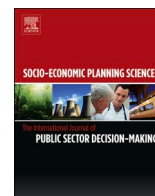




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Using MCDA to assist an Intermunicipal community develop a resilience strategy in face of the pandemic caused by the SARS-CoV-2

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ABSTRACT

The topic of regional economic resilience has been the subject of intense debate in the academic and political fields over the past decade and gained a new sense of urgency because of the pandemic caused by the SARS-CoV-2 virus as territories faced relevant impacts on their economies and social structures. The economic downturn, the increase in unemployment, and the deterioration of social conditions lead policy makers to search for solutions to make their territories more resilient to this type of event. The current article discusses how multicriteria decision analysis (MCDA) was used to help a Portuguese Intermunicipal Community, formed by 16 councils, develop a strategy to make its territory more cohesive, competitive, sustainable, and resilient. In addition to discussing an innovative application of a MCDA technique, this article illustrates how, through a MCDA approach, it was possible to reach a consensus among several policymakers, despite each of them having their own political agendas.

1. Introduction

The first confirmed case of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2, also known as COVID-19) occurred in Portugal on March 2, 2020. This pandemic severely impacted the Portuguese economy, with the International Monetary Fund [1] estimating an 8% recession and a raise in the unemployment rate to a maximum of 13.9%. The pandemic impacted all economic sectors but took a special toll on tourism. This is important since this paper considers the case of the Algarve, which is the most southern region of mainland Portugal, housing 451 006 people [2] and covering 4997 km². The Algarve has been recently considered the leading beach destination in the world [3] and, not surprisingly, is very dependent on tourism [4]. It was in this context that the Intermunicipal Community of the Algarve (AMAL), a collective entity of public and associative nature, formed by the 16 municipalities in the region, faced with a significant reduction in the economic activity of the region, needed to formulate a strategy to minimize the effects of the pandemic on the Algarve's economy and to make the region more resilient to future crises. In particular, in addition to the required short-term responses targeted at providing a quick mitigation of the impacts of COVID-19, it was also considered that the region should take this opportunity to identify and select a set of projects targeted at addressing the excessive specialization of its economy on the

tourism sector. To achieve this objective, a research team including the authors of this article and a representative of AMAL was formed. The team decided that a Multicriteria Decision Analysis (MCDA) methodology should be adopted in supporting the decision process since the strategy and the selection of projects had to account for the stringent budget restrictions faced by AMAL and the multiple and sometimes conflicting objectives of the different municipalities belonging to AMAL. As a result, the objective of this paper, which constitutes an in-depth case study, is to demonstrate how a MCDA approach assisted by four decision support tools (SODA - Strategic Options Development and Analysis, MACBETH - Measuring Attractiveness by a Categorical Based Evaluation Technique, Equity and Benefit Vs Doability Graphs) can be used to support the development of a regional strategy targeted at addressing the effects of the COVID-19 pandemic. Such approach allows decision makers to develop valuable insights about the problems at hand and discuss their possible solutions. Furthermore, MCDA enables decision makers to learn about their own priorities and those of the other stakeholders, and consequently, make better informed choices. This view is shared by many prominent researchers in the field (e.g., Refs. [5–7]). MCDA also provides decision makers with an explicit evaluation process, which might be helpful in justifying and explaining to others the reason why a particular option was selected [8,9]. This is an important feature that is very valuable in certain settings such as the one discussed

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in this article. Using Operations Research (OR) tools in this intervention is also consistent with recent research that recommends employing MCDA methods to help tackle challenges raised by the COVID-19 pandemic (e.g. Refs. [10–12]). Importantly, this paper adds to the literature since, to the best of the authors' knowledge, it is the first to show the benefits of using a MCDA approach to support the development of a post-COVID-19 regional strategy. Furthermore, by employing a hybrid approach to assist project selection, it contributes to addressing one of the gaps in the literature identified by Ref. [13].

The present case study details the process required to achieve the main goal of the Intermunicipal Community of the Algarve. All relevant actors were actively involved, and each decision-maker's main areas of concern were identified and explicitly taken into account. In particular, the process started with a diagnosis and a first assessment of the impact of the COVID pandemic on the regional economy. It then pursued with the identification of the way forward and of the options that needed to be considered to diversify the region's economic base. The process culminated with the approval of a medium and long-term strategy for the Algarve, which has at its core the aim of mitigating the region's current specialization around the tourism sector. As part of this regional strategy, a set of projects was identified and thoroughly evaluated. This evaluation process required the development of a decision support model to assess and rank the projects that presented the most potential to support the established regional strategy and was carried out using the MACBETH approach (Measuring Attractiveness by a Categorical Based Evaluation Technique), proposed by Ref. [14]. In the end, in addition to discussing an innovative application of a MCDA technique, this article illustrates how, through a MCDA methodology, it was possible to ensure a broad base of understanding and promote consensus among several policymakers, despite each of them having their own political agendas. As such, given its in-depth case study structure, this paper might prove valuable to researchers and practitioners that require a roadmap for generating consensus among different political stakeholders in a context of extreme uncertainty.

In order to thoroughly document the process followed and the results achieved, the remainder of this article is organised into several sections. It starts by describing the problem in section 2. Then, in Section 3, we review the most relevant literature and in Section 4 we introduce the methods used during the intervention. Section 5 discusses the case study and the process adopted to address the objectives of the article. Finally, Section 6 is devoted to discussing the main results achieved and the recommendations resulting from the intervention.

2. The problem

2.1. The economy of the Algarve and the impact of the COVID-19 pandemic

In 2018, the Algarve region represented around 4.7% of the national economy, both in terms of Gross Domestic Product (GDP) and employment. In the same year, the region's GDP per capita was 110.1% of the national average. Yet, in 2017 (the last year for which data is available), the average annual remuneration in the Algarve was only 89.7% of the national average (23 939 euros). Table 1 shows a comparison between the economic structure of Portugal and the Algarve.

As can be seen in Table 1, the Algarve's economic structure is significantly different from that of Portugal. In particular, the region's Gross Value Added (GVA) is highly concentrated in the accommodation sector (22.4% vs. 5.4% in Portugal). In contrast, the contribution of the manufacturing industries to the region's GVA is almost inexistent, especially in relative terms (2.2% vs. 13.8% in Portugal). The same conclusions apply when one considers the level of employment per economic activity depicted in Table 1. Unreported statistics show that these characteristics have been stable throughout the 2013–2017 period.

Not surprisingly, the Algarve is one of the most penalized regions in

Table 1

Comparative economic structure of Portugal and the Algarve, most relevant economic sectors, 2017.

Sectors	Portugal		Algarve	
	% of GVA	% of Employment	% of GVA	% of Employment
C – Manufacturing Industries	13.8	15.6	2.2	3.1
G - Wholesale and retail trade; repair of motor vehicles and motorcycles	14.3	15.0	12.6	16.3
I - Accommodation, catering, and similar	5.4	6.9	22.4	20.6
L - Real estate activities	12.5	9.0	17.6	17.6

Source [4]:

Portugal by the COVID-19 pandemic. Data from the Employment and Professional Training Institute (EPTI), the public body responsible for Portugal's employment policy, shows that, in January 2020, the number of people in the Algarve officially looking for a job was only 0.3% higher than in January 2019. Yet, at the end of February 2020, the unemployment rate raised rapidly in the region and, by March 2020, the number of people registered in the EPTI had increased 41.4% relative to the previous year. By April, this figure peaked to 123.9%. The impact of the COVID-19 pandemic was, however, just beginning. According to the Association of Hotels in Portugal [15], around 70% of the hotels in the Algarve were (at least temporarily) closed by November 2020. Many other sectors were also without customers, such as rent-a-cars, restaurants, bars and clubs, entertainment, and maritime-touristic companies. This reality, associated with the psychological effects of the loss of income by a significant part of the population, which traditionally works in the tourism industry, triggered AMAL's concerns about the likely impacts of the COVID-19 pandemic on the regional economy.

2.2. AMAL in the context of the administrative organization of Portugal and its role in developing a post-crisis territorial strategy

Portugal is a unitary state, with two executive power levels: the central government, sworn in by the Assembly of the Republic, and the local government. The executive of the city councils, designated as Local Power, is elected by direct suffrage, and their functioning takes place with a deep respect for the principle of municipal autonomy. The State's organization and functioning is based on clear competencies defined by the Law, which defines the perimeter of the intervention of each power level. This means that there is no hierarchical relationship between the central and the local power, with each of them having their own laws and powers. In 2013, however, a new normative framework, dealing with the political and administrative organization of the Portuguese State - Law N.º 75/2013 – was introduced, establishing a new intermediate scale. In particular, this law introduced a set of attributions that strengthened the relevance of intermunicipal entities (metropolitan areas and intermunicipal communities), at the level of regional development programs and the management of community funds, as well as through the establishment of a new governance model. This new legal context created the intermunicipal community of Algarve. In 2020, within the scope of the powers delegated by the Law, AMAL decided to implement a regional strategy to minimize the effects of the pandemic in the Algarve's economy. Right from the outset of the crisis, this intermunicipal entity coordinated the joint intervention of the sixteen municipalities that currently exist in the Algarve. In addition to implementing responses to short-term issues, such as the purchase of protective masks and hospital ventilators, AMAL also aimed at developing a strategy targeted at mitigating the impact of the pandemic, but more importantly, at preparing the region for the future, making it more cohesive, competitive, sustainable, and resilient.

3. Literature review

3.1. Regional resilience

In the last decade, the topic of regional economic resilience has been the subject of intense discussion in the academic and political fields. Some studies examine the strategies of different regions to respond to previous crises (e.g. Ref. [16]), while others explore how resilience is measured and how public policy can be used to strengthen regional resilience (e.g., Refs. [17–19]). Another strand of the literature considers the role of innovation in promoting economic resilience [20].

Most of the extant literature focuses on the financial crisis of 2008/2013, which is very different from the pandemic situation the world has been facing. Yet, some insights can still be gained by looking at the characteristics that seem to make certain regions more resilient to crises than others. For instance, after reviewing the literature [21], identify four main types of resilience: (1) engineering resilience; (2) economic resilience; (3) ecological resilience; and (4) social resilience. For the present paper, the concept of economic resilience is important as it discusses the ability of a given territory to self-organize and adapt to a significant exogenous shock [22]. In this context [23], argues that economic resilience is a region's capacity to preserve and maintain its vitality in times of crisis whereas [24] claim that building regional resilience is a dynamic process that depends on the region's ability to withstand a given shock and ultimately achieve a new balance [25]: page 13) further develop this concept, defining regional economic resilience as *“the capacity of a regional or local economy to withstand or recover from the market, competitive and environmental shocks to its developmental growth path, if necessary, by undergoing adaptive changes to its economic structures and its social and institutional arrangements, to maintain or restore its previous developmental path, or transit to a new sustainable path characterized by a fuller and more productive use of its physical, human and environmental resources.”*

From the perspective of policy management, some authors claim that the degree of regional economic resilience depends on development strategies, socio-economic characteristics, and the diversification of the economy [24], and that it can be altered through strategic management. In addition, when discussing regional resilience, it is also important to underline the role of public policies. Pivotal in our discussion is the issue of diversification, which requires significant political support. In effect, underdiversified economies usually are not very resilient even if they are able to grow in the short-term. Put differently, as [21] highlight, an economic “lock-in” indicates that the economy is unable to adapt rapidly to changes, which is troublesome in the presence of an exogenous negative shock. As result, all measures aimed at adjusting the economic structure, strengthening the level of scientific innovation and technological development and those that promote the rational development of ecological resources and ensure environmental protection, are paramount to improve regional resilience [21].

The concept of regional resilience is very important in the context of this study. In fact, as previously mentioned, AMAL feared the impact of the COVID-19 pandemic given the excessive concentration of the Algarve's economy around the tourism sector. As a result, this public entity needed a strategy that dealt with the short-term effects of this exogenous shock and paved the way for a more resilient region. The fact that AMAL was leading the development of an appropriate response to the COVID-19 pandemic is consistent with the view expressed by Ref. [26]: 128), who argue that “although central authorities have important roles to play in COVID-19 response, local governments, being closer to people, are best-positioned to form the first line of defense.”

