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# Logical Structure of Actions to Reduce the Impacts of Traffic Incidents

Marina Leite De Barros Baltar[1]; Victor Hugo Souza De Abreu[2]; Andrea Souza Santos[3]

[1]Transport Engineering Program (PET), Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ), Brazil.

[1]mabaltar@gmail.com

[2]Transport Engineering Program (PET), Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ), Brazil.

[2]victor@pet.coppe.ufrj.br

[3]Transport Engineering Program (PET), Alberto Luiz Coimbra Institute for Graduate Studies and Research in Engineering (COPPE), Federal University of Rio de Janeiro (UFRJ), Brazil.

[3]andrea.santos@pet.coppe.ufrj.br

**Abstract**

*Traffic incidents (such as broken-down vehicles, accidents, flat tires and other) constitute an important concern in the urban context, impacting the sustainable development. Thus, currently, the proposition of efficient traffic incident management systems has been encouraged to re-establish road safety and restore the network's traffic capacity. Thus, this paper aims to investigate the main impacts of traffic incidents and elaborate a logical structure of actions that should be employed to improve their management. The results show that many impacts can be identified in the three spheres of sustainable development and improvement actions must accelerate responses to emergencies, invest in Intelligent Transportation System (ITS), develop urban planning with a focus on more roads secure and enforce existing laws and regulations.*

**Key-words:** Impacts, Traffic Incidents, and Sustainable Development Goals.

## 1. Introduction

Road transport sector constitutes an important link that facilitates the economic and social development of cities. The reason is that it meets the needs of passengers and freight transportation between points of origin and destination, thus allowing the entire society to have access to goods and services available in cities (Santos et al., 2021). However, the intensive use of road infrastructure, in an unbalanced matrix, makes the circulation of traffic susceptible to strong impacts such as the


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occurrence of road incidents, thus causing serious damage to fluidity and road safety (Islam, 2019; Baltar et al., 2021b).

Road interruptions caused by the incidents lead to traffic jams that increase travel time, consumption of fossil fuels, environmental pollution (noise, visual and atmospheric), direct and indirect costs to the economy, among other impacts on the quality of life of the urban pollution (Taylor, 2008; Rao and Rao, 2012; De Palma and Lindsey, 2011; Grote et al., 2016; Nitsche et al., 2016).

Thus, road traffic incident management is a functional part of the holistic approach to solving traffic problems (Škorput, Mandžuka and Jelušić, 2010). Furthermore, through this field of traffic engineering it is possible to achieve many, if not all, of the Sustainable Development Goals (SDGs) of the 2030 Agenda for Sustainable Development of the United Nations (UN, 2015). Hence, road administrations must manage incidents safely and efficiently (Nitsche et al., 2016). Therefore, effective practices need to be encouraged to better detect, respond and clear incidents in a timely manner, in order to re-establish road safety and restore traffic capacity in the transport network (Hajibabai and Saha, 2018).

Thus, this study seeks to present a general framework of the impacts of traffic incidents on sustainable development and to elaborate a logical structure of actions that should be used to reduce them, and, consequently, comply with the SDGs. To fulfill your purposes, this paper, in addition to this introductory section; in Section 2, it deals with the methodology used to develop the research; in Section 3, it seeks to indicate and discuss the taxonomy of traffic incident impacts; in Section 4, present a logical framework for actions to improve incident management; and, finally, in Section 5, there are the final considerations, including proposals for future research.

## 2. Methodology

The methodology adopted to develop this research is divided into 4 phases, which are: (i) bibliographic review protocol; (ii) creation of the research repository; (iii) development of the general framework for the impacts of traffic incidents on sustainable development; and (iv) elaboration of a logical structure of actions that should be employed for good incident management.

In Phase 1, the inclusion and qualification criteria (quality and applicability) and the search method are defined. It should be noted that, as inclusion criteria, the following were considered: (i) coverage time: preference for studies published in the last 10 years; (ii) framing with the proposed objective; and (iii) source prestige. Furthermore, as qualification criteria are: (i) are the arguments

presented clearly and without a subjective bias? (ii) is there a technical innovation or contribution to the state of the art? (iii) seeks to highlight the impacts of traffic incidents and/or indicate actions that can be taken for good traffic management?

