The Environmental Risks Related to Visitors' Trips to Festivals: Transport Planning for Sustainability

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***Abstract*—It is scientifically demonstrated in the international literature that transportation systems planning interventions can have impacts on the environment, on the quality of life and on the social equity of a given area. Nowadays it is widely accepted that sustainability is made up of three different interacting components, i.e. the economic sustainability, the environmental sustainability and the social sustainability. Any policy to be adopted should not only respect the environment but also be socially acceptable. Events, such as concerts, festivals and other cultural events, are gaining an increasing interest in the international literature especially with respect to the identification of their impacts on the environment. In this manuscript, the emissions produced by visitors travelling to and from events have been analyzed. The case study is the city of Naples, in the South of Italy, where every year several festivals are organized on the Caracciolo promenade. During a festival in 2018, a mobility survey was carried out, interviewing 979 visitors and a modal choice model was then calibrated. Then, the estimated modal choice model was applied considering future hypothetical scenarios. Specifically, different policies concerning the supply of private/public transport services were hypothesized. The different scenarios were related to both long-term (i.e. the opening of a new metro line) and short-term (e.g. increase in parking fees or increase in the frequency of the metro line) interventions. For the different scenarios hypothesized, the effects on the environment and users' satisfaction were estimated. Comparing the results with the current scenario, results show how increasing car costs or travel times lead to a less use of this transport mode to reach the place where the festivals take place. However, this policy brings dissatisfaction from a great part of travelers. On the contrary, policies based on public transport bring an increase in users' satisfaction and therefore a less reduction of car use and consequently of environmental impacts.**

Keywords— events, transport planning, users satisfaction, environment, surplus, equity impact, modal choice model

I. Introduction

The World Commission on Environment and Development in 1987 defined “sustainable” a development that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. Sustainable development is aimed at improving the quality of life in the long term [2]. Sustainable management of natural resources should be accompanied by economic growth generating and supporting wealth and well-being, as well as social justice and equal opportunities [3]. Sustainability is made up of three fundamental components: economic sustainability, environmental sustainability and social sustainability [2].

These three aspects are interconnected with each other and, in a long-term perspective, none of the three can exist without the others. Any policy to be implemented should not only respect the environment but also be socially acceptable, fair and economically sustainable. Economic sustainability promotes the use of available resources in an efficient and responsible way [4]. Social sustainability refers to the ability to guarantee conditions of human well-being (safety, health, education, democracy, participation, justice) equally distributed by class and gender [4]. Environmental sustainability is the ability to maintain the quality and reproducibility of natural resources [4]. At the center of the political and scientific debate on sustainability is the transport sector: the daily travel of people and goods affects both the environment and the quality of life of people ([5], [6]). For this reason policies in the context of transport are increasingly tending towards sustainable mobility ([7]–[9]). The latter increases the quality of the urban areas reducing the negative externality (e.g. air pollution, greenhouse, gas emissions, road congestion and accident) produced by the private transport modes and increasing the users' satisfaction ([10], [11]). With the aim of reducing the negative impacts of cars [12], although there is more and more progress in clean automotive technology, in order to create a sustainable transport system it seems necessary to reduce the use of the car. For this reason, cities are becoming active in this direction especially in implementing measures encouraging more sustainable modes of transport such as active modes (walking, cycling), or using shared private means of transport ([13]–[15]).

Different travel demand management (TDM) measures are now proposed by transport planners. TDMs are strategies aimed at changing travel behavior in order to increase the efficiency of the transport system and achieve specific planning objectives [16]. Many factors influence people's transport decisions and TDM strategies work to encourage more efficient travel models by improving the available transport options, stimulating the change of travel mode, time or destination, improving accessibility to land use, leading to transport policy reforms [17]. The types of TDM measures that can be implemented are many ([17], [18]): physical changes such as the increase in attractiveness related to alternative travel modes and technical improvements that make cars more energy efficient; legal measures which include banning car traffic in city centers, reducing speed limits and introducing parking rules; economic measures [18] such as road pricing, fuel and car taxation and the reduction of costs for public transport; information and education measures which aim at changing people's perceptions, attitudes, beliefs, values and personal rules regarding the use of the car [18]. However, policies which reduce car use and increase car costs are environmentally but not socially sustainable as they are the cause of strong public opposition and poor political feasibility, therefore they are difficult to implement [18]. In 2013 Awasthi et al. [13] analyzed the various transport projects for sustainable mobility of the Luxembourg government. In their contribution, three urban mobility projects for the city of Luxembourg were analyzed through a multi-criteria analysis:

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(1) implementation of the new tramway in the city center, (2) the reorganization of the existing bus lines in the city to optimize the service and (3) the implementation of car sharing stations for electric vehicles in the city. Among the three alternatives, the implementation of car sharing service was the most environmentally, economically and socially sustainable. Another policy, analyzed by Pagliara [17], to reduce systematic trip related the work purpose, is the introduction of teleworking involving the reduction of the total vehicle traffic for more sustainable mobility. Teleworking can significantly reduce commuting trips for participating employees (10% of vehicle travel and 15% of vehicle mileage) [19].

