Decision-making process for evaluating socio-economic impact of green transport policies in insular areas

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Abstract- Green transport policies, especially in insular areas, have to account for the unique characteristics and growth prospects with respect both to tourism development and travel behavior of residents. This paper evaluates the impact of green transport policies, moving one step further in research by rating the proposed policies in terms of their effectiveness in achieving a wide variety of economic, social, environmental, and other public policy goals (sustainability). Under this scope, the approach developed is based mainly on two decision methods that is the cost - benefit and multicriteria analysis, using data derived from stated preference surveys on residents and tourists as well as observations of actual choices. Thus, alternative policies are given qualitative ratings, and the weights derived from preference surveys on policy makers are applied to calculate a composite total score for each alternative. Based on this information, an advanced decision-making model for policy makers is developed for evaluating the socioeconomic impact of foreseen green transport policies in islands taking into account their unique characteristics.
Keywords – Cost Benefit Analysis, Multicriteria analysis, transport policy, socio-economic evaluation

I. INTRODUCTION

Transport researchers have to deal with complex multi-criteria decisions related to alignment alternatives, different transit mode-choice, and environmental impacts. Public transportation decision making is described as both a technical and political process [1]. These decisions may involve various stakeholders, such as officials, governmental agencies, and the general public [2], while relevant criteria can be mixed with tangibles and intangibles ones. Thus, both Cost Benefit Analysis (CBA) and Multi-criteria Analysis (MCA, Analytical Hierarchy Process/ AHP) have emerged as decision support and evaluation methodologies with wide-ranging applications.

Cost Benefit Analysis is a common tool to evaluate the impacts of transport investments in many countries [3], based on the monetization of costs and benefits related to a policy [4]. Within this context, factors that cannot be directly valued (such as time and environmental cost) are converted to monetary values through other methods, such as direct opportunity cost methods and the 'hedonic (substitute) prices' method [4,5]. All of the values used in the analysis are represented in monetary terms for a single point in time expressed as the Net Present Value (NPV) [6]. At last, CBA and its main output Cost-Benefit Ratio (CBR) compares trade-offs [4], where the unitary value of benefits from transport investments to society have to exceed the opportunity cost of using the same resources elsewhere, in order for the project to be feasible [6].

However, CBA is not often used when assessing improvement measures for the mobility of cyclists and pedestrians [3], as it is difficult to estimate important impacts, such as health benefits and insecurity [3, 7]. Thus, Cavill et al. [8] have conducted a review of economic analyses regarding cycling and walking taking into account health effects, where 13 cases adopted CBA for comparing walking and/or cycling infrastructure: [9-13]. The CBR ranges from -0.4 to 32.5, with a median of 5:1 [8]. Sælensminde [3] utilized a CBA to evaluate walking and cycling track networks in three Norwegian towns, taking into account the reduced insecurity and health benefits associated with improved NMT infrastructure. In the relevant study, the unit values of the benefits were derived from an extensive archive of governmental and academic studies related to the Norwegian context, and a sensitivity analysis was performed to gauge the boundaries of possibility for the return on these investments. Brown et al. [14], Chapman et al [15] conclude that when in case of active travel investments (cycling and walking), it is possible to have positive return on investment, especially when considering health and carbon emission reduction benefits.

However, CBA process is considered not to be the most appropriate process in evaluating transport infrastructure projects. Damart & Roy [16] suggest that CBA structure should also include conclusions derived from collaborative public debate by maintaining the rationality of the original decision-making process.

Regarding applications of MCA and in particular of AHP in transport plans, they are equally as prolific and diverse: stakeholder preference assessment in transportation planning [17], transit market priority analysis [18], transportation system improvement projects [19], and carrier selection [20]. AHP by providing a tool to help planners structure a complex, multifaceted decision-making process has been applied in combination with a geographic information system in transit-oriented development (TOD) and in defining the location of a freight terminal [21]. Thus, the contribution of the AHP in transport related planning is that may: i. rank decisions with multiple criteria or objectives; ii. use criteria that may be mixed (tangibles and intangibles) with no underlying scales; and iii. include preferences and priorities of multiple participants or "stakeholders" in the planning process through observation, reflection, communication, and negotiation. The choice of rating functions (discrete or continuous) is determined by the type of criteria, available data, as well as empirical studies [22-23] and AHP provides a multicriteria evaluation with a robust ratio scale method that is helpful in land-use transportation planning decisions with multiple and diverse criteria. The increasing popularity of AHP as a multicriteria evaluation methodology is attributed to its flexibility to deal with ambiguity of multi-objectives, with mixed tangible and intangible criteria or objectives (social, political, financial, functional), and group decision making [24].

Transportation project or prioritizing without modeling tools is typically based on heuristic methods, rules of thumb or decision-makers' personal experiences. These methods are common in current practice because they are easy to apply and do not require quantifiable data. However, as the number of alternative projects and the performance measures used to analyze each projects worth is increased, it becomes more difficult to make efficient decisions using these simple methods. In addition, most decision-making bodies spend a substantial amount of time trying to accommodate the needs and wishes of all parties when multiple decision-makers each have their own preferences.

In our paper, both CBA and AHP provide a plausible methodology for our case study. CBA is applied in order to compare the Business-as-usual (BAU) Scenario with three different scenarios of public transit planning (Scenario 2: Bike Lanes; Scenario 3: Pedestrianizations; Scenario 4: Park and Ride) with respect to economic parameters, and AHP is used to show how complex multilayered public transit planning and decision making is unified to account for local criteria, different participants, and diverse choice of corridor and route alternatives. Through the methodology applied, a combined decision – making process is presented for prioritizing different public transit plans, taking into account both quantifiable (including travel time savings, construction costs, reduction in air emissions and revenue generated) and qualitative measures, which are more difficult to measure, as are mainly answered with 'yes" or "no".

The rest of the paper is organized as follows. Methodology applied is explained in section II. Experimental results are presented in section III, while concluding remarks are given in section IV.

II. METHODOLOGY

In order to quantify and evaluate collected data, Cost-benefit analysis (CBA) and Analytical Hierarchical Process (AHP) with the use of Key Performance Indicators (KPIs) are used, aiming at figuring out which projects offer the best value for money, one of the core criteria for making decisions especially in public orientated projects.