In Phase 2, direct searches are carried out in databases such as Web of Science, Scopus and Science Direct, through combinations of keywords such as: traffic incidents, incidents impacts and incident management. Cross searches were also carried out in the most relevant studies, that is, they were considered references cited in the papers found by the direct searches, in order to further increase the scope of this study. Finally, there is a complete analysis of the studies found and application of inclusion and qualification criteria for the final screening of studies, thus obtaining the research repository for the development of logical reasoning for the development of this research. The objective was to strike a balance between scope and relevance to the subject.

Phase 3 consists of pointing out, through a literature review, the main impacts of incidents, in each of the three spheres of sustainable development. In the social sphere, the impacts on the quality of life of the urban population and on the urban apparatus are related; in the economic sphere, the impacts on economic production and on public and private costs are related; and, in the environmental scope, the impacts on climate change, air and noise pollution and the consumption of natural resources are related.

In Phase 4, a logical structure of actions is elaborated to be used to reduce the impacts generated by incidents based on those surveyed in Phase 3. In this step, the sector, actions, outputs, results and impacts that were defined were defined are mitigated from the proposed actions. In addition, the 2030 Agenda SDGs that can be achieved with actions to improve traffic incident management are pointed out. The final goal is to ensure consistency, comprehensiveness and relative ease of understanding for the decision makers who will use it.

## 3. Impacts Raised by Traffic Incidents

One of the justifications used by the UN (2020) when announcing the Second Decade of Action for Road Safety (2021-2030) was precisely the need to comply with the SDGs, which demonstrates a strong link between traffic accidents and sustainability. In addition, traffic congestion, which has as one of its main causes the occurrence of traffic incidents (Islam, 2019), is a growing problem in the urbanization of economies that results in wasted time, health problems due to pollution and contributes to the accumulation of Greenhouse Gas (GHG) emissions (Brent and

Beland, 2020). Thus, this section will present the impacts caused by the incidents raised through a literature review and areas related to them, as proposed in the methodology.

### 3.1. Social Scope

As for the social impact, it is observed that the incident brings impacts related to quality of life and the urban apparatus. When it comes to quality of life, it is observed that the incidents are responsible for worsening physical and mental health and travel time. It is known that traffic incidents are responsible for the increased risk of unnatural death and disability.

WHO (2018) states that approximately 1.3 million people die each year on the world's roads and between 20 and 50 million suffer non-fatal injuries. Brazil, specifically, was the country with the third highest number of deaths from traffic accidents in the world, surpassed only by India and China. In addition, traffic is the main cause of death among young people in a global context and low- and middle-income countries have mortality rates from road traffic injuries more than twice as high as high-income countries (OMS, 2015), making the disparity of development between them clearer. It is noteworthy that, according to Sánchez-Mangas et al. (2010), the most relevant factors that explain the probability of death in an accident are associated with variables related to the individual and, more specifically, to the non-use of safety measures (for example, seat belts or other safety elements), another relevant factor is the consumption of alcohol, medication or drugs, which strongly impact the reasoning ability of drivers.

Furthermore, Requia et al. (2018) proved the correlation between traffic emissions and human health, showing that it is aggravated at the most congested times. Knowing that incidents are one of the main causes of non-recurring traffic jams (HAAS, 2006), they also impact the health and quality of life of the population as a whole and not just those directly involved in the incidents. Zheng et al. (2020) showed that the level of congestion generated by incidents is mainly associated with the types of traffic accidents, the types of vehicles involved and the time of occurrence. Delays and unpredictability in travel times between origins and destinations also affect the quality of life of the urban population (Hojati et al., 2016; Islam, 2019). Noland (1998), for example, shows that unreliable travel times generated by non-recurring congestion affect people by disrupting the schedule of their activities, and may even lead to the cancellation of an activity. Furthermore, this unpredictability can generate some form of anxiety or cause some additional planning costs.