The aim of this paper is to evaluate the impacts of the different mobility policies with respect to different aspects of sustainability for a specific case study, i.e. festival events on the promenade of the city of Naples (Italy). Only in 2018, 13 festivals took place, causing relevant environmental impacts and congestion problems.

The environmental impacts produced by events, such as concerts, festivals and other cultural initiatives, are gaining an increasing interest in the international literature especially with respect to the identification of their impacts on the environment ([20]–[23]). Regarding the sport events, within the UN Environmental Program (UNEP), there is the Global Forum for Sports and the Environment, which brings together stakeholders to review and evaluate the impact of sporting events on the environment. Furthermore, the sustainability measures planned for future sports events are proposed.

The measurement and monitoring of environmental effects of events can provide the public administration with information concerning how they might affect the health of visitors, travelling to reach events [24], as well as the residents living in the closer areas. Several are the contributions present in the international literature dealing with the environmental impacts of events. They have a negative impact on the local ecosystems by bringing pollution and waste into biologically diverse areas; they can release carbon emissions, they can contribute to the climate change and the high consumption of energy.

The quantification of these impacts can be carried out with a series of approaches ([23], [27]). However, some environmental impacts are directly measurable because related to visitors traveling (to and from events) and related by the freight transport [28]. Others, more hidden, can be calculated with the help of some techniques, like the ecological footprint analysis ([29]–[33]). With the aim to estimate the impact of the events on greenhouse effect, the computation of the carbon emissions is another relevant method. This approach has the main advantage of using one single measurement unit in terms of tons of carbon dioxide emissions produced by the activities and the global carbon dioxide emissions are included in a full ecological footprint analysis.

The environmental impacts related to visitors traveling (to and from events) are directly correlated to the events' size (the bigger is the event the higher are the environmental effects), to the number of daily visitors and to the relative transport mode chosen. Schmied et al. [34] highlighted the role of transport since it was responsible for approximately 90% of the greenhouse gas of all the large sporting events in Germany in 2005. Pagliara et al. [6] estimated that, for an Italian event where 74% of people use car or motorcycle to reach the festival area, the environmental impact is of 59 tons of CO_2 and 114 kg of PM_{10} pollutants by the single event.

For these reasons, local administrations proposed a series of initiatives relative to the Travel Management Plan ([35],[36]) which aimed at reducing the environmental impacts of events. Mobility policies obviously have an impact on users' mode choices, therefore on the environmental impacts that follow but also on the satisfaction of the trip [37].

The objective of this paper, starting from the results reached by [6], is to evaluate the environmental and social impacts of the different mobility policies proposed for the case study. Starting from the surveys conducted in 2018 [6], a mode choice model for festival visitors has been calibrated. Through the application of the mode choice model, the impacts on the environment and on users' satisfaction for the different mobility policies have been assessed. To evaluate the impacts on users' satisfaction the measure proposed by [37] has been implemented.

The structure of this manuscript is as follows. Section 2 deals with the case study; in section 3 the mode choice model estimated is described; while section 4 proposes the mode choice model specification in the future scenario. Finally conclusions and further perspectives are presented in section 5.

II. THE CASE STUDY

In southern Italy is the city of Naples which is the city with the highest population density in Italy with almost one million of inhabitants [38]. The city is located in the Gulf of Naples and is considered one of the most beautiful ones in Italy, given its location close to the sea and its landscape. To make the city more sustainable from a transport point of view, several initiatives have been undertaken since 2011, one of which consists in the traffic limitations in the historical part of the city and on the Caracciolo promenade (located in the city center, close to the sea) making the travel from one borough to another easier. At the same time, the neighboring areas are subject to an increase of pollution and emissions due to congestion.

Numerous festivals were organized after the closure of the Caracciolo promenade. Participation to the festivals was free, there was no entrance ticket to access the site. Only in 2018 thirteen events were organized on the Caracciolo promenade, which were attended by over 2,093,640 visitors during a total of 50 days.