This paper implicitly assumes, therefore, that public policy can help solve an economic specialization problem of a specific Portuguese region, an issue that could be explored under different theoretical perspectives. One that seems particularly promising is how the concept of Pareto efficiency relates to the existence of market failures. According to Ref. [27]; p.171), Pareto efficiency occurs when the available resources

cannot be reallocated to make one economic agent better off without making at least another one worse off. When the market is not in equilibrium, thus generating shortages or surpluses, it is said to be Pareto inefficient. When this is the case, it is possible to find a new equilibrium by improving the allocation of resources to benefit at least one economic agent without harming the interests of all the others [27]; pp.185-187). Under this set up, many scholars argue that governments should intervene when the free market system of perfectly competitive markets does not lead to Pareto efficiency [28]. In effect, such imperfections may arise due to different underlying conditions such as the presence of asymmetric information or significant externalities [29], which the government may help mitigate.

Data covered in this paper indicates that, in the Algarve, competitive markets lead to an economic structure that is overconcentrated around tourism-related activities. Such specialization pattern has no parallel in the country, and the recent sanitary crisis shows that, in extreme circumstances, it can be detrimental to the well-being of those who work and invest in the Algarve. To this point, statistics from Portugal reveal that, while the Portuguese GDP fell by 8.3% in 2020, the Algarve sustained a comparable loss of 18.3%, which was motivated by the collapse of the wholesale and retail trade, transportation and accommodation and food service activities in the region.¹

A related issue is whether diversifying the region's economic basis is actually an optimal course of action for the Algarve. In fact, comparative advantage theory, which is at the heart of the theory of international trade, advocates that, given its intrinsic characteristics, any given economy is likely to produce a particular set of good and/or services at a lower opportunity cost than its competitors. This explains why different regions and countries can benefit from trade and justifies why economic specialization occurs. The last 60 years have shown that the Algarve is clearly able to compete in the international tourism market. For instance, in the last few years, the region has collected dozens of international awards related to golf, the quality of its beaches and its touristic resorts.² This helps explain why, according to statistics from Portugal, the Algarve has enjoyed a compounded annualized rate of growth in the number of guests of 5.55% between 2013 and 2019 and, in the same period, the total gross revenue generated by the hotel industry increased by an impressive 11.93%. Not surprisingly, in 2019, i.e., the last pre-Covid year, the Algarve accounted for 30% of the total Portuguese revenues generated in this area of business.³ Given the above, it is open to debate to what extent promoting multiple economic activities other than those that are tourism-related will help increase the region's economic resilience.

3.2. Project selection methods and the MCDA methodology

As reviewed by Refs. [13,30]; several modelling approaches exist to assist project selection. [31] classified the existing approaches into five main groups: ad hoc methods, comparative approaches, scoring approaches, portfolio matrices, and optimization approaches. Later on [32], proposed a slightly different taxonomy of models for project selection. According to this taxonomy, project selection methods can be grouped into six main categories: benefit measurement methods, mathematical programming approaches, cognitive emulation approaches, simulation and heuristic models, real options and ad hoc models. More recently [13], offered yet another classification, grouping the alternative methods into three large groups: frameworks and

¹ <https://www.gee.gov.pt/pt/indicadores-diarios/ultimos-indicadores/30851-ine-contas-regionais-3> (accessed on the 27th of December 2022).

² <https://www.turismoalgarve.pt/pt/5614/premios.aspx> (accessed on the 28th of December 2022).

³ Raw data available here: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=539849079&DESTAQUESmodo=2&xlang=en (accessed on the 28th of December 2022).

decision support systems, optimization methods, and scoring methods. In the particular case documented in this article, we opted for a hybrid approach, which combines problem-structuring tools with an analytic method for multi-criteria analysis whose results are then represented in a benefits vs doability graph in order to identify those projects that are doable. Finally, an efficiency frontier, representing the set of projects with the best benefit/cost ratio, is then formed to prioritize the projects and form packages of projects. In doing so, the study represents an important departure from previous research and contributes to addressing one of the gaps in the literature identified by Ref. [13]; who emphasize that there is a dearth of research on the use of hybrid methods to assist project selection and suggest that using hybrid tools could improve this process.

The choice for this approach was also determined by the fact that the most “traditional” planning techniques seem to be out of touch with today’s reality, as they usually aim to find a single, optimal solution to build a desired and secure future. This hypothesis is unrealistic, given that it is not possible to predict what [33] calls discontinuities. In this context, MCDA aims to support managers in decision-making based on an interactive process of reflection and learning, providing knowledge about the problems they face and possible solutions [34]. As emphasised by Ref. [35]; the main distinction between MCDA methodologies and traditional assessment methodologies is the ability of the former to allow the incorporation of the experts’ or decision-makers’ subjective values into the assessment models. Additionally, these models allow the analysis of variables of different nature simultaneously. In summary, MCDA techniques help identify solutions that can support decision-makers in fulfilling their determinations. The fact that MCDA has recently proved beneficial in assessing policies designed to mitigate the impact of the COVID-19 pandemic (e.g. Ref. [36] provides further support to the adoption of this approach in our particular context.

The case study documented in this article adopts a multicriteria approach to decision support that is based on three fundamental phases as illustrated in Fig. 1 [35]: (1) the structuring phase; (2) the evaluation phase; and (3) the prioritization phase. The process is a participatory one, which can be applied with a variable geometry to different contexts, and requires a dynamic relationship between two agents, the facilitator, and the decision-maker. The facilitator serves as a catalyst, using his/her knowledge, sensitivity and experience to promote action strategies. The decision-maker is usually a high-ranking member of the organization where the work is carried out and can be just one person, who can be accompanied by his/her technical staff and/or members of the administration or, as in the case study described here, a board of decision-makers accompanied by their technical staff.

As the use of a MCDA methodology to design a strategic plan is a cyclical process, the plan’s monitoring must be a process parallel to its elaboration. The monitoring process is extremely important as it enables the constant validation of the work being carried out, in terms of the

costs of the actions, their planning and entities involved, advances and setbacks [37].

3.3. MCDA for supporting strategic plans

The use of a MCDA methodology in the context of the definition of a strategic plan is justified on the grounds that it allows a high level of participation and discussion among the different actors and promotes a better understanding of their value system. This methodology also allows establishing a more transparent process in building the final solution, which is helpful when one needs to justify the options and choices made to a third party. This is an important feature as a model’s transparency makes it easier for users to understand the solutions reached and allows the entire decision-making process to be audited, which can be particularly relevant for public sector organizations [38].

The contribution of the MCDA methodology to strategic planning has long been recognised by Ref. [39]; who emphasises that, through a facilitator, the MCDA methodology has the potential to foster a high participation of the different actors and decision-makers in the discussion of possible solutions. According to this author, MCDA provides to the entire strategy construction process a high level of participation. It is also important to highlight that, through MCDA, it is possible to submit the results and conclusions to extensive sensitivity analyses [40]. Linking a stakeholder approach to the MCDA is not only theoretically desirable, but it is also feasible without assuming, however, that the final proposal is the only possible one. In effect, the application of the MCDA methodology is based on a “game” between the objective and the subjective, combined with uncertainty and instability [37]. Therefore, different facilitators and/or different decision-makers could eventually have reached a different final solution to the one we discuss here.

The fact that we have adopted a friendly-to-use MCDA technique (i. e., MACBETH) also facilitated the strategy formation process and established an excellent communication and consensus generation channel between the facilitators and the decision-makers. For a recent literature review on how MCDA can promote consensus in group decision making the reader is referred to Ref. [41].

3.4. MCDA for prioritization and resource allocation

As mentioned above, this paper shows how the MCDA methodology helped AMAL finding a solution for the problem being faced by the Algarve region as a result of the COVID-19 pandemic. In particular, considering the stringent budget constraints that existed at the time, a decision had to be made regarding the allocation of the available resources to those projects that had the potential to generate the largest benefits in supporting the building of a strategy for regional resilience. Hence, the decision model must support the decision-makers in choosing the best possible combination of projects, accounting both for their benefits and required resources. Although the potential of MCDA in this context is clear, a review of the literature shows that the number of articles documenting the use of this approach to develop territorial-based plans is very small. In fact [34], is the only somewhat related study we could find. In this case, MCDA is applied to assist the elaboration of a strategic plan for the development of the city of Barcelos, located in the north of Portugal. The municipal executive also intended to implement several interventions while facing a limited budget. It was, therefore, a decision-making process in a context of uncertainty that required the formulation of priorities and their articulation over time. The decision-making process was supported by the MCDA methodology and the software MACBETH [14], which allows cardinal value functions based on absolute judgments of difference in attractiveness to be built. Considering that the city of Barcelos had to comply with the available budget, in addition to accounting for the benefits associated with each action (or package of actions), the authors also had to account for the costs of these actions (or package of actions). To do so, and because the number of alternative actions to assess was quite significant, the authors

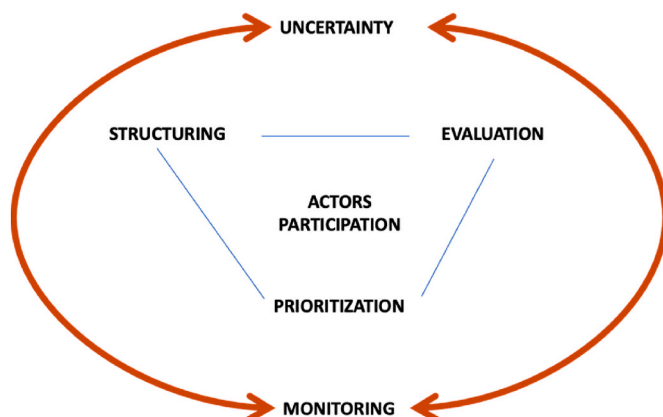


Fig. 1. Decision support planning. Source [37]:

used the Equity software, especially developed by the London School of Economics in 1994, for this purpose.

4. The MACBETH approach and the equity software

The Measuring Attractiveness by a Categorical-Based Evaluation Technique (MACBETH) is an interactive technical procedure proposed by Ref. [14] that uses semantic judgements to quantify the difference of attractiveness between pairs of actions or alternatives. Once the fundamental points of view (FPV) or evaluation criteria are defined, which express the decision-makers' values and their most significant concerns and desires, this technique allows absolute judgements to be made of those actions or alternatives based on differences of attractiveness, rather than on ratios of priority or importance. Through a constructive and interactive learning process, supported by the software M-MACBETH (<https://m-macbeth.com>), this technique uses numerical scales of intervals. More specifically, the technique requires the fulfilment of value judgement matrices, which allow for the definition of local preference scales for the different criteria or FPV involved in the decision process and assists the definition of cardinal value functions for the descriptors created [42]. In doing so, this approach contrasts with the traditional approach of "direct rating" and bisection. Founded on multi-attribute value theory [5], the MACBETH technique uses the additive value model to appraise the overall benefits of the alternatives under consideration and to rank them. Furthermore, through a process of convergent thinking [43], this technique promotes a compromise between the actors involved. For a general overview of the MACBETH technique, the reader is referred to Refs. [14,42,44]. For a recent bibliometric analysis of the technique, please see Ref. [45].

After evaluating the alternatives, it is often necessary to prioritize them [35]. One tool which can help decision makers in this regard is the Equity software package, developed by Catalyze Ltd and Enterprise LSE Ltd (<https://www.catalyzeconsulting.com/software/equity3/>). This software helps distinguish two different prioritization tasks: appraising options and constructing portfolios. This software is particularly helpful in our context as it considers not only the benefits of each project (as derived from the MACBETH technique) but also their costs. In addition, it builds a graph with the different possible solutions, which also defines the efficiency frontier representing the set of solutions with the best benefit/cost ratio. Additionally, the software gives the decision-maker several alternatives to choose from, proposing alternative solutions with the same benefit and lower cost or alternatives with the same cost but with higher benefits.