2.1 Cost-Benefit Analysis (CBA)

Cost-Benefit Analysis (CBA) is an analytical tool for estimating the economic advantages or disadvantages of an investment decision by assessing its costs and benefits. It refers to a list of underlying concepts and in particular:

Opportunity cost, defined as the potential gain from the best alternative forgone, when a choice needs to be made between several mutually exclusive alternatives.

Long-term perspective, ranging from 10 to 30 years or even more. Under this scope, proper time horizon, future costs and benefits, discount rates and any related project's risks should be defined.

For transport projects the process from project identification towards scenario/ route selection and the final project implementation and evaluation of the project, is often lengthy and complex. Throughout this process CBA can provide useful information to decision-makers. This is illustrated in Figure 1 [25].

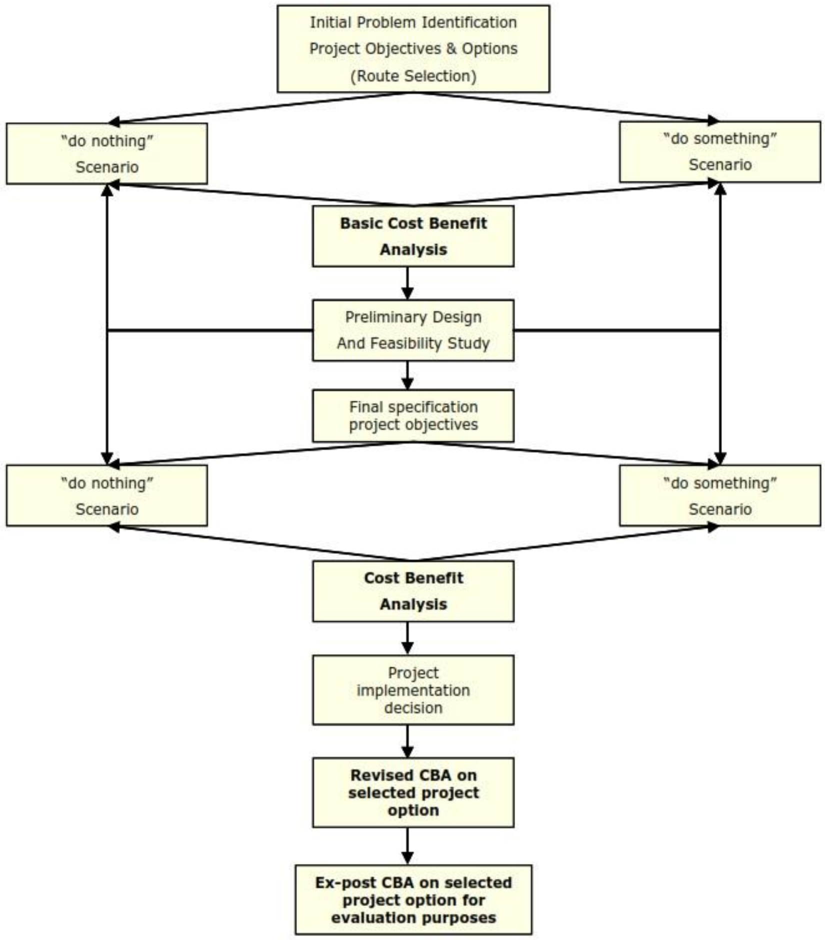

Figure 1 Role of CBA in decision making

In the project initiation phase CBA compares project alternatives and relevant options (route selection) and proceeds with the relative benefits of competing options. Default parameters for issues like traffic composition, average speeds and accident rates are used, while costs are estimated based on agreed unit costs. The next phase refers to a more detailed CBA, in order to define relevant results and different options to facilitate decision-making about the option that will be carried forward and implemented. For a limited number of routes more robust cost estimates will be available, based on the preliminary design as well as on an assessment of project impacts for the selected routes. An environmental impact assessment is also carried out for each of the alternative routes. CBA process steps are illustrated in Figure 2 [26].