Nowadays it is possible to access to the Caracciolo promenade (Fig.1) with: (i) the private car, but the availability of parking spaces is limited; (ii) the bus service, however, there are no dedicated lanes and this area is subject to heavy traffic; (iii) the Metro Line 2 via the Mergellina and Piazza Amedeo stations, where the nearest station is 2.5 km away. In the coming years there will be a change in the accessibility of the area. By the end of 2021 three new stations of Line 6 of the Naples metro will be inaugurated, called Chiaia, Arco Mirelli and San Pasquale. Today line 6 has four stations and is 3 km long. To ensure a modal exchange with the other Naples metro lines, the project will consider the addition of another 3 kilometers by 2022.

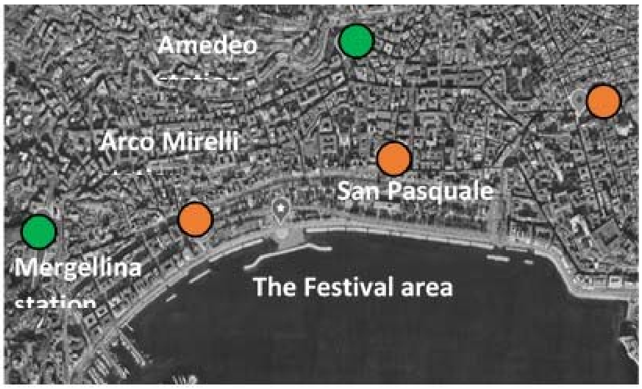

Fig. 1. Caracciolo promenade and the nearby stations. The yellow line indicates the street of the festivals, in green the stations of line 2 are reported and in orange the new stations of line 6 are highlighted. Source: Authors'elaborations

In 2018, during one of the most important festivals (the Buffalo mozzarella festival), a survey was conducted through a CAWI (Computer Assisted Web Interviewing) interview.

The survey was submitted to 979 visitors during the Buffalo mozzarella festival and it was divided into two parts: the first part consisted of an RP (Revealed Preference) survey in which the socio-economic and travel characteristics of the respondents were collected; the second part contained an SP (Stated Preference) exercise in which the interviewees' willingness to reach the festival was investigated using Line 6 in the hypothetical scenario in which the Chiaia station would be operating. The results showed that 74% used a private car to reach the festival site. In [6], the environmental impacts due to traffic on the Caracciolo seafront produced by the events were calculated using the COPERT software. The results showed that during the thirteen events organized on the Caracciolo promenade, 793 kg of PM10 and 408 tons of CO2 were emitted in one year.

III. THE MODE CHOICE MODEL

The mode choice model was calibrated starting from the results obtained from the mobility survey (described in the previous section and in [6]). The database from which the model parameters were calibrated (estimated) was composed of 979 real observations. Using the Geographic Information System (GIS) software, the travel times to reach the festival area (Caracciolo promenade) were estimated starting from the origins declared by the users for the various modes of transport. The mode choice model proposed in this paper has a binomial Logit specification, which is the simplest random utility model (for details see [39]). The assumption are those of the theory of random utility, i.e. based on the concept that the visitor is a rational decision maker. Each of them gives to alternative j of his choice set a perceived utility (U_{ij}) and chooses the alternative j of the maximum utility [39].

The perceived utility U_{ij} is estimated as the sum of the systematic utility V_{ij}, which represents the expected value (the mean) of the utilities perceived by all visitors, who have the same context of choice as visitor i (same alternatives and attributes), and a random residual ε_{ij}, which represents the deviation (unknown value) between the utility perceived by the visitor i from this value. The Binomial Logit model is based on the assumption that the random residuals ε_j are independently and identically distributed (i.i.d.) according to a Gumbel random variable (r.v.) of zero mean and parameter θ.

For this case study the choice set is limited to only two alternatives: private car and public transport (the fastest way between rail and bus). In the best model (compared to validation tests), the systematic utility V_i for the two choice alternatives is expressed by the following equation:

$$V_{CAR} = \beta_1 T_{-CAR} + \beta_2 COST_{-CAR} \quad (1)$$

$$V_{PT} = \beta_1 T_{board\text{-}PT} + \beta_2 COST_{-PT} + \beta_3 T_{Access\text{-}urban\ area} +$$

$$+ \beta_4 T_{Access\text{-}extra\text{-}urban\ area} + \beta_5 T_{waiting\text{-}PT} + ASA \quad (2)$$

where:

T_{-CAR} [h]: is the total travel time relating to car, which is calculated using GIS .

$COST_{-CAR}$ [€]: is the travel cost associated to car, which is obtained as the sum of the following costs:

- *i)* fuel cost: calculated as a function of the distance travelled for fuel average car cost per kilometer;
- *ii)* toll cost: information taken from the highway company website (www.autostrade.it/it/home);
- *iii)* parking cost: estimated as the average cost of parking in the study area for the average travel time to attend the festival (declared in the survey).

