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Allocation of Residential Areas in Smart Insular Communities:
The Case of Mykonos, Greece

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ABSTRACT

Smart cities and communities constitute urban environments where cities' potential, ICTs, and human capital are intelligently interconnected under the framework of sustainability. Citizens form a city's identity while ICTs support the smart management of citizens' needs. 'Smart people' is among the main dimensions of a smart city, something that entails the active role of citizens during the development of infrastructures and decision-making processes. This paper focuses on the smart exploration of possible residential areas in the island of Mykonos (Greece). Emphasis is placed on the effective management of land, the protection of natural resources, and the establishment of a sustainable pattern of housing development. The problem is analysed with the support of a methodological approach that incorporates crowdsourcing, living labs, and participatory evaluation as the main components of its backbone. Geographical Information Systems and multi-criteria decision analysis are also utilized as an integrated Spatial Decision Support System.

KEYWORDS

Crowdsourcing, GIS-Based MCDA, ICT, Living Labs, Participatory Evaluation, Smart Cities, Sustainable Planning

INTRODUCTION

Smart cities and communities have already become a dominant trend supporting sustainable urban development through the exploitation of innovative ICT applications and infrastructures. Under this framework issues such as economic prosperity, social development, sustainable management of the available resources and standards of living are dealt under the concept of 'smartness'. This implies the adoption of ICTs in order to support city functions and the inclusion of citizens in a smart urban environment. The majority of smart city definitions integrate concepts like 'smart economy', 'smart people', 'smart environment', 'ICT infrastructure', 'intelligent development', 'ICT-based solutions', 'smart collaboration', etc. (Caragliu, Del Bo & Nijkamp, 2009; Dameri, 2013; Giffinger et. al, 2007; Meijer & Bolivar, 2015; Neirotti et al., 2014). Despite the fact that a general definition, corresponding to all kinds of cities, has not been found yet, such concepts are used to indicate the *"transition from a world of materials and energy to the one of data and information"* (Batty, 2017, p.5). Data and

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information cut horizontally all dimensions of a smart city and are constantly incorporated in almost any function that takes place in the city.

The concept of 'smartness' concerns not only large metropolitan areas and cities but also smaller communities such as rural regions and islands. Smart rural development entails the reinforcement of innovation, knowledge background and local skills. It may also be seen as an important factor having the potential to enhance sustainability in rural regions through the elimination of digital divides, the adoption of new technologies by the agricultural and tourist sectors, the effective management of natural resources by exploiting ICTs, the development of smart rural economies and the inclusion of rural population in efforts aiming at 'smart transition'.

Islands are often perceived as rural regions with particular features due to their insular character. In many cases they are remote areas, located far from urban centres and facing problems of accessibility, availability of resources, lack of health infrastructures, etc. Tourism is a dominant economic sector in the majority of islands, worldwide. This entails the need for accommodation infrastructures and facilities and the consequent exertion of pressures on natural resources such as water, land and energy, specifically during the peak tourist season. In this context, housing development and suitable site selection becomes extremely important not only in cases of dense-populated urban areas but also in smaller communities, facing similar problems due to the seasonal and massive population flows.

Islands in the Aegean and Ionian Sea constitute an indicative case in Greece. The majority of them are small-scaled islands with limited natural resources and high rates of tourist development. Housing development and coverage of accommodation demand becomes a great challenge due to the limited space; the specific terms and conditions regulating the building sector, and the legislative framework concerning the sustainable management of natural and cultural resources and the protection of local identity. Smart real estate and smart management of land uses may contribute to the sustainable development of residential areas and the reduction of pressures put on natural resources, especially in islands with significant tourist flows and high demand of housing infrastructures.

Mykonos is a representative example, being a small island in the Aegean Sea that faces the problem of increased accommodation demand especially during the summer. Some preliminary steps towards its transition into a smart community have already taken place. Mykonos belongs to a smart network of islands, the 'DAFNI Network of Sustainable Greek Islands' that hosts about 40 island municipalities (DAFNI, 2019). Among the main priorities of the DAFNI network, are (DAFNI, 2019): the establishment of low carbon local economies; the design and implementation of smart solutions in the sectors of water, energy, mobility, etc.; the enhancement of participative actions; the sustainable management of natural and cultural resources; the sustainable development of the tourist sector, and; the promotion of investments. In this context Mykonos, along with other Greek islands, will have the opportunity to build a 'smart profile' by exploiting ICTs and relevant innovations in order to confront existing multifaceted problems and design their future development. The effective use of resources and the management of pressures put on natural environment are critical factors that should be taken into account. Addressing such a problem through the adoption of a 'smart rationale' may contribute to the generation of eco-friendly and sustainable solutions.