Reverberating this, Kabit et al. (2014) states that incident-induced delay is one of the most important indicators to quantify its impacts on traffic. Therefore, it is essential to eliminate accidents

as quickly as possible (Haule et al., 2020) to reduce uncertainties, as predicting traffic conditions in urban networks is a priority for traffic management centers and this becomes very challenging when the network is affected by traffic incidents that vary in time and space (Shafiei, 2021). In addition to the impact on quality of life caused by congestion, it is noteworthy that transport systems play a critical role for daily commuting, logistics and business travel and that a faulty system leads to greater losses in travel time and costs incurred for rescheduled trips (Hsieh and Feng, 2020). Therefore, incidents also have a direct impact on the urban apparatus.

At this point, the need for city resilience is highlighted, as the successful functioning of a city depends heavily on the good functioning of different infrastructure systems (Reiner and Mcelvaney, 2017) and an interruption in capacity (in the case of incidents) it can lead to an interruption in another network (Guidotti et al., 2016). Balal et al. (2019) considered five parameters to analyze the resilience of a lane, which are: queue length, segment speed, segment travel time, occurrence lane delay and detour route delay.

The lack of resilience and the long lines of non-recurring traffic jams reduce the attractiveness of the city, as they lead to distrust in the reliability of urban transport systems. A reliable road network depends on the efficiency of infrastructure and its services and how operations can be successfully restored after a disaster (Hsieh and Feng, 2020). In addition, these queues cause travel delays and lost production that are difficult to measure.

It is known that the type of land use can influence traffic demands and travel speeds on the roads, consequently the attractiveness of the destination (Wen et al., 2017). Furthermore, a study by Geng, Bao and Liang (2015) showed that traffic congestion, pollution, noise and higher crime rates negatively affect housing prices. And a survey carried out in Florence found that congestion in the central region has caused increasingly prominent activities to move to developing areas, which are now one of the most attractive parts of the entire settlement (Ma et al., 2018).

As for accessibility, it is worth mentioning that this is a fundamental concept in the analysis of transport and urban planning. Typically, accessibility refers to the "ease" of achieving activity and service opportunities and can be used to assess the performance of a transport and urban system (Chen et al., 2007). In their study, Chen et al. (2007) showed that network-based accessibility measures consider the consequence of one or more link failures in terms of network travel time or generalized increase in travel cost. Therefore, a traffic incident reduces the accessibility of the network on which it occurs.

### 3.2. Economic Scope

As for the economic impact, it is necessary to consider both, the loss of production due to congestion queues, the private cost involved in the incident and the public cost related to health and the cost of infrastructure. Specifically in Brazil, Lima (2003) and IPEA (2015) showed that the cost of accidents with victims is mainly linked to loss of production (42.8%) and damage to property (30%), as well as medical and hospital costs, which represent 15.9%. As can be seen, it is necessary to look at both direct and indirect costs to have a more accurate idea of the real cost of an incident. It is often difficult to calculate the actual cost of the incident as most of them are undervalued or are considered impossible to estimate, as they are costs of traffic-related externalities, they do not have a market value (Jakob et al., 2006).

The loss of production can be related both to illness and disability, as proposed by Wit and Methorst (2012), and to the delay generated, in the latter case it can be obtained by converting the lost time into displacements for the workforce (Motta, 1997). Kabit et al. (2014) emphasize that the cost of delay is a function of the occupant's time, vehicle operating expenses and external costs, such as air pollution. Therefore, efficient traffic management can have a positive impact on national economic growth, which imposes tremendous pressure and a great challenge on local traffic management agencies to provide their services more effectively and efficiently to mitigate the impacts of congestion due to recurring and non-recurring events.