It is important to stress, however, that there are several other MCDA methods and corresponding supporting software that could have been used in this study. Amongst some of the best known and most popular MCDA methods are the Analytic Hierarchy Process (AHP), Analytic Network Process (ANP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Vise Kriterijumska Optimizacija i Kompromisno Resenje (VIKOR), Elimination and Choice Translating Reality (ELECTRE) and Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE). For a comprehensive review of these and other methods, the reader is referred to Ref. [46]. [47] provide, in turn, an overview of the state of multiple criteria decision support software. Considering that the problem at hand is characterized by the existence of multiple decision-makers, where divergent opinions are likely to emerge, the use of a game-theoretic approach like the one proposed by Ref. [48]; can also provide a valuable alternative to the MCDA approaches above as it allows a strategic analysis of the choice of alternatives, as opposed to the traditional focus on the aggregation of preferences.

While many different methods exist, it has long been recognised that each method has strengths and weaknesses making it difficult to argue that one is superior to the others in supporting any decision-making process (e.g. Refs. [49,50]). In the particular case documented in this paper, the choice of method and supporting software was determined by

two main factors: 1) the MACBETH method is suitable for addressing the objective of the research and 2) two members of the research team had previous concrete experience in using the MACBETH method and the M-MACBETH software to develop understanding and to inform decision making in a wide range of organizational contexts.

5. Empirical application

5.1. The setting

As previously mentioned, as soon as the pandemic was declared, the political agents in the Algarve decided to develop a strategy to tackle its short-term effects and to pave the way for a more resilient region. The Regional Secretary of AMAL was appointed to monitor this project, since he oversees the institution's technical department. Actual decisions regarding specific actions or projects had to be made by the President of AMAL or the entire inter-municipal council, depending on their nature. In fact, AMAL's President represents and manages the intermunicipal council but has no additional power relative to its other 15 members. As such, one of the main challenges was achieving an unequivocal consensus among the different mayors, something that could prove difficult given that they all had their own political agendas and belong to three different political parties. In fact, ten mayors were elected by the Socialist Party (Socialists & Democrats family), five mayors were elected by the Social Democratic Party (European People's Party family), and one mayor had been elected by the Unitary Democratic Coalition, a coalition between the Portuguese Communist Party and the Ecologist Party "The Greens" (European United Left - Nordic Green Left family). As part of the effort to find appropriate solutions, a research team was then formed, which was responsible for helping in the identification and evaluation of the projects with most potential to contribute to the goals set forward by AMAL. The team was aware that generating consensus could be problematic and, as a result, decided to follow a MCDA methodology as suggested by Ref. [14]. This could help ensure that a sufficiently transparent, comprehensive, and participatory process was implemented so that the different decision-makers could help characterise the problems faced and participate in the final decisions. It is this process and the results of each of its steps (i.e., structuring, evaluation, and prioritization) that we discuss in the following sections.

5.2. Structuring phase

The structuring phase had to deal with what [51] define as an unstructured problem. In effect, the setting suggests the existence of: (1) multiple actors; (2) multiple perspectives; (3) incommensurable and/or conflicting interests; (4) important intangible issues; (5) key uncertainties. Furthermore, building trust between the research team and the sixteen decision-makers (i.e., the mayors of the municipalities) was paramount to the success of the intervention. As such, beginning with a decision-making conference [38] that involved all the decision-makers at once was unfeasible since not all of them would be comfortable with sharing their views and concerns regarding the past, present, and future of the region. As a result, the problem structuring process was carried out in two stages. The first, consisting of individual interviews with each of the sixteen decision-makers, followed the SODA - Strategic Options Development and Analysis approach [52]. The second stage, occurring at a later moment, required a group session involving all the decision-makers at once.

The first round of meetings represented an important effort of the research team as it required travelling more than 1800 km, over a month and a half, to carry out in-depth interviews with each of the sixteen mayors in their own municipalities' headquarters. However, it allowed learning more about the reality of the region and strengthening the ties with all mayors. All meetings were set up previously with the help of the Regional Secretary of AMAL and, in general, were easy to schedule. The interviews were designed to last at least 60 min and the research team

required the mayor to attend. Following [53]; the research team acted as a facilitator. Hence, all meetings started with a brief analysis of the regional economic structure, and the pandemic's likely impacts. Then, in order to provide the focus for the discussion, the following trigger question was asked: "What do you think should be done in the Algarve region to make it more resilient to crises like the one we are experiencing?" Most mayors immediately started describing their main areas of concern and expressed what needed to be done to address them. In fact, the majority was very engaged with this process since they were interested in the success of the intervention. A few mayors, however, were not as cooperative. In these cases, the research team used a few pre-defined questions to help gather the information it required. It should be stressed that even these more reluctant mayors took a much more active role in providing the team with relevant information once they developed a better understanding of the process and methods that were being used.

In the end, from these conversations, a set of problems/questions emerged that corresponded to the interviewees' understandings and perceptions of the problem [53]. Considering that cognitive maps [54, 55,56]; are important tools to help facilitators structure complex problems and their integrated use with MCDA techniques has been previously documented (e.g. Refs. [57–61]), the team decided to use them in order to keep a record of the main issues raised and to explicitly highlight their relationships. As argued by Ref. [53]; these maps represent a "system of concepts". Cognitive maps are valuable in identifying objectives and in structuring them to form the basis of any quantitative modelling. In fact, such maps are helpful in building a means-ends network [62] as they highlight the alternatives (means) that should be considered to achieve certain objectives (ends). Importantly, the meetings with the mayors followed an approach focused on values [62] and not on the alternatives, something critical for the elaboration of the cognitive maps. The maps generated manually during the meetings were subsequently captured and structured using the mapping software Decision Explorer (<http://www.banxia.com>). An extract of one of these maps is shown in Fig. 2.

Although individual cognitive maps were developed to identify and structure the key concepts raised by each of the 16 mayors that participated in the process, no explicit validation was subsequently sought of these individual maps. This is justified on the grounds that the objective of the intervention was to develop a regional strategy capturing the collective view of the mayors rather than their individual perspectives. Having this in mind and the fact that the time of the mayors was very scarce, the research team opted to seek validation only of the collective map. In particular, following the SODA approach, the sixteen individual cognitive maps were merged into an "aggregated map" [52] and a group session with all the mayors was held to check for the correctness and completeness of such a collective map. Cognitive maps have the advantage of helping to understand the different perspectives of the various interlocutors. Yet, merging different maps into one can be a challenging task [63]. This, however, was not an issue in this case since the different decision-makers shared many areas of concern. Fig. 3 presents an extract of the final map, which was validated at the collective workshop with the decision-makers. The map highlights the key issues that were identified and the links between them. Validation of this map is fundamental to legitimize the results obtained and improve the validity of the approach used.

Both the collective map and the group workshop with the mayors proved very valuable to promote discussion, to share views on the problem, including the main concerns and envisaged solutions, and to reach a compromise solution. As can be seen in Fig. 3, most mayors agreed that public investment should be the key driver of the regional strategy under development. Furthermore, there was a shared view that the Algarve needs to be a more cohesive, competitive, sustainable and resilient region. In order to achieve this goal, six strategic objectives were identified (center of Fig. 3): i) diversification of the economic base; ii) promotion of territorial cohesion; iii) promotion of policies to support

companies and human resources qualification; iv) adoption of a sustainable water resource management model and focus on the production of renewable energy; v) provision for the region of infrastructure and structuring equipment to improve the accessibility and living conditions of the population; vi) empowerment of the region with a governance model that responds to its strategic challenges.

The reason why there is not a perfect match between the concepts in Fig. 3 and the six strategic objectives identified, is because the concepts in Fig. 3 were further refined by AMAL to better reflect the views of the mayors. In particular, it was agreed that particular attention should be given to projects that promoted regional cohesion (Concept 80), and that this objective should be handled autonomously from the one related with the development of adequate governance models. This explains why all the other concepts at the center of Fig. 3 were initially reflected in the objectives above (i.e. Concept 36 reflects objective i) diversification of the economic base; Concepts 14 and 19, reflect objective iii) promotion of policies to support companies and human resources qualification; Concept 8 captures objective iv) adoption of a sustainable water resource management model and focus on the production of renewable energy; Concept 4 reflects objective v) provision for the region of infrastructure and structuring equipment to improve the accessibility and living conditions of the population; and Concept 59 echoes objective vi) empowerment of the region with a governance model that responds to its strategic challenges) except for the second objective (promotion of territorial cohesion). This objective combines the initial description of Concept 41 (Promoting of structural projects) with that of Concept 80, having led to the refinement of Concept 41 to be better aligned with the objective.

At this stage both strategic and operational objectives were identified. This allowed our interlocutors to easily evaluate the reach of the strategy being developed and quickly assess whether it would respond to their most significant concerns. This step was critical to ensure that the decision-makers felt ownership of such a strategy. Once the strategic framework was agreed by the mayors and the final strategic and operational objectives were approved (please, see Table 2), we were able to move to the next stage, which consisted in the elaboration of the value tree [34] with the help of the MACBETH software.

5.2.1. The value tree

As Fig. 4 illustrates, four of the strategic objectives represented in the Strategic Framework (Table 2), and their corresponding operational objectives were structured (using the M-MACBETH software) in a value tree, also known as tree of Fundamental Points of View (FPV) [64]. This tree included the evaluation criteria agreed to be fundamental in the assessment of the projects with the potential to enable the region to respond to the Covid-19 crisis and to make it more resilient.

In what regards the strategic objective related with the promotion of territorial cohesion, it was decided by the President and the Regional Secretary of AMAL and by the research team that it should be reflected at the level of the descriptors (please see section 5.2.2). The same is to say that projects contributing to this objective would obtain a higher score in each of the evaluation criteria than those that did not. Furthermore, the value tree does not include the objective of empowering the region with a governance model that responds to its strategic challenges. In fact, the research team, together with the decision-makers, decided to treat this separately as, irrespective of the projects to be assessed, it was a critical objective to be achieved if the resulting strategy was to be successfully implemented.

5.2.2. FPV descriptors

Once the tree of objectives was derived, its properties checked and the meaning of each of the 18 FPVs agreed upon (marked in red in Fig. 4), the next step of the structuring process consisted of the construction of impact (or performance) descriptors to enable each FPV to properly reflect the judgement values of the mayors and the characteristics of the projects to be assessed. This was initially done by the

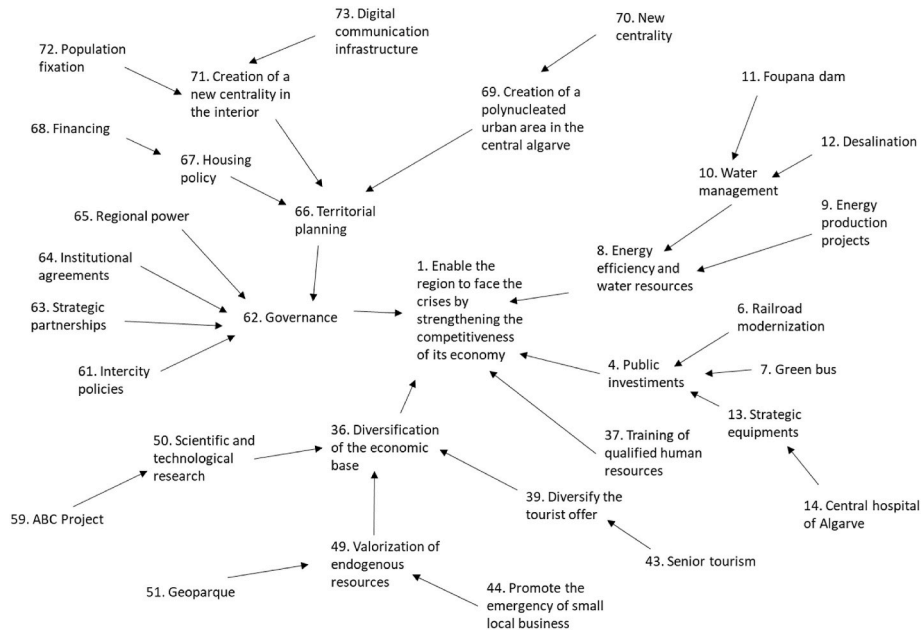


Fig. 2. Part of a cognitive map revealing the key concepts that emerged in one of the interviews.