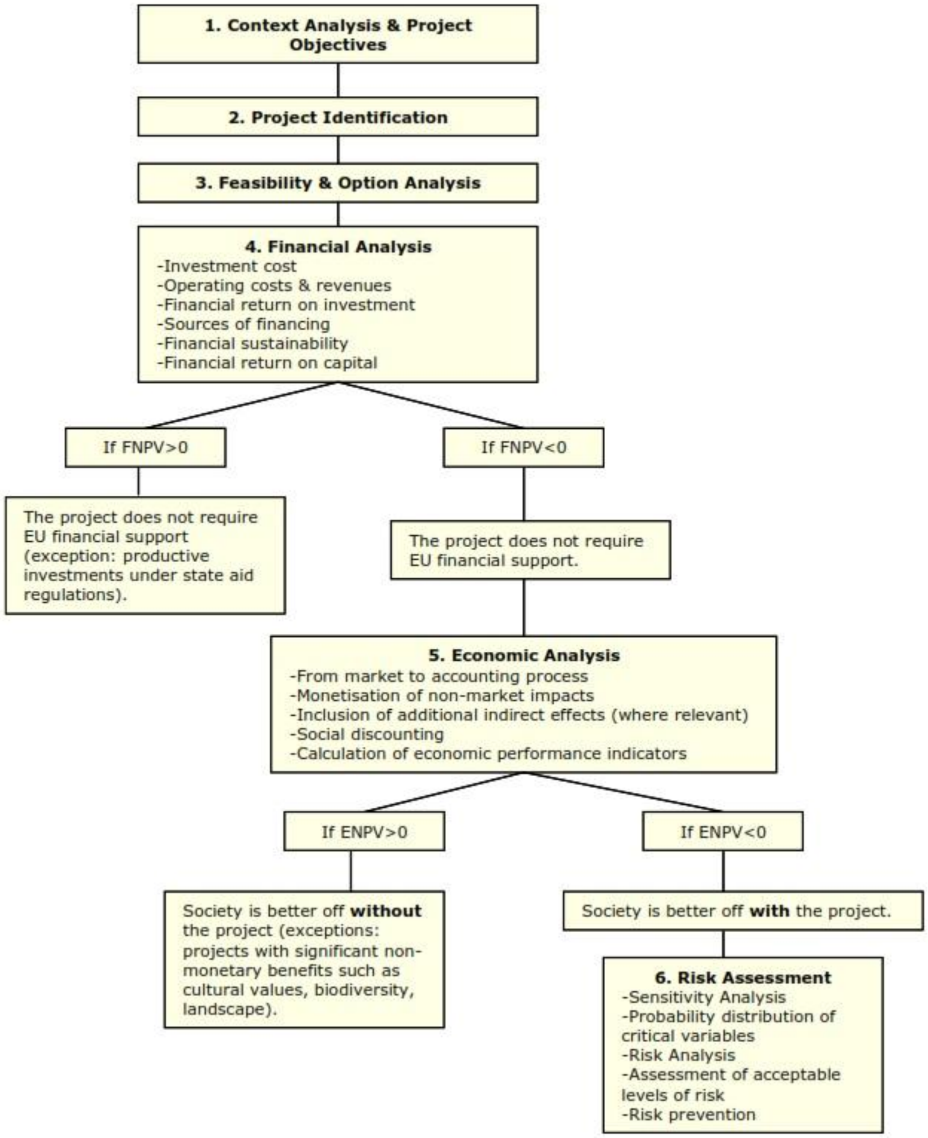

Figure 2 CBA process steps

2.2 Analytical Hierarchical Process

AHP, developed by Saaty [27], is used to determine the relative weights or importance of a given set of criteria in a decision-making problem, contributing to integrate judgments for qualitative and quantitative criteria combined. The AHP methodology includes four consecutive stages: i. development of decision elements; ii. Collection of personal preferences relative to the decision elements defined; iii. Development of relative priorities (weights) of the decision elements and iv. Analysis of relative priorities into general alternative solution priorities.

The first two stages are accomplished by employing the decider's participation whereas the rest are absolutely calculative ones. In any level of hierarchical structure, a comparison of dual pairs of the elements with respect to the preference rate of each one to another, relative to the next higher-level criterion, takes place. Thus, matrices of comparison pairs are developed. The relevant weights are determined as:

$AW = \lambda_{max} W$ (1)

where A stands for the matrix of the quantified dual comparisons, W stands for the matrix of the relative weights and, λ_{max} is the maximum real value of A.

$$C(1,k) = \prod_{i=2}^{k} B_i \tag{2}$$

The following equation gives relative weights of assorted levels into a combined weight:

where, C (1,k) is the combined weights of k –level elements, Bi stands for function vector, where ni matrix derives from vector W.
A decision matrix was created where each decision-maker was asked to compare each criterion against another (Pairwise comparison). The pair-wise comparison method rates each criterion relative to all other criteria within its ratings set. Subjective judgment or intuition is all that is needed to determine how one criterion compares to another. Pairwise comparison is essential when assigning weighted percentages to all criteria defined.

2.3 Key -performance indicators

A key performance indicator (KPI) evaluates the success of a particular activity in which it engages. In our case, success is simply the repeated, periodic achievement of some levels of operational goal (e.g. zero defects, 10/10 user satisfaction, etc.). Considering the KPIs basic principles (non-financial, simple, of significant impact), in our study, the KPIs studied and analyzed are the following:
KPI 1 – ACTIVE TRANSPORT SPLIT: The percentage of people traveling by walking or cycling. Some scenarios are dedicated to rising this number. (Counted on: Percentage of people)
KPI 2 – MOTORIZED TRANSPORT SPLIT: The percentage of people travelling by motorcycle or car. (Counted on: Percentage of people)
KPI 3 – PASSENGER KILOMETERS: Measure of traffic. Calculated by multiplying the number of persons in the network with the total distance travelled. (Counted on: Passenger * Kilometers)
KPI 4 – VEHICLE KILOMETERS: Measure of traffic. Calculated by multiplying the number of vehicles in the network with the total distance travelled. (Counted on: Vehicles * Kilometers)
KPI 5 – MEAN TRIP DURATION: The average duration of a trip made in the network. Calculated by dividing the duration of all trips by the number of trips. (Counted on: Minutes)
KPI 6 – MEAN TRIP DISTANCE: The average distance of a trip made in the network. Calculated by dividing the distance of all trips by the number of trips. (Counted on: Kilometers)
KPI 7 – SHIFT TO ACTIVE: The real number of people choosing to commute by bicycle or walking in the new scenario being evaluated compared to the basic scenario. (Counted on: Number of people)
KPI 8 – SHIFT TO MOTORIZED: The real number of people choosing to commute by car or motorcycle in the new scenario being evaluated compared to the basic scenario. (Counted on: Number of people)
KPI 9 – OVERALL TRIPS CHANGE: The difference between trips made on the scenario under review as opposed to the basic scenario (Counted on: Number of trips)
KPI 10 – 16 HOURLY COUNT IN LINKS: The amount of total traffic per hour in various links of the network. (Counted on: Passenger Car Units (PCUs))
KPI 17 – ACCIDENTS PER MODE: Total accidents on the scenario, calculated with external data (Counted on: Number of accidents)
KPI 18 – COST: Total cost of the scenario under review. (Counted on: Euros)
KPI 19 – EMISSIONS

III. EXPERIMENT AND RESULT

Within this paper, four different scenarios of public transit plans are compared, where relevant data were gathered based on a survey taken place in Chios Island (a small Greek island). Data collection included network and land use data that characterize living and traveling environments, surveys for residents and tourists, and atmospheric pollution data. Based on this information we apply both the CBA and the AHP for 4 different scenarios to analyze and evaluate the impact of green transport policies.
Thus, apart from the Business as Usual Scenario, which means that no actions are undertaken, the different scenarios examined are the 2nd Scenario of developing bike lanes, the 3rd Scenario of pedestrianization, and finally the 4th scenario refers to the creation of Park & ride stations. Table 1 presents the scenarios chosen, as well as the appropriate usage of CBA based on generated revenue or not.