In the private sphere, Wit and Methorst (2012) highlight the medical cost (hospital costs, for example) and the material cost (which includes property losses). The same study cites the intangible cost, such as suffering and pain, which is difficult to estimate. One more private cost to be highlighted is the increase in fuel consumption. Kabit et al. (2014) also states that the extra costs of vehicle operation (fuel consumption), as well as the emission costs, are directly affected by the resulting delay and by the reduction in the average speed of the affected road segments. In the public sphere, Wit and Methorst (2012) highlight the cost of the emergency service and the medical cost (which can be public or private), both linked to health. There is also the cost of infrastructure, due to the expense of rebuilding road infrastructure, such as signaling, lighting, among other. Several studies demonstrate how the delay generated by incidents is responsible for the increase in public costs.

Brent and Beland (2020) examined the relationship between traffic congestion and emergency response times. The results showed that traffic slows down fire trucks arriving at the scene of an emergency and increases the average monetary damage from fires, these effects are highly non-linear. Also dealing with incident response, Sánchez-Mangas et al. (2010) showed that medical response

time appears as a significant variable to explain the probability of death, the results suggest that a 10-minute reduction in response time may be statistically associated with an average decrease in the probability of death by one third.

### 3.3. Environmental Scope

Analyzing the environmental impact, incidents generate an increase in emissions of air pollutants (Thomas and Jacko, 2007; Islam, 2019) and GHG (Baltar et al., 2020b; 2021a), an increase in noise pollution (Riedel et al., 2017) and the depletion of natural resources due to increased consumption of fossil fuels (Corcoba et al., 2016).

Increases in pollutant emissions, which lead to poor air quality, affect public health as a result of respiratory diseases, and the transport sector, especially road, has a strong contribution to this problem (Baltar et al., 2020b; 2021a). To make this situation worse, studies show that the emission rates of air pollutants from vehicles that travel in construction sites or in incidents increase significantly (Avetisyan et al., 2014) and those emissions due to non-recurring congestion generated are higher when compared with the queues of recurrent congestion (Zhang, Batterman and Dion, 2011). Thomas and Jacko (2007), for example, proposed an approach to assess incident impacts on air pollution and the results indicate that the incident induces a 138% increase in carbon monoxide (CO) when compared to normal traffic conditions.

Studies also indicate that traffic incidents and the congestion they generate lead to the highest GHG emissions (Avetisyan et al., 2014; Barth, WU and Boriboonsomsin, 2015; Baltar et al., 2020b). These gases intensify global warming and, consequently, lead to climate change, whose climate threats such as intense precipitation and heat waves have a strong impact on urban infrastructure, including transport infrastructure, and on the population's quality of life (Santos, Ribeiro and De Abreu, 2020).

Another externality generated by traffic incidents is noise pollution. Many studies state that noise exposure is an important determinant in reducing the quality of life of the population in cities (Vijay et al., 2015; Riedel et al., 2017; Khan et al., 2018). Noise can be associated with nuisance, cardiovascular disease and impaired cognitive performance, among other negative impacts on human health (Basner et al., 2014).

Furthermore, traffic incidents (heavy traffic, adverse weather conditions and traffic accidents) cause an increase in the frequency and intensity of acceleration and deceleration. The result is a very significant increase in fuel consumption (Corcoba et al., 2016). Dia, Gondwe and Panwai (2006)

estimated that reducing the duration of a dual lane incident from 30 to 15 minutes resulted in 11.2% reductions in fuel consumption.

### 3.4. Summary of Results

Through the reflections carried out in Section 3.1, 3.2 and 3.3, it is possible to note that traffic incidents have significant impacts on sustainable development. Thus, in order to synthesize the results obtained through the literature review, Table 1 presents a compilation of the main impacts divided by scope, impacted category, impacted subcategory, description and type of impact (primary impact or secondary impact).

In addition to identifying the main impacts that traffic incidents have on sustainable development, thinking about a clean, resilient and sustainable city involves the creation of public policies through effective road management strategies to reduce them (ISLAM, 2019). Therefore, the next section will present actions to reduce the impacts generated by the incidents.