Fig. 3. Extract of the collective map highlighting some of the key issues to consider in designing the resilience strategy for the Algarve.

research team, but all the descriptors were later validated, and whenever necessary, adjusted, by AMAL's president and technical staff.

Impact (or performance) descriptors are associated with each of the FPVs, and through them, it is possible to assess the impact of a specific action on a particular FPV [65]. The descriptors were qualitative and used a semantic and personalized language because of the specificities of each FPV, also guaranteeing their condition of ordinal independence [42,66]. Table 3 shows an example of a descriptor, in this case for the dimension "diversification of the tourism offer", which is a very important one since all the decision-makers worried about the

concentration of tourism around the "sun and beach" product.

As can be seen, FPV1 (Diversification of the tourism offer) became operational by a descriptor with seven levels that value very differently projects with different characteristics. In particular, projects that do not help diversify the touristic offer are very penalized in this descriptor (impact level 0). In contrast, those that help with such objective and have a relevant contribution to the sustainability of the tourism sector, promote territorial cohesion and incorporate high levels of innovation are very valued (impact level VI). The different impact levels emphasize that the Algarve needs to explore other complementary tourism

Table 2
Strategic framework.

Strategic objectives	Operational objectives
I – Diversification of the economic base	1.1 Diversify the tourist offer 1.2 Promote the development of sectors other than the tourism 1.3 Accelerate the development of the agricultural and forestry sector
II – Promotion of territorial cohesion	2.1 Promote the living conditions in the Algarve countryside 2.2 Leverage projects with inter-municipality impact
III – Promotion of policies to support companies and human resources qualifications	3.1 Promote employability 3.2 Train and attract highly qualified human resources 3.3 Create business helplines
IV – Adoption of a sustainable water resource management model and focus on the production of renewable energy	4.1 Implement a regional energy production strategy based on renewable energy 4.2 Promote measures for the efficient management of water resources
V – Provision for the region of infrastructure and structuring equipment to improve the accessibility and living conditions of the population	5.1 Build infrastructures (social, health, education, culture, and sport) 5.2 Improve mobility and accessibility 5.3 Improve the infrastructure network to support the digitalization of the economy 5.4 Provide business parks with the capacity to support critical projects for the region 5.5 Promote urban regeneration and requalification and implement housing policies
VI – Empowerment of the region with a governance model that responds to the strategic challenges of the region	6.1 Implement a new territory administration and management model that responds to the region's strategic challenges 6.2 Coordinate interventions in partnership with other deconcentrated entities in the region 6.3 Ensure AMAL's management of the financing of the Algarve's Economic Recovery Plan

products, meeting the new trends in travellers' preferences, taking advantage of the region's endogenous characteristics, and reducing the strong seasonality that is characteristic of the sun and beach tourism. Importantly, different descriptor tables were created for each FPV, taking into consideration their specificities.

5.2.3. Structuring the actions

The next step was identifying actions and/or projects with the help of AMAL that could support the defined strategy. This yielded a list of more than 700 projects that the different municipalities were already planning to do, which involved a global investment in excess of 740 million euros.⁴ This was problematic since assessing this number of projects was simply not feasible. Yet, many of these projects were not relevant to the AMAL's strategy. For example, while it was commonly agreed that investments in energy and water efficiency were necessary to guarantee the region's environmental sustainability, other projects, such as municipal basic sanitation networks and the paving of streets and sidewalks, had already been financed intensively over the last decades and, therefore, were not a priority. Hence, after discussing the issue with the President and the Regional Secretary of AMAL, a decision was made to consider only the projects that had a contribution to at least one of the following themes: (1) economic and environmental sustainability; (2)

⁴ This list is a combination of projects that were put forward by each of the 16 mayors plus some other projects proposed directly by AMAL. AMAL's projects require at least some cooperation between municipalities and cannot be implemented solely by one of them.

social and territorial cohesion and/or (3) furthering a regional governance model that favours the intermunicipal management of infrastructures and equipment. Additionally, projects that had an innovative nature, focused on technological sectors, or were targeted at building infrastructure and facilities to support the economic diversification of the region were also considered at this stage.

The 700 projects were screened looking for those which met the criteria above. In fact, the President and the Regional Secretary of AMAL were convinced that these are the projects that are critical to balance the Algarve's economic structure and increase the territory's resilience to economic crises. All other projects were clustered into thematic packages and evaluated as such. In the end, two groups of projects were formed and assessed. The first is termed differentiating projects, accounting for those projects that were more promising given the nature of the AMAL's strategy. The second, formed by thematic packages, included projects sharing a similar purpose but that lacked a differentiating nature.

With the screening of the projects, the team concluded the structuring phase of the problem. It is important to bear in mind, however, that several other problem structuring methods exist, which can be used in combination with the MCDA methods. For a review, the reader is referred to Ref. [63].

5.3. The evaluation phase

Projects were assessed in two stages. First, the research team considered the differentiating projects; next, the different thematic packages. The first stage constitutes a particular case of the MCDA with resource allocation [38]. This variant allows identifying as the best decision that which is capable of achieving the greatest possible benefit, guaranteeing an efficient use of the available resources [67,68]. However, as we explain later, in addition to the benefits and costs, the prioritization of projects also accounted for their doability, a critical aspect in the context of this case study.

5.3.1. Building the benefit value functions

Considering the qualitative descriptors developed for the 18 FPV and with a view to evaluating each project, the process of defining value scales and assigning weights to the respective FPV, was based on the MACBETH approach. To this effect, and to obtain a cardinal value function for each of the descriptors, value judgement matrices were first constructed for each descriptor. To assist in filling in the matrices, the MACBETH software was applied based on the predefined categories of semantic differences of attractiveness: *C0 – null*, *C1 – very weak*, *C2 – weak*, *C3 – moderate*, *C4 – strong*, *C5 – very strong* and *C6 – extreme*. As reported by Ref. [66]; these qualitative judgement matrices of difference of attractiveness between pairs of impact levels allow transforming qualitative judgements into value scales. Fig. 5 illustrates the judgement matrix and the respective value scale associated with the descriptor related with the diversification of the tourist offer.

As illustrated in Fig. 5, which regards the FPV "Diversification of the tourism offer", the difference in attractiveness between level 0 and level 6 is extreme. Fig. 5 also shows that, from the point of view of the decision-makers, it is considerably more attractive moving from level 2 to 3, than from level 1 to 2. The differences in attractiveness between each impact level allow the construction of a value scale for each FPV. In this particular case, the value scale indicates, for example, that a project described by level 1, scores 12.5 points while one described by level 4 scores 62.5 points.

5.3.2. Assigning weights to the strategic objectives

The number of actors involved in the decision process (i.e., 16 mayors plus the technical staff of AMAL) made it difficult to arrange regular workshops to debate and determine the value scale for each FPV. As a result, each mayor was asked to assess each evaluation criteria's global attractiveness through the filling of a questionnaire. Fourteen

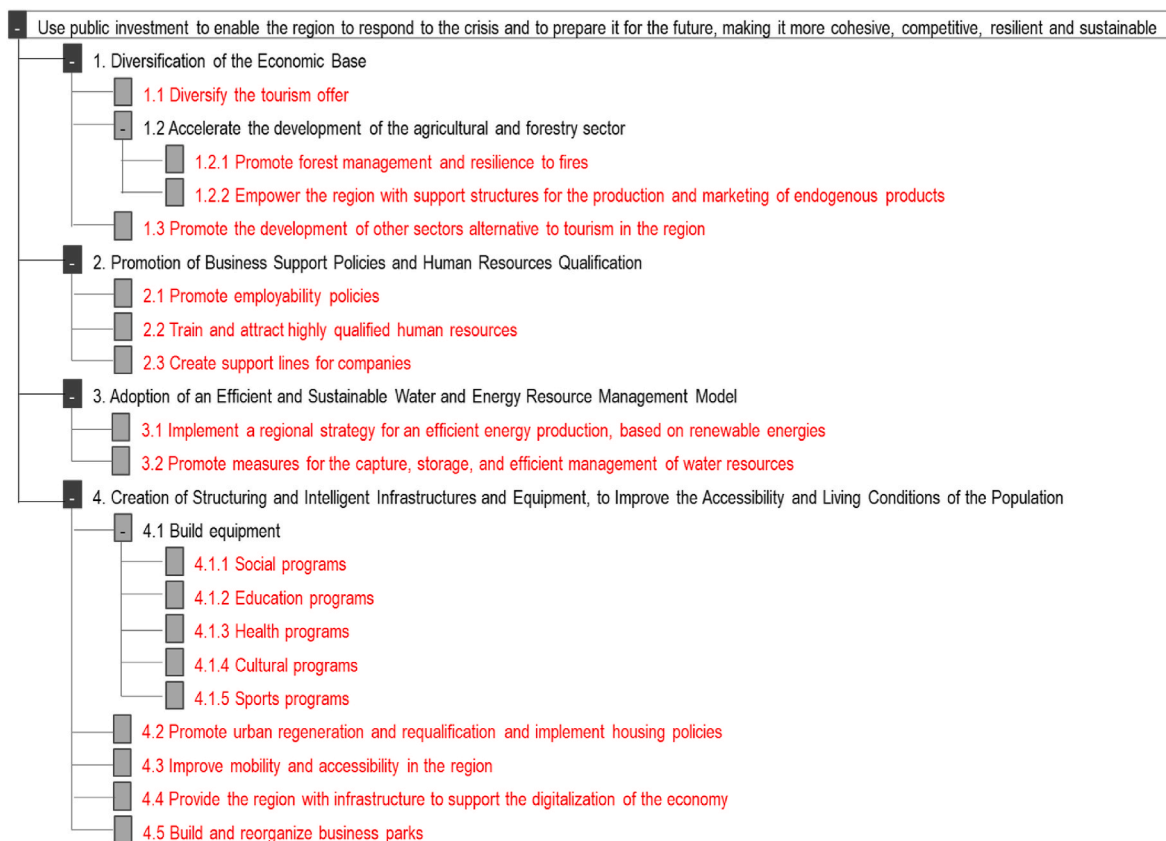


Fig. 4. Value tree of the Algarve's strategy to build regional resilience.

Table 3
Descriptor – Diversification of the tourism offer.

Impact Levels	Description
VI	Projects with a contribution to the diversification of the tourism offer, with a relevant contribution to the sustainability of the sector and territorial cohesion, and highly innovative
V	Projects with a contribution to the diversification of the tourism offer, with a relevant contribution to the sector's sustainability and territorial cohesion
IV	Projects with a contribution to the diversification of the tourist offer and with a relevant contribution to the mitigation of seasonality
III	Projects with a contribution to the diversification of tourism offer through innovative solutions
II	Projects with a contribution to the diversification of the tourist offer located on the coast, but not innovative
I	Projects without a contribution to the diversification of the tourism offer, but qualifiers of the existing offer
0	Projects with no impact on achieving the objective

mayors returned the questionnaire, and their answers were used to determine the weights of each FPV. The questionnaire was designed so that each decision-maker could judge which swings (i.e., from the worst to the best impact level) they consider to be the most impactful to achieve the regional strategy that had been defined in the previous stage. This qualitative swing weight process [66] made it possible to establish the weights of each FPV. Table 4 shows the frequency of the answers provided by the mayors.