Table - 1 Scenarios Description

Scenarios	Scenarios Description	Revenue Generating	CBA Type
Scenario 1 - BAU (Business As Usual)	To do nothing	No	Social CBA
Scenario 2 – Bike lanes	Bike lane connection from Karfas/Kampos to Vrontados through the City of Chios and various alternates.	No	Social CBA
Scenario 3 – Pedestrianization	Analyze and propose a way to manage traffic flows at the times of ship arrival (bypass road/opening of port road for motorized vehicle for some hours/port move to other place) with the creation or widening pedestrians.	No	Social CBA
Scenario 4 – Park and Ride	Creation of Park & Ride stations (Driverless minibuses or Golf cars or Bike Sharing System).	Yes	Both CBA &
		No	Social CBA

The relevant benefits are disaggregated by region or economic group. Credible forecasts of future demand are based on an analysis of the relevant socio-economic variables that will drive demand for each different scenario. As demand analysis plays a crucial role in many different aspects of each scenario appraisal process, the analysis highlights throughout a CBA appraisal where demand forecasts significantly impact the outcomes of the project.
In our case, all KPIs are quantified. Thus, the KPI of Overall Trip is measured as the same to all 4 Scenarios. That confronts us to calculate and create another rate, the rate of Passengers/Km. This rate is presented below in Table 2 and takes into account the estimation results about the fluctuation of vehicles, GDP, population etc.

Table – 2 Rate of Passengers/Km

Scenarios	Passengers/km (count in 1000)
Scenario 1 - BAU (Business As Usual)	1,233,166.9
Scenario 2 – Bike lanes	1,706,967.2
Scenario 3 – Pedestrianization	1,324,974.6
Scenario 4 – Park and Ride	1,479,498.2

Based on scenarios that have been aforementioned in Table 1, financial analysis is evaluated only to scenario 4 were a revenue can be generated. In the rest three scenarios including BAU no revenue is expected thus a social CBA is used. From this two-way CBA analysis of Social CBA and simple CBA a predominant scenario is selected, as follows.
More specifically, the benefits of BAU Scenario are:
Comfort with € 0.20 per vehicle-kilometers (user benefits) / 28570 vehicle-kilometers
Travel time with € 6 per hour / 4417 hours
The relevant costs are separated as follows:
Operating Costs with 1.18 € per km/ 28570 kilometers
Accidents with 0.22 € per km/ 28570 kilometers
Air pollution/ Climate changes/ Noise with (0.03 € + 0.04 € + 0.36 €) = 0.43 € per kilometer / 28570 kilometers
Road Deterioration with 0.01 € per kilometer / 28570 kilometers
Traffic Congestion with 0.46 € per kilometer / 28570 kilometers
Maintenance Cost with 0.6 € per kilometer / 28570 kilometers
The following Figure presents the financial performance of BAU Scenario based on Cost Benefit Analysis and presents a projection of Present Value of Benefits, the Present Value of Costs and the Cumulative Net Present Value (m. euros).

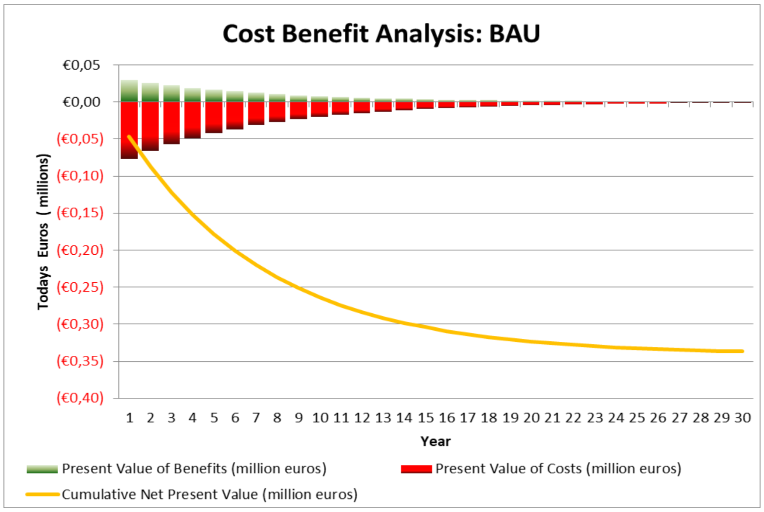

Figure 3 CBA BAU Scenario

The Benefits for the Bike Lanes scenario are: i. Reduced insecurity/ Comfort with € 0.20 per cycle-kilometers (user benefits) / 39547 cycle-kilometers, ii. Public health benefits with € 2.35 per cycle hour / 9603.77 cycle hours, iii. Reduction of external costs for motorized transport is € 0.05 per vehicle-kilometers (reduced car traffic)/ 11% reduction: 3142.7, iv. Travel Time accounts for € 4.7 per cycle hour/ 9603.77 cycle hours, v. Decongestion value equals to € 0.19 per vehicle-kilometers (reduced car traffic)/ 11% reduction: 3142.7 and vi. Reduced parking costs are estimated at € 0.03 per vehicle-kilometers (reduced car traffic)/ 11% reduction: 3142.7. The relevant costs of Scenario 2 are: i. Maintenance Cost accounts for 0.03 € per cycle-kilometer / 39547 cycle-kilometers, ii. Security/ Insurance Cost equals to 0.02 € per cycle-kilometer / 39547 cycle-kilometers, iii. Delay is € 0.02 per minute (road crossing) / 576226 minutes and iv. Injury Costs are estimated to be 0.71 € per cycle-kilometer / 39547 cycle-kilometers.

The following figure presents the projected Present Value of Benefits, the Present Value of Costs and the Cumulative Net Present Value of the scenario 2 based on Cost Benefit Analysis.

