in percentage in relation to base case). Second, it is informative to compare maximum possible improvement of CO2 emissions decrease due to change in the particular variable. The results are presented in *Table 1*. Detailed effects of different scales of implementation of each strategy is presented in *Table 2*

Table 1. Multi-criteria summary of strategic options

Parameter	**Change in CO2 emissions (if 20-25% change of parameter)**	**Maximum possible CO2 reduction due to parameter change**	**Robustness**
Loading of a car	-38%	-66%	HIGH
Trip distance	-25%	-25%	MEDIUM
EV	-22%	65%	LOW
Remote aid	-20%	-50%	HIGH
Weight	-19%	-37%	MEDIUM
Age of the fleet	-8%	-25%	LOW

Table 2. Scales of strategies' implementation and their effect on CO2 emissions

	Number of scenarios met without budget deficit	**CO2 emissions improvement**
Loading of a car 0,5	3 Scenarios	-38%
Loading of a car 0,75	4 Scenarios	-57%
Loading of a car 1	4 Scenarios	-66%
Average trip distance 15 km	2 Scenarios	-25%
Kerb weight 150 kg & Maximum seats 2	3 Scenarios	-22%
Kerb weight 900 kg Maximum seats 4	1 Scenario	-19%
Kerb weight 2400 kg & Maximum seats 7	1 Scenario	-1%
Kerb weight 3150 kg & Maximum seats 12	3 Scenarios	-37%
Age of the fleet 5	1 Scenario	-8%
Age of the fleet 0	1 Scenario	-25%
Electric vehicles 0,25	1 Scenario	-22%
Electric vehicles 0,5	0 Scenario	-43%
Electric vehicles 0,75	0 Scenario	-65%
Remote aid 0,1	1 Scenario	-10%
Remote aid 0,2	2 Scenarios	-20%
Remote aid 0,3	3 Scenarios	-30%
Remote aid 0,4	3 Scenarios	-40%
Remote aid 0,5	4 Scenarios	-50%

Increasing loading of a car, meaning using higher percentage of seat capacity of vehicles with average trip, demonstrates one of the highest improvements in CO2 emissions among all strategies. It can be also characterised by the high level of robustness, as from the level of loading equal to 0,5, the IHO can operate in three out of four scenarios, and from 0,75 – in all four plausible futures. This strategy also enables a significant reduction of transportation costs, which is achieved by the reduction of the required size of the fleet. At the end of the first period, the current number of vehicles in the fleet decreased by the number of unnecessary vehicles (*Figure 5*), thus the costs can become negative for some time.