As can be seen in Tables 4, 8 mayors considered the swing between the status quo regarding the diversification of the tourism offer and the impact level VI to be of extreme importance in making the Algarve region more resilient. In contrast, no mayor considered the swing between the worst and the best possible impact levels of the criterion related with the building of cultural facilities to be of extreme importance, and only a

minority deemed that it had a very strong importance.

The weights derived from the answers to the questionnaire were later validated by the mayors. Fig. 6 summarizes the final set of weights used in the evaluation process.

As shown in Fig. 6, the FPVs related with the diversification of the tourism offer and the promotion of measures for the capture, storage, and efficient management of water resources, with a weight of 8.56% each, were considered by the mayors as the most important to compare the performance of the projects in contributing to the regional strategy. Conversely, the FPVs related with the building of equipment in the sports or in the culture sector, with a weight of 0.6% and 0.15% respectively, were considered as the least relevant for the same purpose. This highlights the main concerns of the mayors regarding the type of projects that should help bring forward the strategy developed in the previous step.

5.3.3. Calculation of the benefits of each project

As previously mentioned, two types of projects were considered: the differentiating projects (34 out of the initial 700) and thematic packages. Yet, this paper only discusses the evaluation of the former as these are the projects that are more likely to impact AMAL's resilience strategy. In fact, their eventual implementation has the potential to reduce the specialization in the tourism sector and add to the productive areas of the Algarve, something the previous literature shows is important to build the resilience of a regional economy (e.g. Refs. [16,17,69]).

The evaluation process of each project starts with the assessment of its partial attractiveness. To do so, the partial impact values in each FPV are computed based on the descriptors and the cardinal value functions defined in the previous stages. This is systematically done for all the 34 projects and all FPVs. Tables 5 and 6 summarize the results for two projects. The first is the construction of the Central University Hospital of the Algarve (Project 224), which is the highest-ranking project in the



Fig. 5. MACBETH judgments matrix for the “Diversification of the tourism offer” criterion and thermometer value function.

list. The second is the requalification of the regional road 268 Aljezur/Vila do Bispo (Project 409), which is the lowest-ranking project considered in the analysis.

Table 5 shows the qualitative assessment carried out for each of these projects. For instance, the level 6 (niv6) of project 224 in the FPV 6 indicates that this project, if implemented, will contribute to train, and attract highly qualified human resources to the region. In contrast, project 409, has a level of 0 (i.e., niv0) in the same FPV, indicating that the requalification of the regional road in question is unlikely to attract skilled people to the region. Table 6, in turn, shows the quantitative scores (i.e., the benefits) associated with the contribution of each project to each of the 18 FPV considered in the analysis. These scores are obtained using the value scales associated to each FPV. As discussed previously, these value scales allow quantifying the impact of the projects on each objective.

The final score of each project, as illustrated in the last column of Table 6, is obtained, in turn, by using an additive model. In practice, the partial benefits of each project displayed in Table 5 are multiplied by the “weights” of each objective (i.e., FPV) to generate the final score.

Table 6 shows that project 224 has a global impact of 30.42 and project 409 an impact of 5.75. The same is to say that project 224 is considerably more impactful to achieve the strategy envisaged by AMAL to the region than project 409.

Having completed this phase, the next step consisted of comparing the overall attractiveness of each project with its estimated costs. Table 7 summarizes such information.

As can be seen from Table 7, according to our classification scheme, the building of the Central University Hospital of the Algarve (project 224) has the potential to generate the greatest benefit to the region. This project is closely followed by the development of the Commercial Port of Portimão and of the Technological Park at the Autódromo Internacional do Algarve. Other ventures with the potential to significantly contribute to the diversification of the economic base of the Algarve, all of which require a strong investment in technological areas, are projects 707, 430 and 780. Table 7 also shows that projects that do not have a clear innovative nature (e.g., 409, 786) or those that are inherently immaterial (e.g., 144, 727) do not score high in terms of their perceived benefits.

Recall that one of the strategic objectives of AMAL is to promote territorial cohesion. Hence, it is important to show the territorial impact of each of the differentiating projects under analysis. This is done with the help of Fig. 7.

This map proved important since it allowed the mayors to verify that the selected projects were somewhat evenly distributed across the Algarve, not concentrating in areas near the sea and/or with high population density. As a result, their actual implementation could further the much-needed territorial cohesion.

5.4. The prioritization phase

The last stage of the process was to help prioritize the future investments. In effect, as shown in Table 7, each project has a particular estimated benefit but also entails a given cost. Given that (financial) resources are scarce, it is important to determine which combination of projects is the best possible one. An additional issue, which is very relevant in the context of this article, is the development stage of each of the projects under consideration. In effect, some projects were mere intentions, while others had already been approved and were only waiting for funding to be implemented. As a consequence, choosing between projects could not only be done according to a traditional cost-to-benefit framework since the decision-makers were aware that the available funding would have to be used in a relatively short period of time.

To address this issue, particular attention was paid to the methodology proposed by Ref. [35]. The authors recommend following 6 steps when prioritizing projects: (1) enumerate the projects, (2) use the multicriteria value model to determine the additional benefit (Bi) that each project (i) should generate if financed, (3) define the cost (Ci) of each project, equal to the amount of financial support to be granted, if selected, (4) calculate the benefit/cost ratio ($R_i = B_i/C_i$) for each project, (5) order projects from the highest to the lowest benefit/cost ratio, and (6) scroll down the list, choosing the projects within the available budget. According to Ref. [38]; this methodology must be followed in non-profit organizations to privilege each project’s social impact (benefit). Although interesting, the methodology proposed by Ref. [35] does not deal with the difficulties/obstacles associated with the implementation of each specific project, an issue that is bidding in this article’s context. As a result, this methodology was adjusted so that the benefit/cost ratio could only prevail when two or more different projects had the same level of doability. This adjustment was discussed and agreed with the President and the Regional Secretary of AMAL. Doability was interpreted as per [70]; who establish four levels of doability: (I) “Pearls”, which are very beneficial projects that have high doability; (II) “Oysters”, which are projects with a high benefit but that are difficult to implement; (III) “Bread and Butter” – projects with a low benefit but that are easily implemented; (IV) “White Elephants” - projects of low doability and benefit.

Based on the benefits estimated on the previous stages and on the information collected regarding the doability of each project, a doability matrix was then constructed. Fig. 8 summarizes such matrix. As can be seen, the projects with the most significant benefits are not always those that should be implemented first. For example, the Central University Hospital of the Algarve (project 224), despite having the potential to generate the highest benefit, is not considered a pearl as its high costs make it less doable than several other projects. Fig. 8 also illustrates how doability penalizes the interest in promoting a given project. This is the

Table 4
Weighting judgments ranking.

Criteria Evaluation	Of the 18 areas of intervention, which is in your opinion the most important to enable the region to respond to the crisis and to prepare it for the future?	Degree of Importance						
		no	Very Weak	Weak	Moderate	Strong	Very Strong	Extreme
1.1 Diversify the tourist offer	Highly innovative projects with an important contribution to the diversification of tourism offer and territorial cohesion	0	0	0	0	2	4	8
3.2 Promote measures for the capture, storage, and efficient management of water resources	Projects with an unmistakable impact on the circular water economy and water sustainability in the region (including collection and storage)	0	0	0	1	0	3	9
4.1.3 Build equipment or develop programs in the health sector	Projects which consubstantiate the construction of equipment or programs in the health sector that are considered strategic for the Algarve region	0	0	0	0	3	5	5
3.1 Implement a regional strategy for an efficient energy production, based on renewable energies	Projects that directly contribute to the decarbonization of the region's economy and promote the energetic self-sustainability	0	0	0	0	4	4	5
4.3 Improve mobility and accessibility in the region	Regional projects that require a response to the regional sustainable mobility policy, whose implementation considerably improves the region's connections with the outside	1	0	0	0	5	3	5
2.2 Train and attract highly qualified Human Resources	Projects that promote the high qualification and training of human resources or that support the permanent displacement of highly skilled human resources to the region	0	0	0	0	4	6	3
1.3 Promote the development of other sectors alternative to tourism in the region	Projects in alternative sectors to tourism and agriculture, with a well-defined business structure, based on technology, focused on exports and with a relevant impact on the qualification of human resources	0	0	0	1	1	3	7
4.5 Build and reorganize business parks	Projects aimed at the construction of business areas, of a strategic character, of inter-municipal scope, with a well-defined business plan and with strategic partners already identified	0	0	0	1	3	6	3
2.1 Promote employability policies	Projects with a high impact on employment in the area where they are located or recommending measures with a range of 12 months or more	0	0	0	2	3	4	4
2.3 Create support lines for companies	Projects that recommend measures that cover the simplified lay-off, tax arrears, loans, exceptional lines of credit, and support for the capitalization of companies or with an unmistakable impact on strengthening the regional business fabric with effects in the medium and long term	0	0	1	0	5	4	3
1.2.1 Promote Forest Management and Resilience to Fires	Projects that promote an adequate forest management, with an undeniable contribution to the development of endogenous products and prevention of forest fires, based on innovative solutions	0	0	0	4	3	2	4
4.2 Promote urban regeneration and requalification and implement housing policies	Regeneration and/or requalification projects taking place within the scope of urban operations of Urban Rehabilitation with a strong component of housing policy	1	0	0	1	3	5	3
4.1.1 Build equipment or develop programs in the social area	Projects which consubstantiate the construction of equipment or social programs that are considered strategic for the Algarve region	0	0	1	4	5	2	2
1.2.2 Empower the region with support structures for the production and marketing of endogenous products	Projects to support the production and commercialization of endogenous products with a well-defined business structure, located in the <i>Barrocal</i> /Inland of the Algarve, of a supra-municipal scope, with an innovative business plan and focus on regional and extra-regional commercialization	0	0	1	3	4	3	2
4.1.2 Build equipment or develop programs in the education sector	Projects which consubstantiate the construction of equipment or programs in the education sector that are considered strategic for the Algarve region	0	0	1	3	5	3	1
4.4 Provide the region with infrastructure to support the digitization of the economy	Digital infrastructure installation projects that directly serve regional strategic projects	0	1	0	1	7	4	0
4.1.5 Build equipment or develop programs in the sports sector	Projects which consubstantiate the construction of equipment or programs in the sports sector that are considered strategic for the Algarve region	0	1	1	5	3	3	0
4.1.4 Build equipment or develop programs in the culture sector	Projects which consubstantiate the construction of equipment or programs in the culture sector that are considered strategic for the Algarve region	0	1	0	4	3	4	0

Note: One mayor only expressed the level of importance of FPVs 1.1, 4.3 and 4.1.1. In addition, two mayors did not express their opinion regarding the importance of FPVs 1.2 and 4.1.4. Hence, the total number of answers per FPV varies accordingly.

case of the Sotavento Business Area (project 592) and the Geoparque (project 785), which generate some of the highest benefits but are relatively hard to implement. Finally, Fig. 8 provides evidence that creating an intermodal transport hub (project 753) should not be a priority. In effect, this project is classified as a white elephant, suggesting that implementing it is not only very challenging but also does not bring significant benefits to the strategic objectives of AMAL.

The equity software was next used to help prioritize the projects. It uses the benefit/cost ratio to find the efficient project's portfolios along

the admissible range of cost [67]. In addition, within each equity area (i.e., the sector to which each project belongs), projects are ranked in decreasing order of their doability. Fig. 9 summarizes the results considering all projects under analysis and ignoring any budgetary limit. This combination generates package P (i.e., the initial package), that mixes a certain number of projects at a cost of almost 565 million euros.