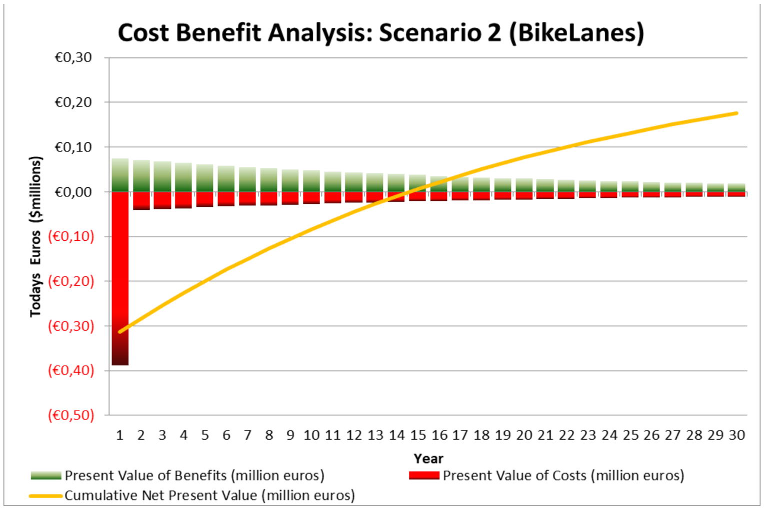

Figure 4 CBA Scenario 2

The Benefits and the costs for the Pedestrianizations scenario (Scenario 3), as well as the projected Present Value of Benefits, the Present Value of Costs and the Cumulative Net Present Value are presented in the following table and figure respectively.

Table – 3 Benefits and costs of Scenario 3

Benefit 1 Reduced insecurity	€ 0.15 per km (user benefits)/ Ped kms: 30697	Cost 1 Maintenance Cost	€ 0.2 per km / Pedkms: 30697

Benefit 2 Public health benefits	€ 4.8 per walk hour / 4819.86 walk hours	Cost 2 Security/ Insurance Cost	€ 0.1 per km / Pedkms: 30697
Benefit 3 Reduction of external costs for motorised transport	€ 0.05 pervkm (reduced car traffic)/ 7% reduction: 1999.9	Cost 3 Delay	€ 0.02 per minute (road crossing) / 289192.2 minutes
Benefit 4 Travel time	€ 2 per walk hour / 4819,86 walk hours	Cost 4 Injury Costs	€ 0.3 per km / Pedkms: 30697
Benefit 5 Reduced parking costs	€ 0.03 pervkm (reduced car traffic)/ 7% reduction: 1999.9		
Benefit 6 Decongestion value	€ 0.19 pervkm (reduced car traffic)/ 7% reduction: 1999.9		
Benefit 7 Benefits of walking schemes	€ 0.05 per km (user benefits)/ Ped kms: 30697		

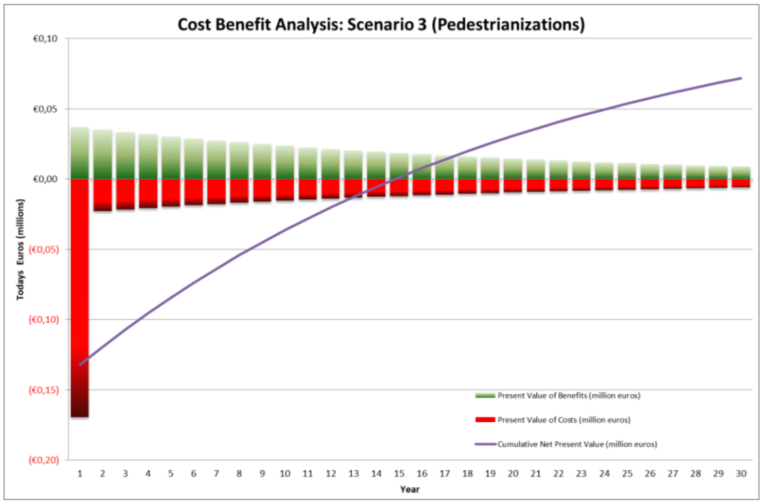

Figure 5 CBA Scenario 3

Finally, the Benefits for the Park and ride scenario (Scenario 4) are summarized as follows:
Reduced insecurity/ Comfort with € 0.20 per cycle-kilometers (user benefits) / cycle-kilometers: 34277
Public health benefits with € 2.35 per cycle hour / 8632.6 cycle hours
Reduction of external costs for motorized transport with € 0.05 per vehicle-kilometers (reduced car traffic)/ 6% reduction: 1714.2
Travel Time with € 4.7 per cycle hour/ 8632.6 cycle hours
Reduced parking costs with € 0.03 per vehicle-kilometers (reduced car traffic)/ 6% reduction: 1714.2
Revenues for renting / parking with 40 bikes on average/day/2.5 € & 350 parking on average/ day/3 €
Revenues for using buses with 800 passengers (alle retour) on average/day/1 €
Decongestion value with € 0.19 per vehicle-kilometers (reduced car traffic)/ 6% reduction: 1714.2
The relevant Costs of Scenario 4 are: i. Maintenance Cost accounts for 0.03 € per cycle-kilometer / 34277 cycle-kilometers, Security/ Insurance Cost equals to 0.02 € per cycle-kilometer / 34277 cycle-kilometers, iii. Delay is € 0.02 per minute (road crossing) / 517956 minutes, iv. Injury Costs are estimated for 0.71 € per cycle-kilometer / 34277 cycle-kilometers and Operating parking cost is estimated as 50% of revenues.
As for the last scenario, the projected Present Value of Benefits, the Present Value of Costs and the Cumulative Net Present Value are presented in Figure 6.

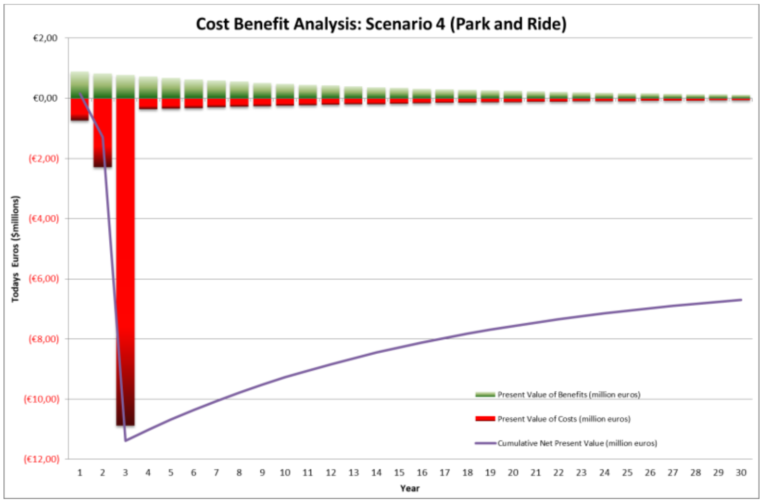

Figure 6 CBA Scenario 3

In the following Table, the main results of the economic analysis, as well as the main assumptions for all Scenarios are presented. The relevant data are used as input data for the further Analytical Hierarchy Process Analysis.