Table 1 - Impacts of Traffic Incidents

| Scope | Impacted Category | Impacted Subcategory | Description | Impact Type |
|---|---|---|---|---|
| **Social** | Quality of life | Physical Health | Increased number of deaths and injuries, including physical disability | Primary impact (Accidents) |
| | | | Increased Respiratory Diseases | Secondary Impact (Congestions) |
| | | Mental Health | Increased Traffic Stress | Secondary Impact (Congestions) |
| | | Travel time | Reduced travel time reliability | Secondary Impact (Congestions) |
| | Urban apparatus | Resilience | Reduction of urban resilience (ability to resist shocks) | Primary impact (Incidents in general) |
| | | Accessibility | Reduced ability to access goods and services | Secondary Impact (Congestions) |
| | | Attractiveness | Increased visual pollution and negative media advertising | Secondary Impact (Congestions) |
| **Economic** | Production | Loss of economic production | Reduction of economic production (city income and production of goods and services) | Secondary Impact (Congestions) |
| | Private cost | Cost of goods | Increased material losses (vehicles, vehicle components, etc.) | Primary impact (Incidents in general) |
| | | Health cost | Increased expenditure on private health (medical expenses) | Primary impact (Accidents) |
| | | Fuel cost | Increased fuel costs | Secondary Impact (Congestions) |
| | Public cost | Health cost | Increase in public health expenditure (expenditure on rescue teams and medical expenses) | Primary impact (Accidents) |
| | | Infrastructure cost | Increased expenses for the reconstruction of road infrastructure (vertical signage, lamppost, pavements, etc.) | Primary impact (Accidents) |
| **Environmental** | Climate change | GHG | Increased GHG emissions, which lead to Global Warming and, consequently, Climate Change | Secondary Impact (Congestions) |
| | Atmospheric Pollution | Air quality | Increased emission of atmospheric pollutants | Secondary Impact (Congestions) |
| | Noise Pollution | Noise | Increased urban noise | Secondary Impact (Congestions) |
| | Natural resource | Fuel | Reduction of fossil fuel reserves (depletion of natural resources) | Secondary Impact (Congestions) |

Source: Own Author (2021)

## 4. Logical Reasoning of Shares to be Used

Currently, it is noted that building new infrastructures is no longer viable when looking for a sustainable city, as this strategy encourages the use of private vehicles and increases vehicular emissions (Hofer, Jäger and Füllsack, 2018). Measures that reduce incidents number or that seek to reduce the total time of those that occurred are essential to reduce their social, environmental and economic impacts (Islam, 2019). It is noteworthy that strategies to prevent incidents are obviously preferable to strategies designed to respond to incidents. Furthermore, traffic organizations need to strike a balance between (economic) benefits and investment in a wide range of traffic management measures (Steenbruggen, Nijkamp and Van der Vlist, 2014).

To increase traffic safety and thus reduce incidents, drivers and pedestrians need to understand their social responsibility and public bodies need to promote and legislate strategies to achieve a higher level of road safety (Haque, Chin and Debnath, 2013). Corroborating this, Zhang, Yau and Chen (2013) states that to reduce traffic accidents incidence, for example, and mortality rates, measures such as traffic regulations and legislation are needed - targeting different types of vehicles and groups of drivers with respect to the various human, vehicular, and environmental risk factors. These measures can include road safety programs for target driver groups, focused enforcement of traffic regulations and improvements to transport facilities.

Therefore, Welle et al. (2018) indicate actions that can be implemented to create a safe mobility system on the roads, which are: (i) building compact and connected cities; (ii) design smarter roads; (iii) offer a variety of secure mobility options; (iv) keep speeds at safe levels; (v) enforce existing laws and regulations; (vi) better educate drivers and urban planners; (vii) require universal vehicle safety standards; and (viii) accelerate response to emergencies. Thus, efforts must be made, both at the governmental and individual levels, to reduce fatalities in traffic accidents, and for this it is necessary to implement traffic laws (Khurshid, 2021). An example of modifications that can be implemented, as proposed by Rossi et al. (2020), is the reduction in the speed on the roads. In their study, the study demonstrated that implementing speed limits of 30 km/h in a case study city brought health benefits, due to the reduction of traffic accidents, mortality resulting from them and exposure to noise (noise pollution).