As can be seen, Fig. 9 shows two interesting alternatives to package P. Alternative B (the better package) offers a higher benefit with less investment; alternative C (the cheaper package) offers almost the same

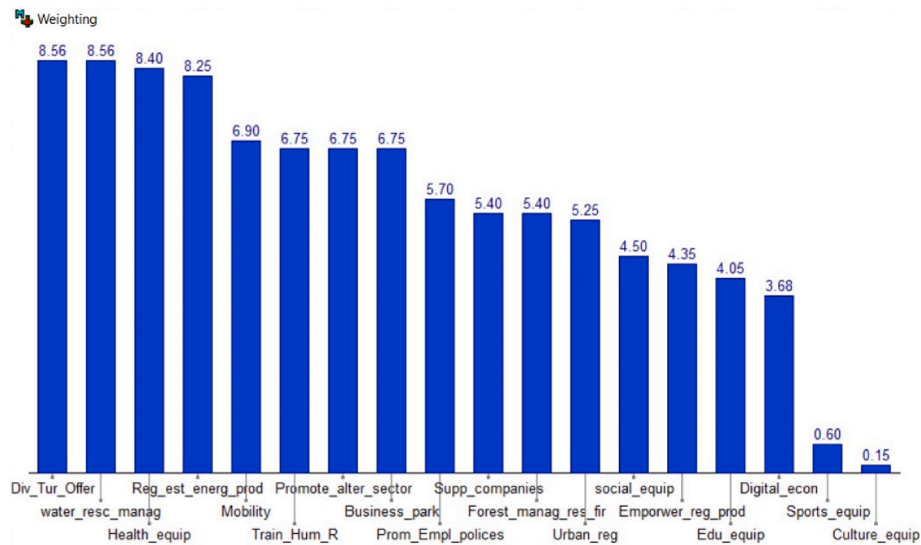


Fig. 6. Weighting objectives.

Table 5

Level of partial attractiveness of two differentiating projects.

Projects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
224	niv1	niv0	niv0	niv4	niv6	niv6	niv4	niv0	niv0	niv0	niv0	niv6	niv0	niv0	niv0	niv0	niv0	niv0
409	niv1	niv0	niv0	niv0	niv2	niv0	niv1	niv0	niv0	niv0	niv0	niv0	niv0	niv0	niv0	niv3	niv0	niv0

Note: 1 - Diversify the tourism offer; 2 - Promote forest management and resilience to fires; 3 - Empower the region with support structures for the production and marketing of endogenous products; 4 - Promote the development of other sectors alternative to tourism in the region; 5 - Promote employability policies; 6 - Train and attract highly qualified human resources; 7 - Create support lines for companies; 8 - Implement a regional strategy for an efficient energy production, based on renewable energies; 9 - Promote measures for the capture, storage, and efficient management of water resources; 10 - Build equipment or develop programs in the social area; 11 - Build equipment or develop programs in the education sector; 12 - Build equipment or develop programs in the health sector; 13 - Build equipment or develop programs in the culture sector; 14 - Build equipment or develop programs in the sports sector; 15 - Promote urban regeneration and requalification and implement housing policies; 16 - Improve mobility and accessibility in the region; 17 - Provide the region with infrastructure to support the digitization of the economy; 18 - Build and reorganize business parks.

Table 6

Partial values and overall attractiveness of two differentiating projects.

Projects	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Final Score
224	12.5	0	0	63.6	100	100	77.8	0	0	0	0	100	0	0	0	0	0	0	30.42
409	12.5	0	0	0	23.1	0	11.1	0	0	0	0	0	0	0	0	40	0	0	5.75

benefit of package P but at a much lower cost. Yet, none of these packages is actually acceptable. Packages P and B exceed the expected budgetary limit of 260 million euros, which is the value that the region is likely to receive from the Portuguese Central Government to implement its resilience strategy via a one-off program, funded by the European Union under the umbrella of the Union’s sizeable recovery plan for Europe. In fact, AMAL’s annual budget is very small (4.6 million euros in 2022) and, thus, would not be appropriate to tackle the financial requirements of a strategic resilience plan such as the one being discussed in this paper. In contrast, Package C does not exhaust the expected budgetary limit, which is clearly suboptimal. Accordingly, a new scenario was considered, which entails removing from the analysis a few projects so that the expected budget can be met in practice. In particular, this scenario excludes the costly projects that, according to the Portuguese law, are a responsibility of the Central Government. These include the building of public hospitals (i.e., projects 224 and 142), most of the projects that deal with environmental valorization and water efficiency (i.e., projects 791, 587 and 537) and also the most costly projects related with energy efficiency (i.e., project 243). Fig. 10 illustrates this alternative scenario.

As can be seen in Fig. 10, the alternative scenario includes several

projects in the cultural area, those related with the requalification of the hotel offer and the Port of Portimão, which is considered a strategic regional project. This is the proposal that was approved by the decision-makers, which is regarded as a very good outcome for two fundamental reasons. On the one hand, its implementation would allow the mayors to develop a large majority of the differentiating projects that fall within their level of responsibility while complying, at the same time, with the expected budget. On the other, this scenario legitimises the mayors’ request for the Government to become accountable for the implementation of the more costly but equally strategic projects that, according to the law, must be pursued by the Portuguese Central power.

6. Conclusions and recommendations

The COVID-19 pandemic put regions and countries to the test, exposing many of their structural weaknesses. The Algarve was especially penalized given the central role that tourism-related activities play in its economy. It was in this challenging context that AMAL contacted the authors of this manuscript to help develop a regional strategy that could respond to the short-term social and economic impact of the pandemic and, at the same time, prepare the Algarve for the future. This

Table 7
Measure of the project's benefits and estimated costs.

N	Project	Cost (€)	Benefit	N	Project	Cost (€)	Benefit
224	Construction of the Central University Hospital of the Algarve	300 000	30.42	419	Center for the Valorization of Endogenous Resources and Experimentation of Fruit Species	4 750 000	17.05
694	Development of the Commercial Port of Portimão	34 600 000	29.31	900	Protected Marine Area of Community Interest	10 000 000	16.55
725	Technological Park at the Autódromo Internacional do Algarve	13 855 000	28.26	787	Mobile slaughterhouse	850 000	16.44
587	Foupana Reservoir	15 000 000	27.45	783	Development of the banks of the Guadiana River	9 043 291	15.82
707	MarPark	2 500 000	26.33	784	Development of the banks of the Arade River	4 100 000	15.82
790	Faro European Capital of Culture	18 500 000	24.53	724	Expansion of Portimão Municipal Aerodrome	4 000 000	14.78
785	Geoparque (w/cultural quarter of the city of Loulé)	17 850 000	24.49	243	A medium-sized photovoltaic plant (50MWp)	30 000 000	14.08
430	ABC Loulé Building Health Research Center (Loulé)	13 500 000	24.45	753	Intermodal transport hub	12 500 000	13.93
592	Sotavento Business Area	7 500 000	24.43	219	High-speed digital network in the interior of the Algarve	15 000 000	13.91
780	Algarve Tech-up - 2nd phase + PTIA	10 000 000	22.94	712	Guadiana International Road Bridge	9 000 000	12.43
791	Construction of a Seawater Desalination Infrastructure	60 000 000	22.19	788	Networked Museums and Networked Cultural Programming	5 000 000	12.16
460	Green Bus Olhão-Faro-Loulé-S.B. Alportel	5 500 000	21.63	142	Relocation/construction of Terras do Infante Hospital in Lagos	25 000 000	12.15
789	Mediterranean Diet - Symbol of regional identity	6 950 000	21.41	717	Camping/Glamping/Caravans and pool construction in Alcoutim	6 000 000	10.81
160	Rehabilitation and electrification of the Algarve railway line	65 000 000	21.41	727	Sagres - Places of globalization	1 000 000	8.35
792	Water collection in Pomarão for connection to the Odeleite dam	70 000 000	21.14	786	Renewal of the municipal fleet by electric vehicles	3 000 000	8.13
537	Dam of Monte da Ribeira	6 000 000	20.38	144	Southwest Coast - Intangible Heritage of Humanity	1 000 000	5.94
901	Creation of the Nautical Zone in Tavira	8 500 000	18.18	409	Requalification of the Regional Road 268 Aljezur/Vila do Bispo	2 500 000	5.75
Total Investment		798 148 291€					

Note: This table ranks the differentiating projects according to their likely impact/benefit for the region. Information about the expected cost of each project is also provided, which will be used to calculate individual benefit/cost ratios in section 5.4.

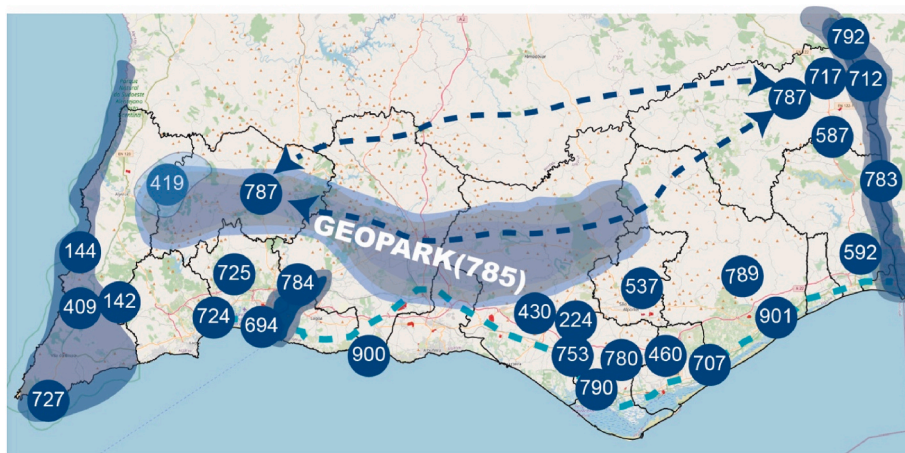


Fig. 7. Territorialization of differentiating projects.

represented a major challenge, as there were more than 700 projects to be assessed in a context of uncertainty that had to account for the views of sixteen different policy makers. To tackle such complexity, the research team used a MCDA approach to support the decision-making process. The fact that the MCDA approach allowed the integration of several heterogeneous measures into a single indicator of the overall performance of each project is considered a very valuable contribution. Furthermore, the MCDA approach is also transparent and easy to use, allowing decision-makers to clearly see how, via an aggregative model, their beliefs and preferences turned into composite indicators of overall

performance. The fact that the technique allowed to explicitly address the trade-offs between the different points of view of the decision makers was also valuable. Given that these points of view represent the interests of different stakeholders, their scoring and weighing was a collective process that provided an opportunity for the working group to learn about the problem situation and about the values and priorities of the different participants. Finally, the use of the MCDA approach enabled the decision-makers to develop an explicit evaluation process, which can be used to justify and explain to others (e.g., Government or electors) why a particular project was selected over some other possible

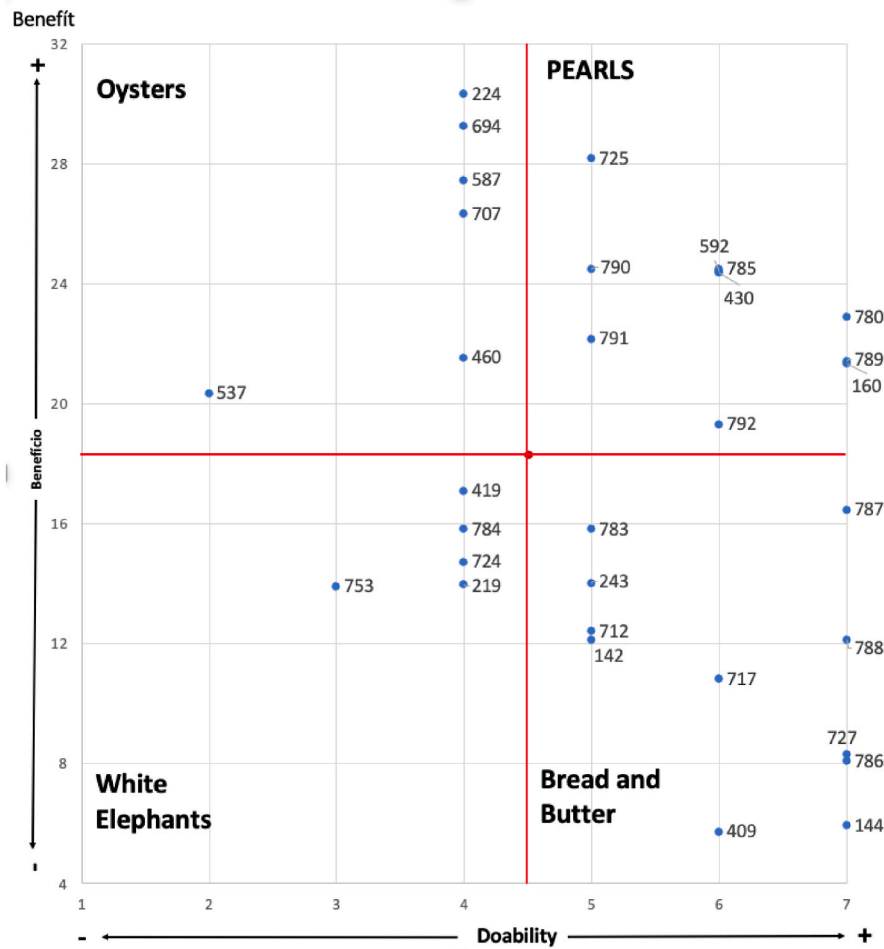


Fig. 8. Benefit versus doability graph.