Table 4 - Summary results of Economic Analysis (4 scenarios)

Main results/ assumptions	BAU	Scenario 2	Scenario 3	Scenario 4
Capital Costs	-	346,500.00 €	145,500.00 €	14,350,000.00 €
Whole of Life Costs	2,485,590.00 €	1,645,767.54 €	871,561.32 €	29,934,614.20 €
Present Value of Benefits	214,334.54 €	1,204,474.65 €	621,488.99 €	13,759,281.50 €
Present Value of Costs	551,224.85 €	1,028,705.32 €	526,732.41 €	19,330,212.75 €
Benefit Cost Ratio	0.39	1.17	1.18	0.71
Net Present Value	-336,890.31 €	175,769.33 €	94,756.58 €	-5,570,931.25 €
Key Assumptions				
Public Sector Discount Rate	5%	5%	5%	5%
Appraisal period (years)	30 years	30 years	30 years	30 years

Apart from the aforementioned data, different scenarios weights were estimated based on specific questionnaires gathered from stakeholders. Thus, each scenario is weighted and evaluated through this process from 0-10, where 0 equals to null and 10 is the High score with respect to Environmental impact, Social and Economic impact, Sustainability and finally the Overall impact. By considering those scores, the following table is developed that is consisted by a Multi-criteria AHP Analysis with all the four weighted Scenarios based on the three aforementioned impacts and a final Weighted Score.

Table 4- Multi-Criteria Analysis - Scenarios weights

Criteria	Criteria Weight	Option 1: Scenario 2 (Bike Lanes)		Option 2: Scenario 2 (Park and Ride)		Option 2: Scenario 2 (Park and Ride)		Option 4: BAU	
		Score (out of 10)	Weighted Score	Score (out of 10)	Weighted Score	Score (out of 10)	Weighted Score	Score (out of 10)	Weighted Score
Environmental impact	33.1%	6.00	1.98	3.82	1.26	3.21	1.06	0.00	
Social/ Economic	36.5%	0.76	0.28	0.40	0.14	10.00	3.65	0.32	0.12

impact									
Sustainability	30.5%	0.50	0.15	0.50	0.15	0.43	0.13	0.50	0.15
Overall	100.0%	7.2677	2.4	4.7164	1.6	13.636	4.8	0.815	0.3

The experimental AHP methodology application design as concerning an early evaluation of the four scenarios is shown in the following tree-view:
Environmental Impact (L:0.330)
Emissions (L:0.310)
Emissions/ Passenger * km (L:0.357)
Emissions/ Vehicles*km (L:0.333)
Social Economic Impact (L:0.365)
Accident per mode (L:0.309)
Mean Trip Duration (L:0.309)
Cost (L:0.306)
Sustainability
Active transport split (L:0.538)
Motorized transport split (L:0.462)
The following Figures provide a general aspect of the scenarios ranking procedure, since it combines a depiction of their classification not only by each criterion individually, but also by all criteria simultaneously.

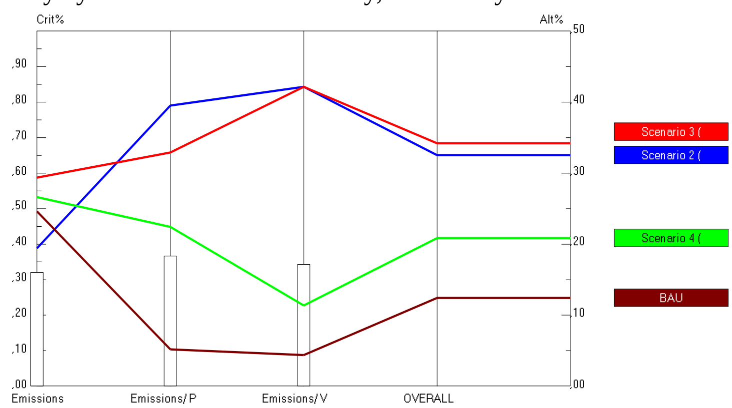

Figure 7 Best Green Transport Scenarios with respect to Environmental Impact

Comparing the four scenarios with respect to their environmental impact scenario 3 gets the higher ranking overall, as well as with respect to the sub-criteria of emissions and sustainability.
The results for the scenarios ranking based on the multi-criteria analysis of the other two criteria and their sub criteria are presented to Figures 8 and 9 respectively, where Scenario 2 (Bike Lanes) gets the best ranking.