This paper focuses on the participatory evaluation of suitable sites for the development of residential areas in Mykonos, in the context of a living lab and, with the support of crowdsourcing techniques and the exploitation of Geographical Information Systems (GIS). Emphasis is placed on reinforcing 'smart people' dimension in the living lab environment where participants cooperate in order to evaluate the most suitable areas for housing development, through the adoption of crowdsourcing and GIS-based Multi-Criteria Decision Analysis (MCDA). The living lab intends: firstly, to train the participants on a theoretical level; secondly, to train the participants on available tools supporting the evaluation process; and thirdly, to implement the benchmarking process per se. Towards this end, a case study is presented, highlighting the advantages that both technological advancements and social inclusion may bring. The goal is the assessment of site options in order possible residential areas to be explored. Such options should satisfy a number of prerequisites and restrictions regarding natural and cultural environment, landscape, traditional character of the island and preferences of stakeholders. The research is based on a profound investigation of all factors related to housing development, stakeholders' engagement, the exploitation of relevant technologies and the establishment of a 'smart agenda' under which the specific problem is dealt. The fact that the island of Mykonos belongs to a broader network of smart islands reinforces the implementation of the proposed approach and the use of respective tools. The concepts of crowdsourcing, living labs and GIS-based MCDA are intertwined and an extensive participatory exercise takes place.

More analytically, stakeholders, representatives of local administration, real estate groups, citizens, tourist operators and representatives of environmental agencies, were invited to participate in a living lab in order to explore the most suitable areas for housing development. The living lab consisted of two main sessions. The first (rehearsal) session concerned the training of stakeholders on issues related to spatial/GIS-based MCDA. Also, a broad discussion between stakeholders and experts took place in order to exchange experience on housing development and deepen their knowledge stock. The second session concerned the application of a field exercise where stakeholders, through crowdsourcing and GIS-based MCDA, evaluated the suitability of possible areas for housing development on the basis of a number of evaluation criteria.

Such a venture intended to stress: a) the additive value that smart technologies may bring in the sustainable management of land uses and b) the benefits of participatory planning in eliciting broadly-accepted solutions and establishing synergies. In other words, this paper attempts to cover existing knowledge gaps in Greece by exploring relevant research questions that concern the utility of participatory/bottom-up approaches, the necessity for the smart transition of small-scaled communities and the advantages that crowdsourcing, living labs and GIS-based MCDA may bring when formulating spatial decisions. Accordingly, key issues, deeply explored, include the main reasons indicating the need for stakeholders' involvement in seeking suitable residential areas, the attainment of broad convergences, the choice of widely accepted solutions and the enhancement of knowledge dissemination and sharing.

THEORETICAL BACKGROUND

Substantive efforts, aiming at the smart transition of large metropolitan areas and smaller communities, have significantly been proliferated during the last two decades. Some typical examples include the smart cities of Amsterdam, New York, Tokyo and Singapore; the medium-sized urban areas of Belfort (France), Jelgava (Latvia) and Kalasatama (Finland), and the smart villages of Dharnai (India) and Túristvándi (Hungary).

Seventeen years before, the establishment of smart communities in certain small islands in the Caribbean began by promoting e-Governance actions as a first step towards being 'smart' (Sealy, 2003). Issues like social digital divides, access to the internet and the need for (Multi) Community Access Centres and telecentres raised (Sealy, 2003). In more recent years, the development of smart microgrid systems in rural communities for enhancing the 'smart energy' dimension (Alvial-Palavicino, 2011; Ubilla et al., 2014); the adoption of e-commerce practices for promoting local products (Maumbe & Brown, 2013); the development of smart tourism in rural regions and islands (Garau, 2015); the creation of climate-smart landscapes supporting mitigation and adaptation purposes (Scherr, Shames & Friedman 2012), and; the promotion of smart energy grids in islands (Sigrist et al., 2017) represent indicative priorities having been set for the smart transformation of rural and insular regions.