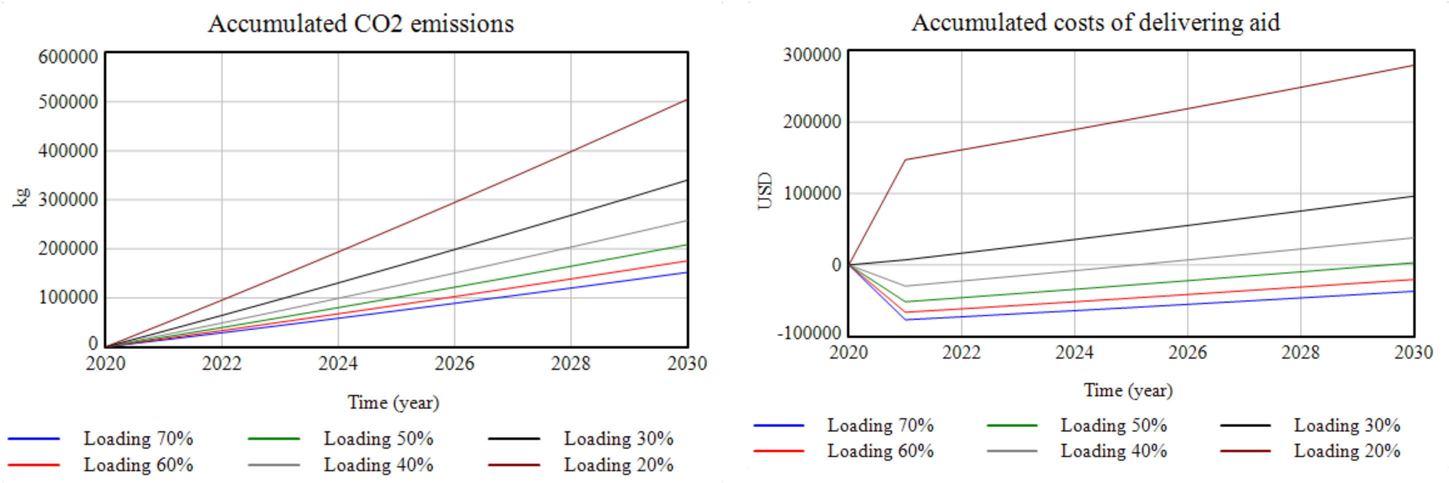

Figure 5. Dynamics of CO2 emissions and costs for the strategies with loading of a vehicle

Reduction of the trip distance strategy is medium robust, as can cover the costs of delivering required number of personnel only in Scenario 1 and Scenario 3. However, the maximal effect on CO2 emissions is one of the lowest among all strategies (around 25% decrease). Nevertheless, it can also contribute positively to costs decrease as it reduces the annual mileage of the fleet.

Electric vehicles increase is a strategy that demonstrates one of the highest among all alternatives maximum in potential decrease in accumulated during 10 years CO2 emissions, which can be reduced by 65% comparing to base case by incorporating 75% of electric vehicles in the overall composition of the IHO-s' fleet (keeping in mind that the main source of electricity is natural gas in the region under focus). Moreover, 22% improvement in environmental impact can be already achieved by introducing 25% of the electric vehicles. Significant drawback of this strategy, however, is its low robustness to potential futures, which can imply restrictions of budgets comparing to base case. The costs of developing this strategy can be met by the budget only while having 25% of the fleet driven by electricity and only in Scenario 1. Initial investments in changing the corresponding share of fleet with electric vehicles is depicted in the value of costs at zero period (*Figure 6*).

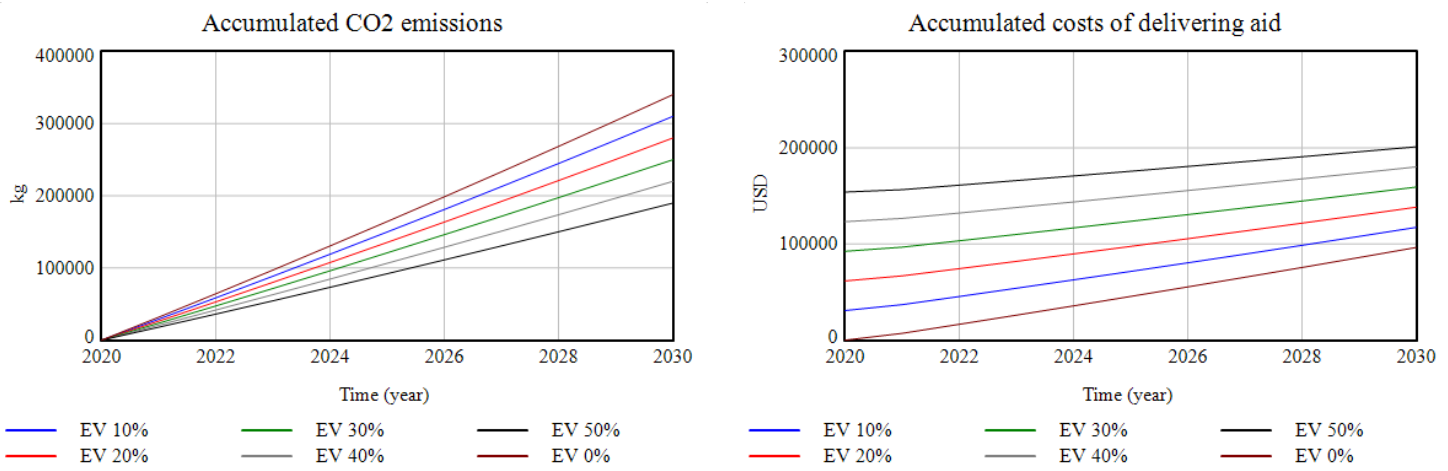

Figure 6. Dynamics of CO2 emissions and costs for the strategies with electric vehicles

Remote aid is a remarkable strategy due to its high robustness to potential futures. From 30% of all workload performing without transportation of personnel, IHO can function within the budget in three out of four scenarios, and from 50% of remote aid – in all scenarios. Consequently, it can also contribute up to 50% of CO_2 emissions reduction. With first 20% of aid delivered without applying means of transportation, 20% of environmental impact can be reduced. This strategy also enables a significant reduction of transportation costs, which is achieved by the reduction of the required size of the fleet. At the end of the first period, the current number of vehicles in the fleet decreased by the number of unnecessary vehicles (*Figure 7*), thus the costs can become negative for some time.