Furthermore, assuming that travelers shared travel costs, the sum of these costs was divided by the occupancy rate of the car.

$T_{board\text{-}PT}$ [h]: is the on board total travel time spent on public transport (bus or train);

$T_{waiting\text{-}PT}$ [h]: is the average waiting time of public transport lines to reach the festival;

$T_{Access\text{-}urban\ area}$ [h]: is the access/egress time to public transport services if both origin and destination are in an urban area;

$T_{Access\text{-}extra\text{-}urban\ area}$ [h]: is the access/egress time to public transport services if either origin or the destination is not in an urban area;

$COST_{-PT}$ [€]: is the public transport travel cost, calculated by referring to Unico Campania fares, taking into account the origin and the number of transfers made by each visitor. Unico Campania fares allow travellers to use all public transport modes with a single ticket.

ASA: is the aalternative sspecific aattribute or modal preference, it takes into account the qualitative characteristics or not explicitly included in the attributes of each mode of transport (e.g. Regularity of the service for metropolitan systems). The relative preference of each modality over a reference alternative can be considered.

Mode choice models simulate the fraction (probability) $p^i[m/od]$ of trips of visitors of category i using mode m among the k modes available (k is equal to 2 car Vs. public transport), from the origin zone o to the festival area (Caracciolo promenade- destination d) for trip purpose of leisure s during the period t in which the festivals take place. The model can be written as follows:

$$p^i[m/odst] = exp(V^i_{m/odst})/\Sigma_k\, exp(V^i_{k/odst}) \quad (3)$$

TABLE I. MODEL CALIBRATION

Parameter	*Car utility*	*Public transport utility*	*Model*
ASA *Std. Error / T-test*		x	0.2 *0.4/ 5.0*
β_3 ($T_{Access\text{-}urban\ area}$) *Std. Error / T-test*		x	-0.2 *0.1/-2.2*
β_4 ($T_{Access\text{-}extra\ urban\ area}$) *Std. Error / T-test*		x	-0.4 *0.1 /-2.3*
β_5 ($T_{waiting\text{-}PT}$) *Std. Error / T-test*		x	-1.9 *0.1 / -4.4*
β_1 ($T_{CAR/board\text{-}PT}$) *Std. Error / T-test*	x	x	-0.9 *0.4 / -3.6*
β_2 ($COST_{CAR/PT}$) *Std. Error / T-test*	x	x	-0.05 *0.4 / -4.5*
Adj. R-Squared			*0.62*

TABLE II. THE VALUE OF TIME

Vehicle types	*Value of Time (VOT) (€/hour for passenger)*
Value of on Board Time (β_1/ β_2)	18
Value of Waiting Time	38
Value of Access Time in urban area	3
Value of Access Time in extra urban area	8

To estimate the parameters of the model, using the BIOGEME software [40], the estimator of maximum likelihood was used. The results of the estimate are shown in Tables I and II . All the parameters are significant being the t-statistics greater than 1.96 and of the expected sign (Table I).

In Table II the value of time are reported. These results are in line with ([41]–[44]) for travel purpose. The cost and travel time parameters are both negative as they are disutility for visitors.

Applying the model to the current choices, it results that 78% of the users chose private transport in line with the results of the survey and estimated by Pagliara et al. [6].

IV. THE ENVIRONMENTAL IMPACT AND USER SATISFACTION IN FUTURE SCENARIO

Applying the mode choice model in the design scenarios, the environment and social impacts of different transport policies can be estimated and compared with the current scenario (the one observed). Different scenarios have been hypothesized. The study has been carried out assuming a rigid demand, which means that the number of people reaching festivals is independent on the policies undertaken and is equal to that of the current scenario. The effects of policies have been studied only with the modal choice (elastic model with respect to the modal choice).

For all the project scenarios, environmental and user satisfaction impacts have been estimated. The environmental impacts, according to [6], have been computed through the COPERT software.

To assess users' satisfaction, the variation the "consumer surplus" between the project scenario and the current scenario has been estimated. Since the adopted model is a Multinomial Logit one, the satisfaction variable can be expressed in a closed form as follows:

$$S(V) = \theta \ ln \ \Sigma_j \ exp(V_j / \theta) \tag{4}$$

where:

V and V_j are the systematic utilities estimated for each transport mode alternative j (car and public transport)

θ is the characteristic parameter of the LOGIT model

The first design scenario has been obtained assuming the new stations of Metro Line 6, Chiaia, San Pasquale and Arco Mirelli, being operational. Car travel time and cost remained unchanged as well as public transport fare. Public transport travel time has been computed as the shortest time path between the origins and destinations considering also the new metro line 6.