A critical issue that should be pointed out is that of smart specialisation. Smart specialisation is strongly related to the specific characteristics and needs of each region in order local problems to be confronted. Such a perspective requires the establishment of place-specific innovation policies (Naldi et al., 2015) that reflect local priorities, address specific needs, strengthen rural economy and enhance social cohesion. Smart specialisation corresponds directly to such a prerequisite, implying the establishment of a localised-oriented pattern of smart development based on the deep understanding of local characteristics, the parameters shaping local identity, the needs of local population, the comparative advantages and peculiarities of each region.

Smart-specialised solutions are proposed in many cases for the integrated development of islands, the organisation of tourism, the effective management of natural and cultural resources, the satisfaction of tourist needs and the engagement of local communities in the decision-making process. The exploitation and enrichment of big data by local communities (Chamberlain, Malizia & Dix, 2013); the establishment of smart energy supply distribution networks (Morales et al., 2017), and smart tourism specialisation (Croes, 2013) are some typical cases.

In Europe, the so-called 'Smart Islands Initiative' has been established as a bottom-up effort of European islands and communities. According to the aspirations of such initiative, islands are territories the future development of which should be based on: the confrontation of climate change impacts; the sustainable economic development; the upgrading of standards of living through the adoption of ICTs, and; the implementation of smart and integrated solutions aiming at the effective management of natural environment and infrastructures (Smart Islands Initiative, 2019). From such a perspective, islands may be transformed into living labs where knowledge diffusion and innovation production in the sectors of energy, transport, water, waste, governance, ICT and economy will take place (Smart Islands Initiative, 2019).

Among the several issues having been investigated in the smart city context, is that of citizens' participation in the efforts towards the development of city's 'smart dimensions', the use of ICTs for serving their needs and the management of possible digital divisions. Citizens represent the core and fundamental 'element' of each city and the majority of them is willing to participate in relevant activities in order best solutions to their problems to be explored. However, they need to be trained and indulge into adopted technologies and practices so that synergies to be created for mitigating emerging problems. Participatory planning, for example, supports the creation of broad collaborative schemes and partnerships and promotes co-design and co-decision processes (Papadopoulou & Giaoutzi, 2017). Crowdsourcing, living labs and participatory evaluation play a profound role in integrating knowledge and innovation emanating from scientists, policy makers, private organizations, NGOs and citizens, while; GIS allow for the mapping of physical reality into a virtual environment and contribute to the management of spatial functions in sectors like transportation, land use, planning, etc. (Tao, 2013).

More specifically, crowdsourcing sets the ground for the participation of 'crowd' in a problem-solving process; a 'cyber or live-brainstorming' exercise where ideas and solutions to published problems are proposed. Living labs enhance the creation of innovation synergies aiming at the design of useful and innovative products. On the other hand, participatory evaluation refers to the multifaceted assessment of a problem that contributes to the integration of knowledge, experience and expertise while it offers additional validity to the evaluation of outcomes due to the inclusion of different perspectives (Campilan, 2000). In such a process, several interested parts cooperate so that proposed alternatives to be evaluated. The alternative with the highest score is the one that suits best to the problem analysed and the most preferred by the majority of participants. Thereby, the role of participants is empowered through a knowledge exchange process and an active involvement in the whole evaluation attempt (Cousins & Whitmore, 1998). Finally, GIS support the collection, storage, manipulation and analysis of spatial data. In many cases, a Geographical Information System is part of an integrated Spatial Decision Support System (SDSS) enabling the management of spatial data and the design of robust spatial-referenced solutions. Through its visualization capabilities, it helps users to better understand the spatial dimension of a problem and the efficiency of the proposed solutions. Participatory-GIS (PGIS) and Public Participatory GIS (PPGIS) embody the participatory dimension and enable the simultaneous use of spatial methods/tools and participatory planning technologies (Brown & Fagerholm, 2015; Rambaldi et al., 2006; Sieber, 2006). Moreover, GIS allow for the application of several spatial MCDA methods, supporting the effective management of geo-referenced alternatives and criteria and enhancing the exploration of spatial relationships.