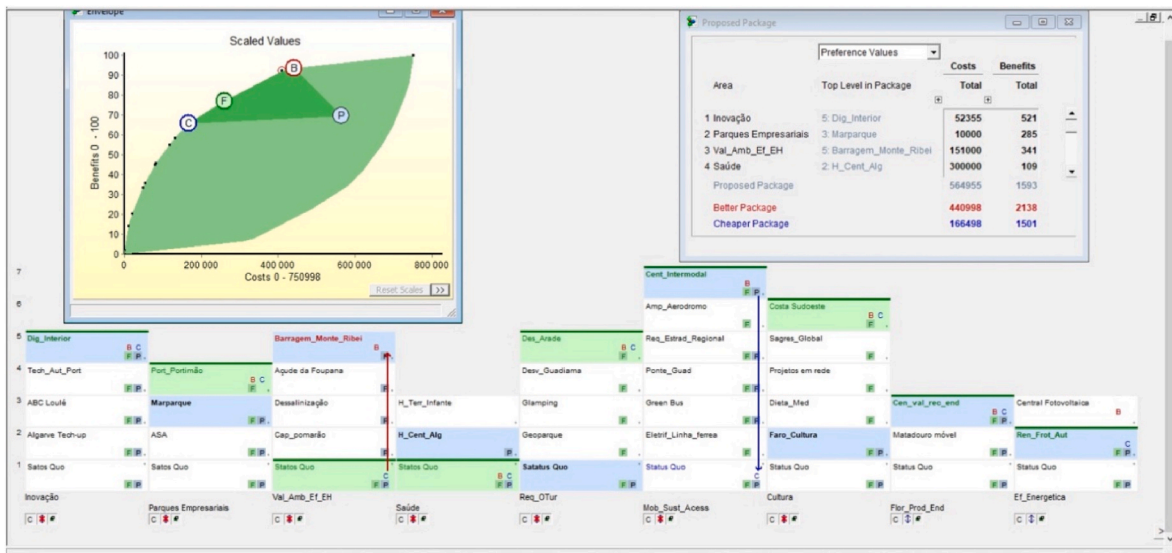


Fig. 9. Prioritizing the differentiating projects without budget limits with the Equity software.

alternatives.

However, the process was not without its own challenges. It is well known that the results of the evaluation of competing projects always generates some controversy. This was a very important issue given this

paper’s delicate political context, with each of the decision-makers intending to secure the largest possible investment for his/her respective council. Hence, the results of the evaluation had to be intensely discussed and scrutinized. By using the M-MACBETH software, the

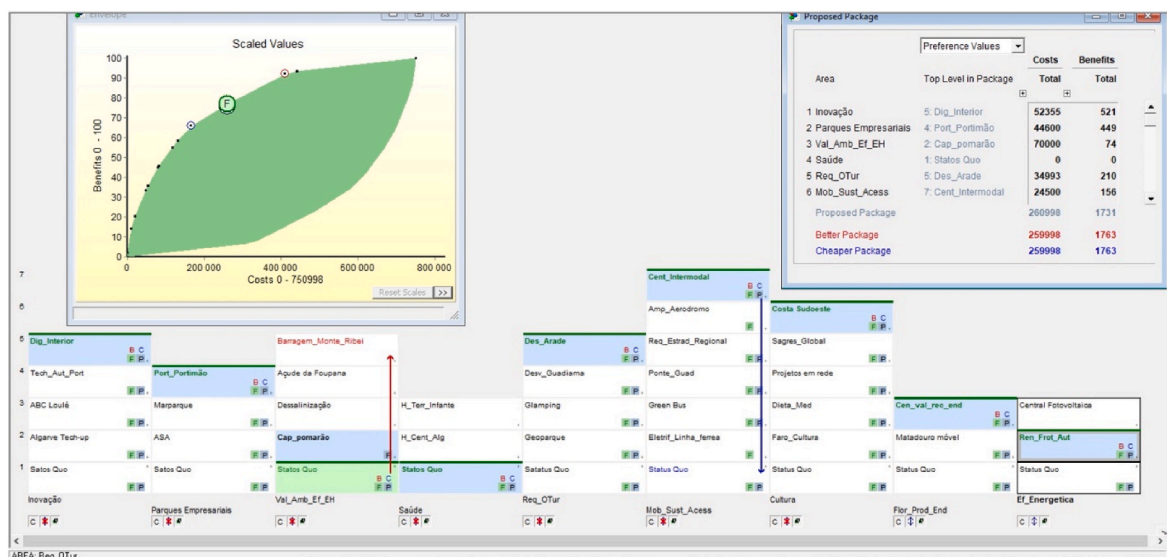


Fig. 10. Prioritizing the differentiating projects considering the expected budgetary limit with the Equity software.

authors were able to explain, whenever doubts emerged, how the MCDA methodology was applied to produce the results. On a few occasions, some adjustments had to be made to better reflect the additional knowledge that emerged from the on-going discussion with the different decision-makers. It was interesting to observe that those who, at the beginning of the process, were less cooperative and showed more distrust about the likely outcome of the process, took a much more active role once they understood the process and the methods that were being employed.

In addition to assessing the benefit of each project of interest, the research team was also tasked with their prioritization according to the expected benefits, costs and doability. This phase was carried out through the joint use of two tools: the Equity software and the benefit versus doability graph. This represented an important departure from other studies in this area, which tend to prioritize investments only based on one of these tools. From our intervention, we realized that Equity is an important tool to support this type of procedure since, when combined with the MCDA methodology, it can help improve the communication between facilitators and decision-makers and increase confidence on the results. However, while this tool can promote the implementation of a participatory and efficient process in terms of resource allocation, as it suggests the ordering of the projects according to their benefit/cost ratio, it does not account for the difficulty in implementing the projects (i.e., their doability). To address this issue, a benefit versus doability graph was employed, which allows accounting not only for the benefits and costs of the projects, but also for their likely easiness of implementation. Making a combined use of these tools, the research team was able to identify the package of projects with the most significant possible benefit, given the existing budget constraints and considering their doability.

Overall, the present case study provides further evidence that a combination of the MCDA approach with other tools can assist decision-makers to arrive at a consistent, credible and justifiable answer/solution for the elaboration of territorially-based strategies. While a solution meeting these characteristics is always desirable, it is particularly critical at moments like the ones experienced during the COVID-19 pandemic, where proper solutions to build a region's resilience are critical. The process and tools used in this study seem particularly important to evaluate each of the proposals accurately and to demonstrate, objectively, the reasons why a given one is better than another, something the traditional methodologies of strategic planning are unlikely to do.

We would like to highlight, however, that the approach proposed

here is not without limitations and weaknesses. For instance, it is inherently subjective in the choice of fundamental points of view or evaluation criteria, and also on the scoring and weighting of these points of view, which means that different actors could eventually have reached a different outcome to the one discussed here. While this subjectivity can be identified as a limitation, it is important to bear in mind that all decision making is subjective and that one of the main advantages of using a MCDA approach is precisely in making this subjectivity explicit and in integrating it, in a transparent and consistent manner, with objective data. Second, the proposed approach is founded on some strong assumptions about the decision maker's preferences, including transitivity, preference independence and summation. However, these assumptions are made to guide the decision-makers to a more consistent and rational thought process. Third, the amount of time and effort required to develop and use an approach like the one described here should not be underestimated. The case study methodology, which this paper resorts to, also has limitations of reliability and validity, providing little basis for statistical generalizations. However, the opportunity this methodology offers to examine, in-depth, the phenomenon under study and to cover contextual conditions, represents an advantage over other methods in accomplishing the objectives of the research documented here. Another limitation of our study is that it is unclear to what extent the intervention of the local government supported by this paper will help drive change in the economic structure of the Algarve as this is contingent on the final set of projects that will ultimately be implemented. Yet, this is a theme that merits further research in the future.

While limitations and implementation challenges exist, the conceptual validity of the process proposed in this paper, taken together with the feedback received from the mayors involved, suggests that these can be addressed and that, in appropriate circumstances, significant benefits can be gained from the general principles highlighted in the present case study for developing a territorially-based strategy. In particular, the evidence collected shows that the approach we have adopted should be encouraged as a forum for discussion and consequently, as a means of improving understanding about the problem faced, about the values and objectives of the different stakeholders and about regional priorities. The engagement of a skilled facilitator/analyst, who is knowledgeable about the methods used and skilled in managing group processes is, however, strongly advised. Importantly, given that the process adopted in this paper is documented in detail, it can be replicated in future studies. In particular, besides testing the usefulness of the approach proposed here in other contexts and using other MCDA methods, further

research could also look at the development of methods to assess the successful implementation of the selected projects.

Credit author statement

Luís Gomes: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – original draft, Project administration. **Sérgio Santos:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – review & editing. **Luís Coelho:** Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Writing – review & editing. **Efigénio Rebelo:** Supervision, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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References