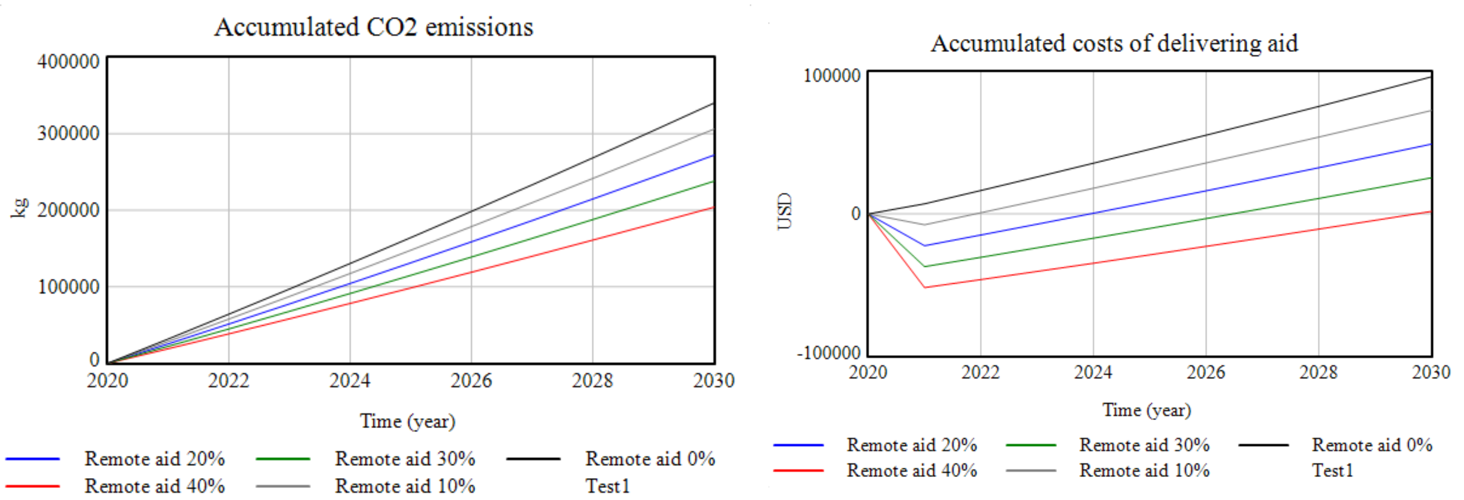

Figure 7. Dynamics of CO2 emissions and costs for the strategies with remote aid

Weight of the fleet adjustment requires corresponding additions of new vehicles procurement and maximum seats capacity. The model simulation showed that having heavy but with bigger number of seats vehicles is the most prominent strategy out of all related to weight, as it can decrease the CO2 emissions by 37% in 10 years comparing to base case alternative. Such direction is also a robust option as can transport required number of personnel in three out of four possible scenarios. Simulation also showed, that maximally small and light means of transportation, such as motorbikes, is also a robust strategy, beneficial for environment at the same time (22% reduction of CO2 emissions comparing to the projection of the base case).

Age of the fleet as a strategy, naturally requiring fleet renewal in case of decrease in age, is a highly vulnerable strategy. Decreasing he age of the fleet by 20% will lead to only 8% decline in CO2 emissions, with 25% maximum possible reduction due to this factor. The strategy is also low robust as required high investments for newer vehicles.