The results show that when the new subway line will be operational, 32% of the visitors will use public transport to reach the festival area.

TABLE III. THE IMPACTS IN THE DESIGN SCEARIO (CHIAIA STATION AND ARCO MIRELLI STATION OF METRO LINE 6 BEING OPERATIONAL)

Scenario	*Δp(car)*	*ΔS*	*ΔEmission*
Design scenario *(Line 6 being operational)* Vs. Current scenario	-32%	+83%	-31%

Source: Authors'elaborations

The Table III shows that, in this design scenario, the emissions caused by visitors' trips will decrease by 31% and the average user's satisfaction will increased by 83%, with respect to the current scenario. The higher satisfaction more than the pollution reduction seems to justify the costs needed to build a metro line. The opening of the metro line can be considered as a mid-long-term intervention since the station is expected to be opened in 2021 and the entire line will be completed in 2024. For this reason, some short-term mobility policies have been hypothesized.

Starting from the current scenario, the environmental impacts and users' satisfaction have been assessed for each design scenario.

The short-term interventions (scenarios) are: 1*)* increasing the cost of parking to € 10; *2) d*efining the whole area as a limited traffic zone (increasing the time to reach the Caracciolo promenade by 15 minutes); *3)* reducing the waiting time from 10 to 6 minutes; *4)* making the ticket for public transportation free for people going to festivals.

While actions 1, 2 and 4 should be implemented by the Public Administration, according with parking and public transport companies for 1 and 4, the intervention 3 can be directly implemented by the public transport company also without more financial resources but only optimizing the service as in [45]–[48].

As expected, the results of Tab. IV show the high acceptability of policies improving transport performance and, on the contrary, the people rejection of actions based on the increase of car travel cost and time. Specifically, while the actions based on travel costs reveal to be symmetric in satisfaction, a little reduction in public transport waiting time (4 minutes) has an advantage in satisfaction more than the disadvantage of 15 minutes of more car travel time. The similarity among changes in car choice probability and emissions is obvious since less cars produces less emissions and their differences are due to the kilometers run by the respondents. The improvement of public transport performances is more appreciated than the reduction of the ticket fare.

The best environmental scenario is the first one which considers an increase of car cost (parking) and dramatically reduces car use to reach the festival location. It should be considered that the car parks located near the Caracciolo promenade have an average rate of 4.5 €/h. Considering an average parking time of 4 hours (average value of the time spent in the event observed), the parking cost is about 18 €. Therefore, supposing an average parking price of 10 € per person can be considered an increase accepted by respondents.

Although it seems to be the best scenario also for public finances, gaining in car parking revenues and public transport ticket selling, it is also the less appreciated by the respondents. It is likely that this scenario will lead to a less number of visitors that is less emission but not more gain for public finances and for festival exhibitors.

It is interesting to note that the most shared policy of Tab. IV has a satisfaction that is half than the long term intervention in Tab. III. It can be argued that the most balanced short term policy is the one improving the public transport performance according to the long period intervention.

TABLE IV. THE IMPACTS OF DIFFERENT MOBILITY POLICIES

Mobility policies	*Δp(car)*	*ΔS*	*ΔEmission*
Parking cost increasing to 10 €	-40%	-39%	-39%
ZTL in the whole area (T_{car} + 15 min)	-19%	-33%	-17%
PT waiting time reduced to 6 min	-13%	+42%	-11%
Free public transport ticket	-5%	+38%	-3%

Source: Authors'elaborations

V. CONCLUSIONS

The environmental impact of festivals is a topic of great interest. In this study, the effects of festivals have been proposed and estimated from the point of view of environmental and social sustainability of a series of mobility policies aimed at reducing the use of the car and encouraging the use of public transport. For each of the hypothetical scenarios, the effects on the environment and users' satisfaction have been estimated. Comparing with the current scenario, results show how increasing car costs or travel times can lead to a less use of this transport mode to reach the festivals' place. However, this policy brings dissatisfaction from a large part of travellers. On the contrary, policies based on public transport bring an increase in users' satisfaction and therefore a less reduction of car use and consequently of environmental impacts.

The approach presented in this manuscript can be adapted to other case studies where festivals take place. Indeed, it will be interesting to provide a way forward to this topic which is not well presented in the current international literature. An interesting future development would be to analyze the different mobility policies from the point of view of social equity through the specification of synthetic indicators, such as the Gini Index.

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