- [1] Kaufman M, Leigh D. Global imbalances and the COVID-19 crisis. *International monetary fund*. <https://www.imf.org/pt/News/Articles/2020/08/04/blog-global-rebalancing-and-the-covid19-crisis>. [Accessed 22 October 2021].
- [2] INE. Censos 2011 resultados definitivos-Portugal. IP: Lisboa-Portugal: Instituto Nacional de Estatística; 2012.
- [3] World Travel Awards. World's leading destination. <https://www.worldtravelawards.com/award-worlds-leading-beach-destination-2020>; 2020, 5 of December.
- [4] INE. Anuário Estatístico de Portugal—2018. Lisboa, Portugal: Instituto Nacional de Estatística; 2019.
- [5] Von Winterfeldt D, Edwards W. *Decision analysis and behavioral research*. Cambridge: Cambridge University Press; 1986.
- [6] Belton V, Stewart T. *Multiple criteria decision analysis: an integrated approach*. Dordrecht: Kluwer; 2002.
- [7] Bana e Costa CA, De Corte JM, Vansnick JC. Macbeth. *Int J Inf Technol Decis Making* 2012;11(2):359–87.
- [8] Belton V. Multiple criteria decision analysis: practically the only way to choose. In: Hendry L, Eglese R, editors. *Operational research tutorial papers*. Birmingham: Operational Research Society; 1990. p. 53–101.
- [9] Goodwin P, Wright G. *Decision analysis for management judgement*. Chichester: John Wiley & Sons; 1998.
- [10] Ayyildiz E, Taskin A. A novel spherical fuzzy AHP-VIKOR methodology to determine serving petrol station selection during COVID-19 lockdown: a pilot study for Istanbul. *Socio-Economic Planning Sciences*; 2022. art. no. 101345.
- [11] Hassad de Andrade L, Moreira Antunes JJ, Araújo de Medeiros AM, Wanke P, Nunes BP. The impact of social welfare and COVID-19 stringency on the perceived utility of food apps: a hybrid MCDM approach. *Soc Econ Plann Sci* 2022;82: 101299.
- [12] Selerio Jr E, Caladad JA, Catamco MR, Capinpin EM, Ocampo L. Emergency preparedness during the COVID-19 pandemic: modelling the roles of social media with fuzzy DEMATEL and analytic network process. *Soc Econ Plann Sci* 2022;82: 101217.
- [13] Mohagheghi V, Mousavi SM, Antucheviciene J, Mojtahedi M. Project portfolio selection problems: a review of models, uncertainty approaches, solution techniques, and case studies. *Technol Econ Dev Econ* 2019;25(6):1380–412.
- [14] Bana e Costa CA, Vansnick JC. MACBETH—an interactive path towards the construction of cardinal value functions. *Int Trans Oper Res* 1994;1(4):489–500.
- [15] Rodrigues H. Hotéis algarvios que não “morreram” com a pandemia fecham com a “cura” [Hotels in Algarve that did not die because of the pandemics close their doors because of the cure]. *Sul Informação*; 2020. November 10, 2020. Accessed October 22, 2021: <https://www.sulinformacao.pt/2020/11/hoteis-algarvios-que-nao-morreram-com-a-pandemia-fecham-com-a-cura/>.
- [16] Giannakis E, Bruggeman A. Determinants of regional resilience to economic crisis: a European perspective. *Eur Plann Stud* 2017;25(8):1394–415.
- [17] Roper S, Turner J. R&D and innovation after COVID-19: what can we expect? A review of prior research and data trends after the great financial crisis. *Int Small Bus J* 2020;38(6):504–14.
- [18] Liu Z, Ma R, Wang H. Assessing urban resilience to public health disaster using the rough analytic hierarchy process method: a regional study in China. *Journal of Safety Science and Resilience* 2022;3(2):93–104.
- [19] Rezaei Soufi H, Esfahanipour A, Akbarpour Shirazi M. A quantitative approach for analysis of macroeconomic resilience due to socio-economic shocks. *Soc Econ Plann Sci* 2022;79:101101.
- [20] Bristow G, Healy A. Regional resilience: an agency perspective. In: *Handbook on regional economic resilience*. Edward Elgar Publishing; 2020.
- [21] Peng C, Yuan M, Gu C, Peng Z, Ming T. A review of the theory and practice of regional resilience. *Sustain Cities Soc* 2017;29:86–96.
- [22] Rose A, Lim D. Business interruption losses from natural hazards: conceptual and methodological issues in the case of the Northridge earthquake. *Global Environ Change B Environ Hazards* 2002;4(1):1–14.
- [23] Polèse M. *The wealth and poverty of regions*. In: *The wealth and poverty of regions*. University of Chicago Press; 2010.
- [24] Dabson B, Heflin C, Miller K. *Regional resilience. Research and policy brief, RUPRI, rural futures lab, Harry S. Truman School of public affairs*. University of Missouri; 2012.
- [25] Martin R, Sunley P. On the notion of regional economic resilience: conceptualization and explanation. *J Econ Geogr* 2015;15(1):1–42.
- [26] Mainali R, Tosun MS, Yilmaz S. Local response to the COVID-19 pandemic: the case of Nepal. *Publ Adm Dev* 2021;41(3):128–34.
- [27] Jehle G, Reny P. *Advanced microeconomic theory*. second ed. Pearson; 2001.
- [28] Bourne R. ‘Market failure’ arguments are a poor guide to policy. *Econ Aff* 2019;39(2):170–83.
- [29] Mazzucato M, Ryan-Collins J. Putting value creation back into “public value”: from market-fixing to market-shaping. *Journal of Economic Policy Reform* 2022;25(4): 345–60.
- [30] Chaparro XA, Gomes LA, Nascimento PT. The evolution of project portfolio selection methods: from incremental to radical innovation. *Revista de Gestão* 2019; 26(3):212–36.
- [31] Archer NP, Ghasemzadeh F. An integrated framework for project portfolio selection. *Int J Proj Manag* 1999;17(4):207–16.
- [32] Iamratanakul S, Patanakul P, Milosevic D. Project portfolio selection: from past to present. *Proceedings of the 2008 IEEE ICMIT 2008*:287–92.
- [33] Mintzberg H. Rethinking strategic planning part I: pitfalls and fallacies. *Long Range Plan* 1994;27(3):12–21.
- [34] Bana e Costa CA, da Costa-Lobo ML, Ramos IA, Vansnick JC. Multicriteria approach for strategic town planning. In: Bouyssou D, Jacquet-Lagrèze E, Perny P, Stowiński R, Vanderpooten D, Vincke P, editors. *Aiding decisions with multiple criteria*. International series in operations research & management science, vol. 44. Boston, MA: Springer; 2002. https://doi.org/10.1007/978-1-4615-0843-4_19.
- [35] Bana e Costa CA, Fernandes TG, Correia PVD. Prioritisation of public investments in social infrastructures using multicriteria value analysis and decision conferencing: a case study. *Int Trans Oper Res* 2006;13:279–97.
- [36] Mitcham J, Keisler J. Multi-attribute COVID-19 policy evaluation under deep uncertainty. *Ann Oper Res* 2022. <https://doi.org/10.1007/s10479-022-04592-9>.
- [37] Ramos IAJ. *Metodologia multicritério de apoio à decisão*. Aplicação ao plano estratégico de uma cidade média. A experiência de Barcelos [Multicriteria decision support methodologies: the case of strategic plan of Barcelos city]. Doctoral dissertation, Faculdade de Arquitectura de Lisboa; 1996.
- [38] Phillips LD, Bana e Costa CA. Transparent prioritisation, budgeting and resource allocation with multi-criteria decision analysis and decision conferencing. *Ann Oper Res* 2007;154(1):51–68.
- [39] Bana e Costa CA. *Struturação, Construção et Exploitation d’un Modèle Multicritère d’Aide à la Decision [Struturação, Construction and Exploitation of a Multicriteria Decision Analysis Model]*. In: PhD thesis. Lisboa: Instituto Superior Técnico, Universidade Técnica de Lisboa; 1992.
- [40] Stewart TJ, Durbach I. Dealing with uncertainties in MCDA. In *Multiple criteria decision analysis*. New York, NY: Springer; 2016. p. 467–96.
- [41] Calache LDDR, Zanon LG, de Souza Feitosa ISC, Arantes RFM, Carpinetti LCR. Multicriteria techniques for consensus in group decision making: a literature review. *Int J Appl Decis Sci* 2021;14:661–88.
- [42] Bana e Costa CA, De Corte JM, Vansnick JC. On the mathematical foundations of MACBETH. In: Figueira J, Greco S, Ehrgott M, editors. *Multiple criteria decision analysis: the state of the art surveys*. New York: Springer; 2005. p. 409–42.
- [43] Kaner S. *Facilitator’s guide to participatory decision-making*. John Wiley & Sons; 2014.
- [44] Bana e Costa CA, Vansnick JC. The MACBETH approach: basic ideas, software and an application. In: Meskens N, Roubens M, editors. *Advances in decision analysis*, vol. 4. Dordrecht, Book Series: Kluwer Academic Publishers; 1999. p. 131–57. *Mathematical Modelling: Theory and Applications*.
- [45] Ferreira FA, Santos SP. Two decades on the MACBETH approach: a bibliometric analysis. *Ann Oper Res* 2021;296(1–2):901–25.
- [46] Greco S, Figueira J, Ehrgott M. *Multiple criteria decision analysis*. Berlin/Heidelberg, Germany: Springer; 2016.
- [47] Weistroffer HR, Li Y. *Multiple criteria decision analysis software*. In: Greco S, Figueira J, Ehrgott M, editors. *Multiple criteria decision analysis*. Berlin/Heidelberg: Springer; 2016. p. 1301–41.
- [48] Leoneti AB. Utility function for modeling group multicriteria decision making problems as games. *Operations Research Perspectives* 2016;3:21–6.
- [49] Weber M, Borcherding K. Behavioral influences on weight judgments in multiattribute decision making. *Eur J Oper Res* 1993;67(1):1–12.

- [50] Ananda J, Herath G. A critical review of multi-criteria decision making methods with special reference to forest management and planning. *Ecol Econ* 2009;68(10): 2535–48.
- [51] Mingers J, Rosenhead J. Problem structuring methods in action. *Eur J Oper Res* 2004;152:530–54.
- [52] Eden C, Ackermann F. SODA—the principles. In: Rosenhead J, Mingers J, editors. *Rational analysis for a problematic world revisited: problem structuring methods for complexity, uncertainty and conflict*. second ed. Chichester: John Wiley & Sons; 2001. p. 21–41.
- [53] Ackermann F. Participants' perceptions on the role of facilitators using group decision support systems. *Group Decis Negot* 1996;5(1):93–112.
- [54] Eden C. Cognitive mapping. *Eur J Oper Res* 1988;36:1–13.
- [55] Eden C. Analyzing cognitive maps to help structure issues or problems. *Eur J Oper Res* 2004;159:673–86.
- [56] Eden C, Ackermann F. Cognitive mapping expert views for policy analysis in the public sector. *Eur J Oper Res* 2004;152:615–30.
- [57] Belton V, Ackermann F, Shepherd I. Integrated support from problem structuring through to alternative evaluation using COPE and V-I-S-A. *J Multi-Criteria Decis Anal* 1997;6(3):115–30.
- [58] Montibeller G, Belton V, Ackermann F, Ensslin L. Reasoning maps for decision aid: an integrated approach for problem-structuring and multi-criteria evaluation. *J Oper Res Soc* 2008;59(5):575–89.
- [59] Ferreira FA, Santos SP, Rodrigues PM. Adding value to bank branch performance evaluation using cognitive maps and MCDA: a case study. *J Oper Res Soc* 2011;62(7):1320–33.
- [60] Santos SP, Belton V, Howick S, Pilkington M. Measuring organisational performance using a mix of OR methods. *Technol Forecast Soc Change* 2018;131: 18–30.
- [61] Pinto BMB, Ferreira FAF, Spahr RW, Sunderman MA, Pereira LF. Analyzing causes of urban blight using cognitive mapping and DEMATEL. *Ann Oper Res* 2022. <https://doi.org/10.1007/s10479-022-04614-6>.
- [62] Keeney RL. *Value-focused thinking: a path to creative decision making*. Cambridge: Harvard University Press; 1992.
- [63] Marttunen M, Lienert J, Belton V. Structuring problems for Multi-Criteria Decision Analysis in practice: a literature review of method combinations. *Eur J Oper Res* 2017;263(1):1–17.
- [64] Bana e Costa CA, Ensslin L, Corrêa EC, Vansnick JC. Decision support systems in action: integrated application in a multicriteria decision aid process. *Eur J Oper Res* 1999;113:315–35.
- [65] Bana e Costa CA, Vansnick JC. Applications of the MACBETH approach in the framework of an additive aggregation model. *J Multi-Criteria Decis Anal* 1997;6(2):107–14.
- [66] Bana e Costa CA, Chagas MP. A career choice problem: an example of how to use MACBETH to build a quantitative value model based on qualitative value judgments. *Eur J Oper Res* 2004;153(2):323–31.
- [67] Lourenço JC, Bana e Costa CA, Morton A. Software packages for multi-criteria resource allocation. In: 2008 IEEE international engineering management conference. IEEE; 2008. p. 1–6.
- [68] Montibeller G, Franco LA. Resource allocation in local government with facilitated portfolio decision analysis. In: *Portfolio decision analysis*. New York, NY: Springer; 2011. p. 259–81.
- [69] Cuadrado-Roura JR, Maroto A. Unbalanced regional resilience to the economic crisis in Spain: a tale of specialisation and productivity. *Camb J Reg Econ Soc* 2016; 9(1):153–78.
- [70] Bana e Costa CA, Lourenço JC, Oliveira MD, Costa JCB. A socio-technical approach for group decision support in public strategic planning: the Pernambuco PPA case. *Group Decis Negot* 2014;23(1):5–29.

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