After analysis of all potential strategies, it is also representative for IHO-s to demonstrate per each scenario separately which strategies are feasible. The results are presented in *Table 3*. Overall, the research revealed, that when the scenario of current state 'The narrow gate" (Scenario 1) continues within next 10 years, meaning that already existing local crises continue to develop with the same pace and receive corresponding funding by donors[3], IHO might apply majority of the strategies to reduce CO2 emissions of its transportation of personnel: increase loading of a car from 30%, optimise travel distance and weight of the fleet, arrange renewal of the fleet until 0 years, increase the share of electric vehicles in the fleet up to 25% or increase the remote aid. All the strategies in this scenario will stay within the budgetary constraints. However, the research reveals, that in case the 'To Each Their Playing Field' scenario develops, referring to 'forgotten crises' when the current crises continues to develop in the common pace, while the funding is scarce and does not meet the needs of the area in the previous operation conditions of IHO-s[4], less strategies are feasible. Loading of a car in this case must be increased up to at least half of the seats, the trip distance needs to be improved by 25% or the weight of the fleet needs to be

[3] Inter-Agency Research and Analysis Network (IARAN). (2017). *The Future of Aid INGOs in 2030*. Retrieved from http://futureofaid.iaran.org/The_Future_Of_Aid_INGOs_In_2030.pdf

[4] Inter-Agency Research and Analysis Network (IARAN). (2017). *The Future of Aid INGOs in 2030*. Retrieved from http://futureofaid.iaran.org/The_Future_Of_Aid_INGOs_In_2030.pdf

restructured either to small and light vehicles or big vans with higher number of seats. Finally, 20% of workload delivered remotely is also a cost-efficient strategy in this scenario.

Table 3. Scenarios and related feasible strategies

Scenario 1	Scenario 3	Scenario 4	Scenario 2
Base case	-	-	-
Loading of a car (**from** 0,3)	Loading of a car (**from** 0,5)	Loading of a car (**from** 0,5)	Loading of a car (**from** 0,75)
Average trip distance (up to 20 km)	Average trip distance (up to 15 km)	-	-
Weight (lighter until 150 kg; heavier until 3200 kg)	Weight (either light of 150 kg OR heavy of 3200 kg)	Weight (either light of 150 kg OR heavy of 3200 kg)	-
Age (until 0)	-	-	-
Electric vehicles (until 0,25)	-	-	-
Remote aid (**from** 0)	Remote aid (**from** 0,2)	Remote aid (**from** 0,3)	Remote aid (**from** 0,5)

On the other hand, IARAN (2017) developed 'Overflow' scenario, where international or global systemic crises outbreaks, exhibiting exponential growth in aid demand, while restricting the abilities of donors to provide even common level of funding. In addition to this, the local driving infrastructure and conditions, being a crucial factor for transportation efficiency, will suffer. This study demonstrates, that in such conditions only increasing the loading of a vehicle at least up to 75% or delivering 50% of assistance remotely can be cost-efficient strategies. However, IARAN (2017) described the fourth scenario '(R)evolution', which supposes that the 'Overflow' scenario can turn halfway, in 2025 in a change in the way humanitarian aid is delivered, implying more coordination, cooperation and optimisation among IHO-s, donors, local NGO-s, etc. In this case, from 2025 exponential growth in demand will be meeting more efficiently by donors' funding. In this case, this study shows that such strategies as loading of a vehicle 50% and higher, minimum 30% of remote aid and optimisation of fleet weight can be cost-efficient feasible strategies.

IHO-s may opt for strategies that are not feasible in all potential future scenarios, however, this implies risks. Therefore, the choice of an IHO for a future strategy is also a trade-off between environmental impact reduction and risk of not being able to finance it in case large crises scenario, such as 'Overflow', enforces.

4. Application of the research

This research was aiming to support IHO-s in decision-making regarding transportation of their personnel from the environmental perspective and systemic view. Multi-criteria decision matrix (*Table 1*, *Table 2*) were developed both to summarize outcomes of the research for decision-makers and to depict existing trade-offs in this field. In case IHO opts for implementation of the flexible or adaptive strategy, depending on the changing environment of key external factors, the roadmap for such decision-making will look the as presented in *Figure 8*.