In fact, if cities are well-planned, well-organized and consciously managed, a synergy can be created between institutions, citizens and professionals capable of improving the population's living and health conditions (Fehr et al., 2016). That is, the link between the morphological and functional characteristics of urban contexts and the impact of public health opens a new scenario in the urban

health theme, considering the phenomenon of urbanization that characterizes contemporary European societies and cities, but especially developing countries and emerging countries (Capolongo, 2020).

Another important point to reduce the incidents number is to understand the aspects that are associated with its increase. Therefore, studying broken down vehicles, for example, Chand et al. (2020) showed that the increase in population density, number of registered vehicles, number of holidays, average temperature, percentage of heavy vehicles and percentage of professionals' earners in a region increase in the number of occurrences of this type of incident. The study by Friedman et al. (2020) showed that the incidence of alcohol-related motor vehicle accidents attended at the study trauma center decreased after the introduction of ride-sharing services, showing that this can be one of the solutions for preventing this type of accident.

According to Barth, Wu and Boriboonsomsin (2015), energy efficiency (reduction of energy consumption) and the reduction of pollutant and GHG emissions have become essential arguments for investments in Intelligent Transportation System (ITS), among which is the incident management system, besides of course the main objectives of improving safety and reducing congestion. Thus, Chen, Ardila-Gomez and Frame (2017) indicates that, for cities in developing countries, the focus of these investments should be on basic infrastructure, including a coherent road network and basic traffic management measures. Therefore, investment in these systems constitutes an important strategy in order to reduce the negative externalities generated by the incidents. It is further noted that greater benefits can be achieved when a multitude of ecological ITS programs are put in place, as well as environmental impact assessments to be carried out (Barth, WU and Boriboonsomsin, 2015). So, traffic management policies are essential for sustainability, as they try to reduce the negative impact on traffic flow using existing infrastructure (Guerrieri and Mauro, 2016).

It should also be noted that a special focus can be given to vehicle technologies such as autonomous driving to reduce incidents. Autonomous vehicles (AV) have been considered the sustainable future for providing greater road safety, an efficient traffic flow and lower fuel consumption and, consequently, $CO_2$ emissions, thus improving urban mobility and therefore good-being of society (Burns, 2013; Le Vine, ZolfagharI and Polak, 2015). AV have the potential to significantly mitigate many of the errors that drivers routinely make (Fagnant and Kockelman, 2015; Anderson et al., 2016; Pereira et al., 2017) and thus, consequently, improve road safety. This is because they have better perception, decision making and execution (Kalra and Paddock, 2016).

Focusing on incidents that have already occurred, that is, acting on the occurrence and not on its prevention, it is observed that incidents affect the operational highway performance by increasing the length, volume, and density of the congestion queue (Islam, 2019). Traffic accidents are typically

the main contributors to non-recurring congestion, which constitutes approximately 60% of total freeway congestion (Skabardonis, Varaiya and Petty, 2003; Systematics, 2005). Furthermore, if the expressway emergency rescue is not properly implemented, it will not only bring all kinds of negative obstacles to people's lives but will also seriously affect people's asset security and stability of social order (Li; Pereira and Ben-Akiva, 2015).

Therefore, the early detection of an incident is essential to define a correct response strategy, which can significantly reduce travel delays, improve traffic safety and optimize real-time traffic control (Yuan and Cheu, 2003). As an example of ITS related to this, there are automatic incident detection (AID) systems, which are algorithms that detect their occurrence by processing data related to traffic parameters, such as traffic flow, average speed and occupancy rate (Chen, Cao and Ji, 2010). That is, they monitor unusual traffic conditions that may indicate an incident or process surveillance images, noting possible incidents and thus reducing detection time (U.S. Department of Transportation, 2021). Varotto et al. (2021) showed that AIDs together with other measures, such as the introduction of variable speed limits (VSLs), can make the road safer.