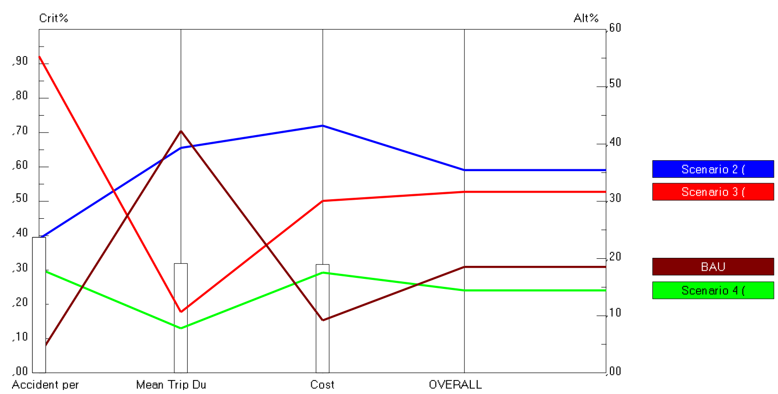

Figure 8 Best Green Transport Scenarios with respect to Social/ Economic Impact

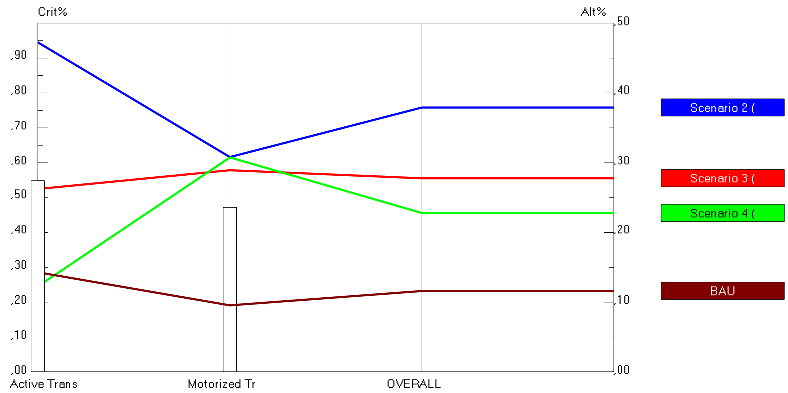

Figure 9 Best Green Transport Scenarios with respect to sustainability

The final ranking of the predefined scenarios is actually drawn into completion by inputting the whole group of characteristics in comparison. The AHP application aimed at ranking specific scenarios by their impacts in certain evaluation criteria related to the environmental, social criteria, as well as sustainability. As per our observations, the final ranking (Figure 10) proves that Scenario 2 gets the best ranking overall.

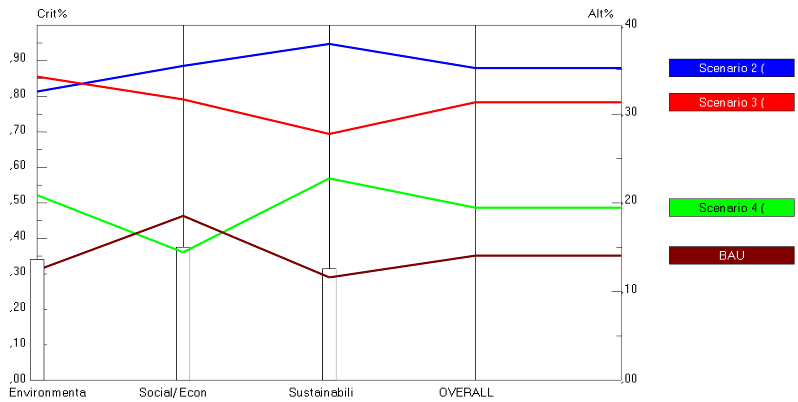

Figure 10 Final ranking for Best Green Transport Scenarios

Considering that investment decision process takes place under conditions of uncertainty, we also conduct sensitivity analysis, by ascertaining the impact of a defined change in our results. Under this scope, we estimate the impact that any change in cost of equity on the discounting factor may have on the scenarios CBA. In case the discount rate raises from 5% to 9.4% benefits are equal to costs for Scenario 2, whereas in all other cases B/C rate is less than 1 and the relevant NPV is negative, meaning that none of the scenarios selected is sustainable and has positive impact to local society (Table 5).

Table 5- Sensitivity analysis: Growth of discount rate

	Scenario 2 (BikeLanes)	Scenario 3 (Pedestrianizations)	Scenario 4 (Park and Ride)	BAU
Appraisal period (years)	30	30	30	30
Capital Costs	€ 346,500.00	€ 145,500.00	€ 14,350,000.00	€ -
Whole of Life Costs	€ 1,645,767.54	€ 871,561.32	€ 28,189,914.20	€ 2,485,590.00
Cost-benefit analysis of monetary costs and benefits at the Public Sector Discount Rate				
Present Value of Benefits	€ 793,371.80	€ 394,363.92	€ 9,607,139.82	€ 214,334.54
Present Value of Costs	€ 795,859.78	€ 396,612.83	€ 16,952,232.92	€ 551,224.85
Benefit Cost Ratio	1.00	0.99	0.57	0.39

Net Present Value	-€ 2,487.98	-€ 2,248.92	-€ 7,345,093.10	-€ 336,890.31

In addition, in case the investment cost refers to the simple investment scenarios, this affects the CBA results positively. In this case, the Scenario 3 according to CBA results gets the best ranking, as BCR equals to 0.39, 1.49, 1.54, and 0.64 and for BAU Scenario and Scenarios 2, 3 and 4 respectively.

Considering the aforementioned, important aspects that may affect the CBA results in a positive and or negative results are the initial investment cost, as well as the relevant discount factor. Any increase in discount factor negatively affects the B/C Ratio and the Net Present Value results, whereas decrease of the relevant investment cost positively affects both B/C Ratio and NPS results. In addition, any change in the cost also affects CBA results: increase in operational costs worsens the relevant results. Since our analysis is mainly based on social cost / benefits estimation, sensitivity analysis based on scenarios' financial aspects is not suggested, as only Scenario 4 presents high operational costs. Other scenarios only include maintenance & security costs, while no revenues are assumed.

To conclude with, walking and cycling are vital in an efficient and equitable transport system, since they provide basic mobility, access to other transport modes, as well as a lot of social benefits such as physical fitness, enjoyment etc. Thus, any scenario that aims at improving transport conditions by including walking and/ or cycling facilities benefits society overall as it is obviously shown through the Cost Benefit Analysis and Multi-criteria Analysis. The evaluation results show that the relevant impacts, especially for Scenario 2 (Bike Lanes), are considered to be the most effective ones in order to solve the particular problem set by the project (green transport in island areas). They also provide multiple and synergistic benefits. Thus, when all impacts of Scenario 2 are considered, the local community can justify much more support for cycling.

IV. CONCLUSION

Based on the aforementioned analysis, a decision on which alternative scenario should be classified first, may differ from the one derived based on financial data, when including socioeconomic data in the analysis. This is mainly achieved through adopting multicriteria analysis methodology.