Based on such theoretical background, the current analysis seeks to mobilize the local community of Mykonos by encouraging its active participation in a decision-making process, concerning the investigation of possible residential areas in the island. A smart approach is adopted, engaging the concepts of living labs, crowdsourcing and GIS-based MCDA in an effort to explore possible solutions for a case-specific problem.

Crowdsourcing and Living Labs

Crowdsourcing is based on the establishment of a digital community that offers solutions to a published problem (Gatautis & Vitkauskaite, 2014; Whitla, 2009). It presupposes the massive participation of the crowd and aims at collecting knowledge, prototypical ideas, targeted solutions and innovative content. In other words, crowdsourcing results in the exploitation of 'Masscapital' (Garrigos-Simon & Narangajavana, 2015) during problem solving.

Living labs enable synergetic innovation production through the exploitation of ICTs and citizens involvement (Eriksson, Niitamo & Kulkki, 2005). They represent open innovation laboratories where stakeholders, scientists, experts and citizens cooperate in order to collaboratively create new products that will serve their needs (Papadopoulou & Giaoutzi, 2017). Furthermore, they promote user-driven innovation while the final products are close to the interests of cities (Schaffers et al., 2011). User-driven innovation constitutes one of the main principles characterizing living labs (Hielkema & Hongisto, 2012), being *"incubators for innovation and knowledge"* (Letaifa, 2015, p. 1416). Issues dealt within a living lab may concern several sectors such as cities' sustainable development, the establishment of low carbon economies, the building sector, the management of landscape, etc. (Voytenko et al., 2016).

MCDA and Participatory Evaluation

Assessing alternatives lies at the core of the decision-making process where the prevailing one represents the most effective solution for a problem under study. Anyone may be compared to a decision-maker as any activity is the result of a decision (evaluation of possible choices) taking place either consciously or unconsciously (Saaty, 2008). Decision making presupposes the clear definition of the problem, the definition of goals, the description of alternative solutions, the determination of criteria upon which alternatives will be assessed as well as the engagement of several interested parts that may be affected by, or affect the final decision (Saaty, 2008). Decision making is a rather complex process due to: the large number of parameters that should be considered, the long-term time horizon that many problems incorporate and the number of stakeholders influencing and influenced by decision making.

Under this framework, MCDA represents a robust tool that systematises decision making at both managerial and practical level. It is preferred in cases where multiple criteria are used in order alternative solutions/scenarios to be evaluated. Such criteria are derived from the goals initially set and reflect the multiple perspectives of a problem. The stages of a MCDA are briefly the following (Bartolini et al., 2005; Hajkowicz, 2008; Nijkamp, Rietveld and Voogd, 1990; Voogd, 1982; Zavadskas & Turskis, 2011): Definition of the decision framework; definition of alternative solutions/scenarios; definition of evaluation criteria; evaluation of alternatives; analysis and interpretation of results, and; elicitation of conclusions. More generally, MCDA includes: the problem definition phase, the phase of analysis and the phase of reasoning. It is a learning process where each stage gives feedback to the following or even the precedent.

An important parameter for eliciting valid and remarkable results is the in-depth analysis of available knowledge and the exhaustive study of variables and factors involved in the problem. In this sense, experts' and stakeholders' engagement is of crucial importance as they put an additive value in the final outcome. The term 'participatory evaluation' has to do exactly with such a perspective. It is inherently linked to the participation of several interested parts in the evaluation process. The scope is the inclusion of additional information, the clarification of misunderstandings, the incorporation of experts' experience and expertise, the management of possible conflicts and the achievement of convergence. According to Cousins and Earl, *"participatory evaluation involves a partnership between trained evaluation personnel and practice-based decision makers; organization members with program responsibility or people with vital interest in the program"* (Cousins & Earl, 1992, p. 399). This means that the evaluation process becomes an open 'laboratory' where synergies, supporting knowledge exchange and co-building the final decision, are created.