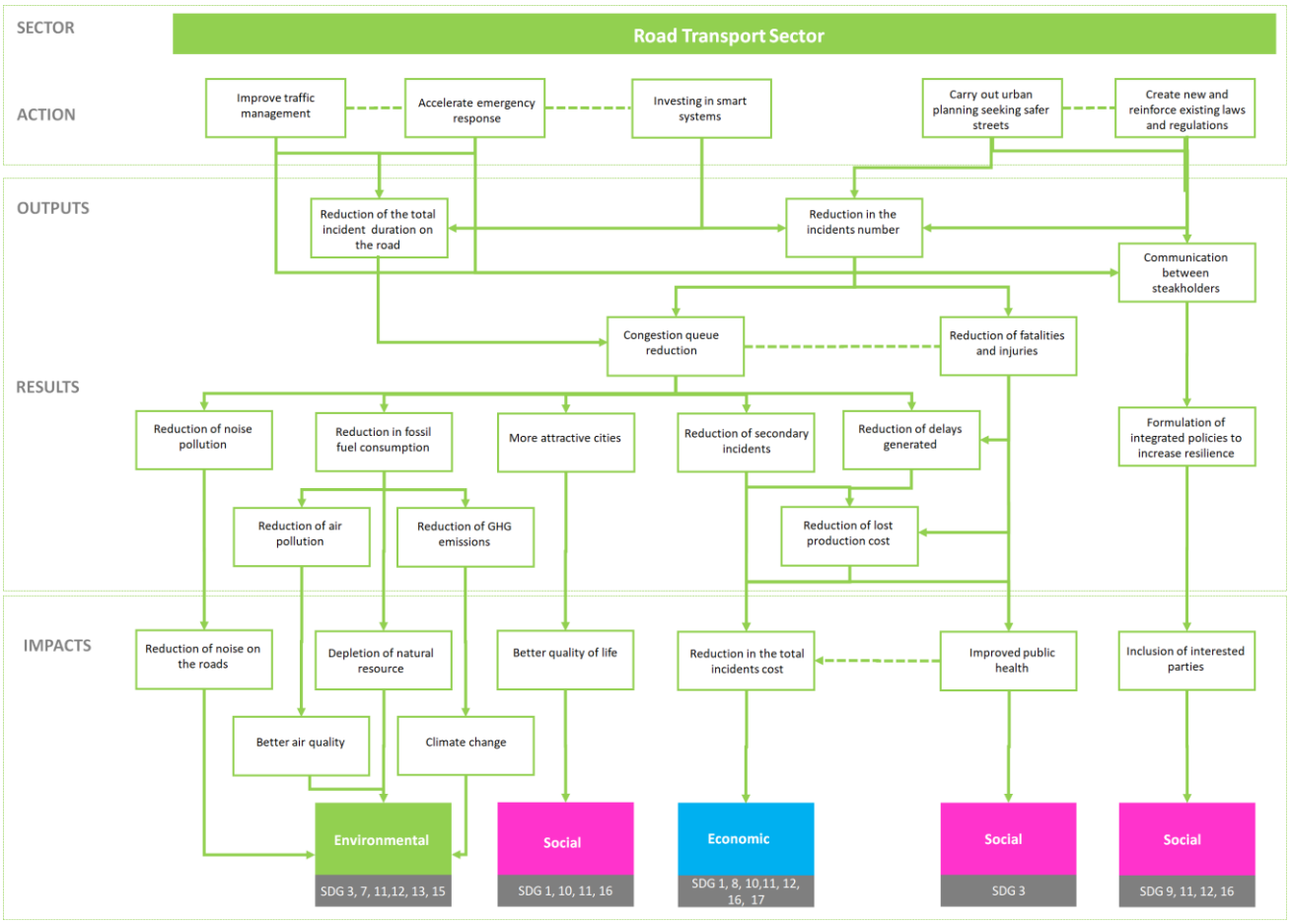
It is also noteworthy that incidents are attended to by service patrols or tow trucks, which aim to minimize the duration of the incident and increase security at the incident site (Salum et al, 2021). The repositioning of these service vehicles can be an important measure to reduce the total time of the incident, as studied by Geroliminis, Karlaftis and Skabardonis (2009), Ozbay et al. (2013), Zhu et al. (2014), Adler, Van Ommeren and Rietveld (2013) and Baltar et al. (2020a). Already dealing with drivers who are impacted due to the congestion queue generated by the incident, Basso (2021) demonstrated that variable message boards are effective, especially for diverting traffic during incidents on the highway or inducing speed reduction and showed that drivers of heavy vehicles and low mileage drivers are more likely to follow messages.