In our case study, CBA and AHP provide a plausible methodology. CBA is applied in order to compare the Business-as-usual (BAU) Scenario with three different scenarios of public transit planning (Scenario 2: Bike Lanes; Scenario 3: Pedestrianizations; Scenario 4: Park and Ride) with respect to economic parameters, and AHP is used to show how complex multilayered public transit planning and decision making is unified to account for local criteria, different participants, and diverse choice of corridor and route alternatives.

Overall, this paper, through the methodology applied, presents a combined decision – making process for prioritizing different public transit plans, taking into account both quantifiable (including travel time savings, construction costs, reduction in air emissions and revenue generated) and qualitative measures, which are more difficult to measure, as are mainly answered with 'yes" or "no". This becomes more important when evaluating projects dealing with passenger transport schemes, as in the presence of externalities, the relevant interest extends beyond the typical financial evaluation of Internal Rate of Return (IRR) and Net Present Value (NPV).

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VI. REFERENCES

[1] M. Wachs, "Management Vs. Political Perspectives on Transit Policymaking", Journal of Planning Education and Research, vol. 4 (3), pp.139-147, 1985.
[2] M. Meyer, E. .Miller, "Urban Transportation Planning: A Decision-oriented Approach", McGraw-Hill, pp 1-642, 2010
[3] K. Sælensminde, "Cost-benefit analyses of walking and cycling track networks taking into account insecurity, health effects and external costs of motorized traffic", Transportation Research Part A: Policy and Practice, vol. 38 (8), pp. 593-606, 2004.
[4] P. Beria, M. Maltese, M. Mariotti, "Multicriteria versus Cost Benefit Analysis: A comparative perspective in the assessment of sustainable mobility", European Transport Research Review, vol. 4(3), pp.137-152, 2012.
[5] B. Wee, "Transport and Ethics: Ethics and the Evaluation of Transport Poli", Edward Elgar Pub, 2011
[6] N. Thomopoulos, S Grant-Muller, MR.Tight, "Incorporating equity considerations in transport infrastructure evaluation: Current practice and a proposed methodology", Eval Program Plann, vol. 32(4), pp. 351-9, 2009.
[7] S. Gössling, A. Choi, "Transport transitions in Copenhagen: Comparing the cost of cars and bicycles", Ecological Economics, vol 113, pp. 106-113, 2015.
[8] N. Cavill1, S. Kahlmeier, H. Rutter, F. Racioppi, P. Oja, "Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: a systematic review", Review of transport economic analyses including health effects related to cycling and walking, Transport Policy, vol. 15, pp.291–304, 2008.
[9] H. Rutter, Mortality benefits of cycling in London. Transport for London, 2006
[10] T. Krag, "Cycling, safety and health", ETSC yearbook 2005 Safety and Sustainability, pp. 50-63, 2005.

[11] G. Lind, C. Hydén, U. Persson, “Benefits and costs of bicycle infrastructure in Sweden”, Nordic Council of Ministers, CBA of Cycling: Nordic Council of Ministers’ seminar. Nordic Council of Ministers: Copenhagen, 2005.
[12] R. Saari, H. Metsäranta, J. Tervonen, “Finnish guidelines for the assessment of walking and cycling projects. From Nordic Council of Ministers. CBA of Cycling: Copenhagen 2005
[13] H. Foltýnová, M. Kohlová, “Cost-Benefit Analysis of Cycling Infrastructure: A Case Study of Pilsen”, Charles University Environment Centre, pp. 1-8, 2002
[14] V. Brown, B.Z. Diomedi, M. Moodie, J.L. Veerman, R. Carter , “A Systematic Review of Economic Analyses of Active Transport Interventions That Include Physical Activity Benefits”, Transport Policy, vol. 45, pp. 190–208, 2016.
[15] R. Chapman, M. Keall, P. Howden-Chapman, M. Grams, K. Witten, E. Randal, A. Woodward, “A Cost Benefit Analysis of an Active Travel Intervention with Health and Carbon Emission Reduction Benefits”, Int J Environ Res Public Health, vol. 15(5), pp. 962, 2018.
[16] S. Damart, B. Roy, “The uses of cost-benefit analysis in public transportation decision-making in France”, Transport Policy, vol. 16(4), pp. 200-212, 2009.
[17] J. Levine, J. Grengs, S. Qingyun, S. Qing, “Does Accessibility Require Density or Speed?”, Journal of the American Planning Association, vol 78(2), pp. 157-172, 2012.
[18] S. Khasnabis, B.B. Chaudhry, "Prioritizing transit markets using Analytic Hierarchy Process", Journal of transportation engineering, vol. 120(1), pp. 74-93, 1994.
[19] M. T. Tabucanon, H. Lee, “Multiple criteria evaluation of transportation system improvement projects: The case of korea”, Journal of Advanced Transportation, vol 29(1), pp. 127-143, 1995.
[20] P.K. Bagchi, “Carrier selection: the analytic hierarchy process”, Logistics andTransportation Review, vol. 25 (1), pp. 63-73, 1989.
[21] A.S. Dantas, R. Antunes, Y. Yamashita, M. Lamar, “Marketing in Public Transportation: a neural network approach”, Paper 9th World Conference in Transportation Research:D1-4137. Seoul, South Korea: University of Canterbury, 2001.
[22] B. Pushkarev, J. Zupan, “Public Transportation and Land Use Policy by Pushkarev Boris Zupan Jeffery M.”, Indiana Univ Pr, 1977.
[23] J. Davis, S. Seskin, “Impacts of urban form on travel behavior”, The Urban Lawyer, vol. 29(2), pp. 215-32, 1997.
[24] E. Forman, M. Selly, “Decision by Objectives: How to Convince Others that You are Right”, World Scientific Publications; Singapore, 2001
[25] Guide to COST-BENEFIT ANALYSIS. Final Report. 16/06/2008”, Working Document No. 4, 08/2006, COCOF Notes, Implementing Regulations
[26] The World Bank, Transport Note No. TRN-5 to TRN-26, January 2005
[27] T.L. Saaty, “The Analytic Hierarchy Process, New York: McGraw Hill. International, Translated to Russian, Portuguese, and Chinese, Revised editions, Paperback, Pittsburgh: RWS Publications, 2000.