Several terms like collaborative evaluation, stakeholder evaluation, etc. have been used to define participatory evaluation (Daigneault & Jacob, 2009) implying the undertaking of differentiated but in any case, similar participatory activities. The concept of 'judgment' is central and refers to either evaluators' or stakeholders'/participants' assessments as to the problem under study (Cousins & Chouinard, 2012). The adopted methods and techniques depend on the problem and the specific conditions under which participatory evaluation takes place. Economic, social, political and a number of various other parameters play a central role in framing the evaluation context (Chouinard, 2013) and constitute key drivers indicating possible participants in each evaluation process. Apart from the methods and techniques going to be used, participatory evaluation places emphasis on identifying stakeholders that should participate (Chouinard, 2013; Greene, 2000).

Thus, the key elements of participatory evaluation are (Chouinard and Cousins, 2015): *training*, strengthening participatory activities; the *evaluator*; the multilevel *context* of the whole process; the group of potential *participants*, and the *learning* dimension.

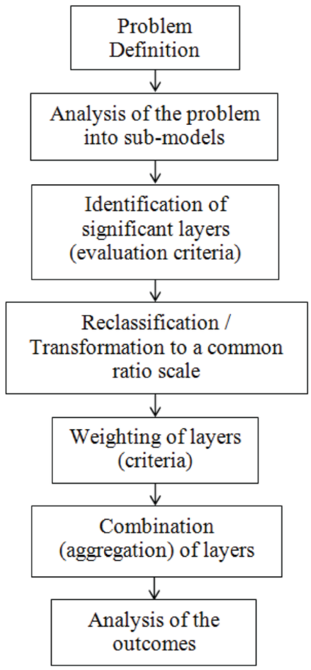
Spatial MCDA

Spatial MCDA addresses problems that incorporate the spatial dimension and involve the management of geo-referenced data. It places emphasis not only on the selection of the most suitable alternative but also on *where* such alternative will be implemented in the geographical space. It combines the advantages of conventional MCDA and spatial analysis and provides integrated solutions by allowing for: a) the exhaustive exploration of possible alternatives, b) their assessment on the basis of multiple criteria, c) the contemporaneous analysis of attribute (non-spatial) and spatial data and d) the visualization of the final decision (result). The key difference between conventional and spatial MCDA is the variability of: a) alternatives scores and b) criteria weights along the geographical space. This is due to the different characteristics of each geographical location (point). Slope for example has different values when moving from a hill to a plain. The same happens with the distance from settlements or the accessibility to the road network. Thus, assessing site suitability for the development of an activity is a very complex issue depending not only on the specific characteristics of such activity but also on the particular characteristics of the possible locations (receptors). For example, when seeking the most suitable site for constructing an industrial unit, criteria such as slope suitability, accessibility to raw materials, proximity to markets, distance from ecosystems, etc. are considered. In such a case, flat locations are preferred to the steeper ones; sensitive ecosystems are excluded, and areas close to raw materials and markets are prioritised.

Spatial MCDA is very popular among geographers and spatial planners. It is used in a wide range of applications concerning site suitability, spatial planning, risk assessment and allocation of resources. Some indicative applications include the: evaluation of flood damage reduction alternatives (Lim & Lee, 2009); experimental siting of artificial reef and spatial rearrangement of aquaculture production (marine planning) (Tammi & Kalliola, 2014); identification of the most preferable locations for the development of solar power plants and assessment of the relevant environmental impacts (Wanderer & Herle, 2015); landfill siting (Ferretti, 2011); healthcare facilities siting (Dell'Ovo, Capolongo, & Oppio, 2018), and; identification of coastal vulnerability hotspots due to climate change (Ishtiaque et al., 2019).

A significant number of Geographical Information Systems embody conventional MCDA tools and enable the assessment of site suitability and spatial allocation of activities/resources by: a) processing spatial data and b) exploiting MCDA algorithms. GIS take into consideration the unique characteristics of each point in the geographical space as well as the spatial variability of alternatives' scores and criteria weights (Lim & Lee, 2009; Malczewski, 1999; Malczewski & Rinner, 2015). Spatial MCDA is usually called 'Overlay analysis' implying the overlay of a set of layers (representing the evaluation criteria) and the generation of an integrated decision map through their combination. Alternatives (locations) are included in the respective layers (Malczewski & Rinner, 2015). The general steps of Overlay Analysis are presented in Figure 1.