With all that has been exposed, it is noted that strategies can be adopted, both to minimize the occurrence of incidents and to obtain a faster response when they occur. Therefore, Figure 1 demonstrates a logical rationale for actions that can reduce the impact of traffic incidents. First, the actions are presented, then the outputs and expected results, then the impacts generated by the incidents that can be reduced by the actions taken and, finally, the SDGs of the 2030 Agenda for sustainable development that can be met with the actions indicated to reduce impacts.

It is worth mentioning that many actions, outputs, results and impacts shown in Figure 1 are interconnected and that more than one action can support the reduction of the same type of impact, as well as the same action can lead to improvements in the three spheres of sustainable development. It is also noted that the actions proposed through literature review seek to reduce the amount or duration

(response time) of traffic incidents; however, they all need to involve all the interesting parts in order for really effective solutions.

Figure 1- Logical Reasoning to Reduce the Impact of Incidents




Source: Own Author (2021)

The proposed actions are often correlated, as well as the results obtained from their joint implementation. Thus, Steenbruggen, Nijkamp and Van Der Vlist (2014) point out that traffic incident management, which constitutes an important tool to reduce and prevent congestion in the road network, involves the coordinated interactions of many public and private actors. Furthermore, Steenbruggen, Nijkamp and Van Der Vlist (2014) further state that informed decisions are a prerequisite for the formulation of successful mitigation, response, preparedness and recovery strategies.

An example brought by Iqbal et al. (2021) is that faster incidents detection provides timely information to passengers, generating better traffic management, in addition to helping other stakeholders (hospitals and rescue, police and insurance departments) in their respective responses. It

is also noteworthy that the accurate classification of these incidents in relation to type and severity helps interested parties to develop better plans for managing the incident site and preventing secondary incidents.

In addition, this more accurate information is important for policies that seek to reduce the number of occurrences. It is noted that governments need to ensure that comprehensive laws cover the main risk factors associated with incidents, considering that the main causes of deaths due to accidents are speeding, driving under the influence of alcohol or drugs and not using a safety belt (Steenbruggen, Nijkamp and Van Der Vlist, 2014).

## 5. Conclusions and Future Studies

This study aimed to present a general picture of the impacts of traffic incidents on sustainable development and to elaborate a logical structure of actions in order to minimize them based on a literature review. The results indicate that traffic incidents and, consequently, non-recurring traffic jams generated by them, have significant impacts on the three spheres of sustainable development, such as reduced quality of life for the urban population, problems related to the urban apparatus, loss of production, costs private and public, intensified environmental pollution and depletion of natural resources.

Thus, actions were sought that can be implemented by transport decision makers, more specifically those related to traffic incident management, to reduce the number of incidents or the duration of their impacts (improvement in the system's responsiveness) in the search for more sustainable cities. The proposed actions, based on the literature review, involve: (i) accelerating responses to emergencies; (ii) invest in ITS; (iii) develop strategies to improve traffic management (such as traffic redirection); (iv) carry out urban planning with a focus on safer roads; and (v) enforce existing laws and regulations, as well as develop new laws for that purpose. In addition, given the need for further studies on the subject, it is suggested to define indicators to assess the impacts raised with the objective of establishing the practical efficiency of the proposed actions, as well as improving the analysis related to the SDGs, considering the compliance with their targets.

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