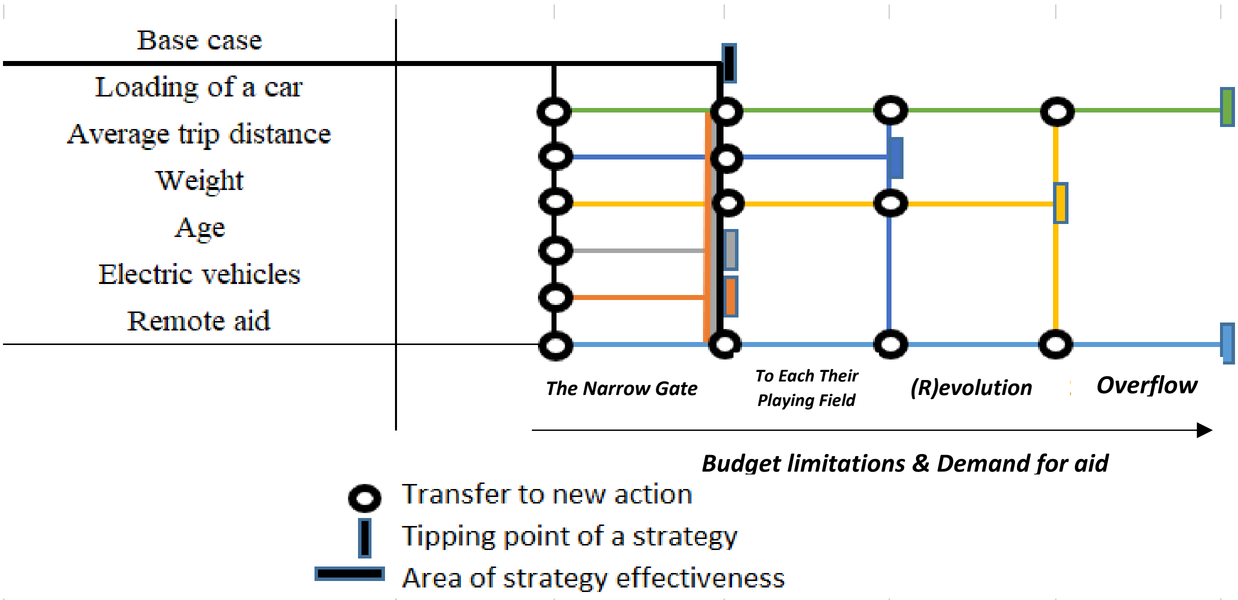

Figure 8. Roadmap of strategies

Summarizing all findings, the related guidelines for IHO-s were developed (*Figure 9*) to navigate IHO-s through the findings of this research and foster their effective usage. The trade-off between risks of not being able to implement the strategy in all possible futures and the maximisation of the reduction of the environmental impact needs to be met by the IHO-s' decision-makers during the group discussion session. By adding these findings with relevant organisational or local factors (if necessary), IHO-s can make informed and robust choice of a strategy rather in an adaptive or permanent manner. This study can be a scientifically grounded basis for IHO-s to start incorporating environmental dimension in the mobility strategic planning of their operations, which is not yet a common practice among IHO-s.

Guidelines for -IHO-s

1.

- Choose a **region** of strategy implementation;
- Define **local** (infrastructure, facilities) and **organisational** factors which might influence implementation of six developed strategies in the target area;
- Collect **information/data** about local and organisational factors and evaluate each strategy with this parameter;
- **Extend the multi-criteria matrix** of strategies (*Table 1*) with relevant organisational or local factors.

2.

- Organise a group discussive **decision-making session**, involving managers and directors of IHO;
- Discuss **trade-offs** and give **weights** collectively to each of strategy criteria;
- Decide on the **type** of strategy (adaptive/permanent).

3.

Permanent strategy

Choose the strategy with the **highest score** considering the weights and parameters' measurements and set a target for the strategy using *Table 2*

Adaptive strategy

For each scenario separately choose the strategy considering the weights and parameters' measurements → compare the costs of transferring and choose the **best pathway** (*Figure 8*) → Decide on a track of strategies with targets using *Table 2*

Figure 9. Guidelines for IHO-s on strategy choice procedure

To obtain even more verified outcomes for a certain IHO operating in the target region, the fleet data of this organisation can be analysed and used for quantification of the validated System Dynamics model. Additionally, other relevant to the case factors may be included. Finally, the strategies can be tested on the range of tailor-made scenarios, that are defined by the target area. Depict all the findings, including organisational insights, in the Multi-Criteria Decision Analysis matrix in the following way (*Figure 10*):

	CO2 emissions	Costs	Amount of aid delivered	Risks / robustness	Organisational factor
Strategy 1					
Strategy 2					
Strategy 3					
….					
Strategy N					

Figure 10. Multi-criteria decision analysis matrix

Finally, the general findings about region-specific external and organisational factors influencing the choice and feasibility of the strategy can be summarized in the following recommendations (*Figure 11*):

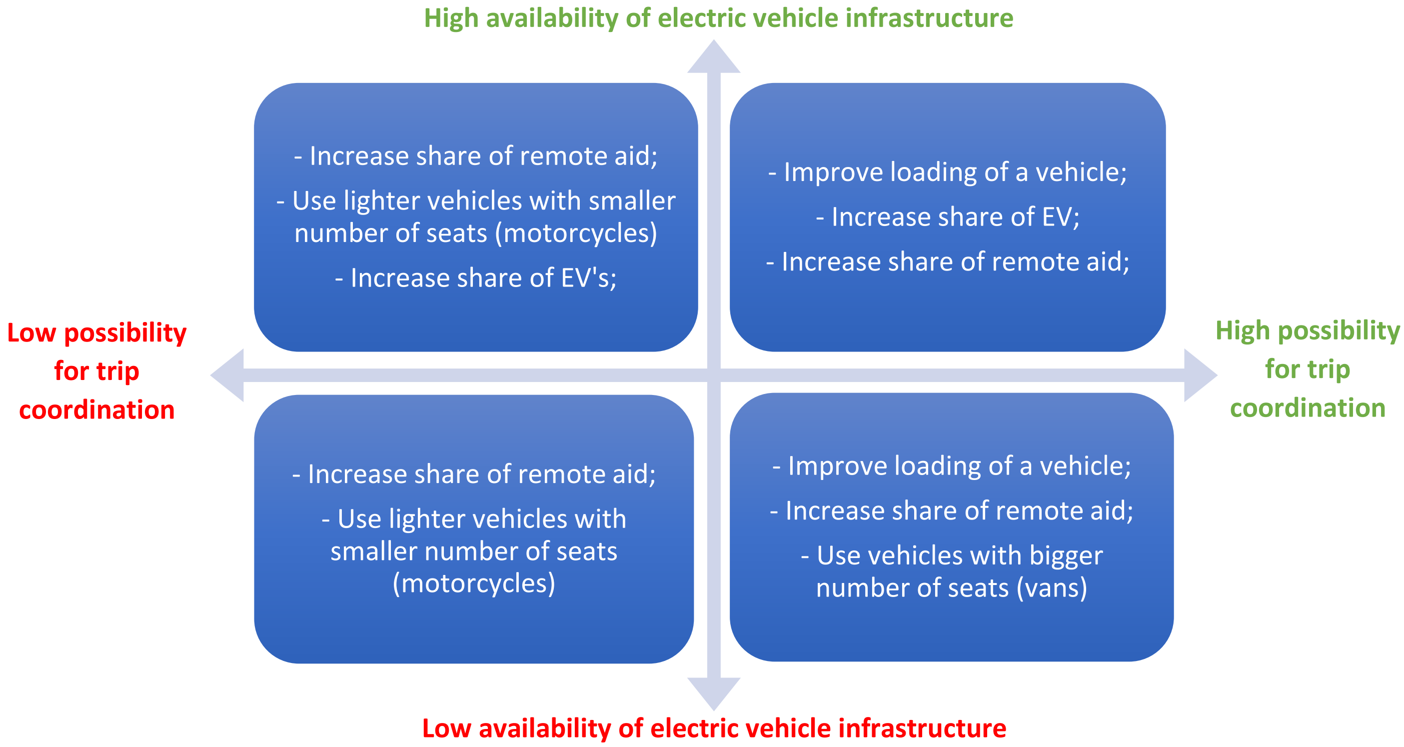

Figure 11. Strategic options feasible in various organisational and regional conditions

The matrix in *Figure 11* represents the most cost-efficient and environmentally friendly strategies for each out of four combination of factors. Availability of electric vehicles' infrastructure in the target area gives opportunity to increase the share of it in the fleet. However, as it requires extra costs, it can be more feasible and less risky if it goes together with cost-saving strategies of increase in vehicle loading or remote aid. At the same time, the strategy regarding loading improvement can be only feasible in the locations where coordination of trips is possible (when they are performed geographically and timely closely). Additionally, in case of coordination and optimisation possibility, using vehicles with higher number of seats will also result in significant CO_2 emissions improvement. In case coordination is constrained by logistical characteristics of the target area, lighter vehicles with less seats (especially, motorcycles) can influence positively the reduction of negative environmental impact of the IHO's fleet.