Figure 1. The multiple stages of a GIS-based MCDA – Overlay analysis



Source: ESRI-ArcGIS online manual, 2019

Among the main MCDA methods having been incorporated in several GIS softwares are the Analytic Hierarchy Process (AHP), the Weighted Sum, the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), a number of fuzzy MCDA methods, etc.

METHODOLOGICAL BACKGROUND

In this section the methodological approach, adopted for the exploration of possible residential areas in the island of Mykonos, is presented. Its rationale builds on the concepts of crowdsourcing, living labs and MCDA, as well as on the active role of citizens in co-shaping the future development of 'their' city. Its main goal is to strengthen 'smart people' dimension in smart communities through the exploitation of collective intelligence, enabled by crowdsourcing (generation of prototypical ideas) and living labs (collaborative innovation) (Papadopoulou & Giaoutzi, 2017). The key axes of such an approach include: a) the extensive use of technology in smart communities and b) the exploitation of human capital in order to enhance participatory actions and collaborative initiatives. It consists of five distinct steps, namely (Papadopoulou & Giaoutzi, 2017):

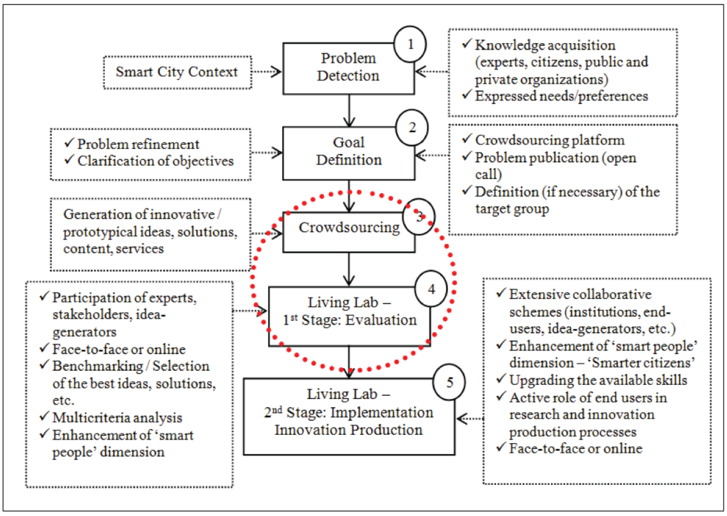
- **Problem detection:** The problem is clearly formulated through the exploitation of existing knowledge and experience;
- **Goal definition:** The problem is 'translated' into a goal to be achieved, it is further refined and specific objectives, playing an explanatory role, are defined;
- **Crowdsourcing:** The problem is outsourced; prototypical solutions and innovative ideas are gathered;
- **Living lab – Evaluation:** Alternative solutions gathered during the crowdsourcing stage are assessed with the support of MCDA. Living lab is an open laboratory where experts, stakeholders and citizens cooperate in order to select the most suitable solution;
- **Living lab – Implementation and innovation production:** This stage involves the creation of a broad collaborative scheme and boosts synergetic efforts through which the most suitable solution turns into an innovative product.

More specifically, the approach adopted, engages a series of scientific components and tools in an effort to investigate possible solutions to existing problems in smart cities and communities. Such components include participatory planning, supported by crowdsourcing and living labs, and MCDA; a robust tool for assessing alternatives on the basis of evaluation criteria, reflecting all aspects of the problem under study. The application of the approach presupposes the organisation of a living lab where several interested parts are invited or/and express their willingness to participate. Its implementation is rather flexible as it may be adapted to the specific needs of each case. For example, crowdsourcing may precede the living lab (1st Stage: Evaluation). In that case, a crowdsourcing platform is developed, a problem is outsourced, and possible candidate solutions are gathered. Then, the living lab is taking place where solutions are assessed and the most effective one is selected. However, crowdsourcing may also be incorporated in the living lab. In that case, the problem is presented in the living lab and solutions are suggested by participants. Regarding the evaluation process, the MCDA method that will be chosen, depends on the particular characteristics of each decision problem. Accordingly, the participants of the living lab have the chance to select, among a variety of available MCDA methods, the one that best suits to each specific case.

In the case of Mykonos, the aforementioned methodological approach was tested against a case study, concerning the exploration of possible site options for housing development. After detecting the problem and formulating the goal, the focus shifted on the implementation of the 3rd and 4th steps of the approach (see Figure 2 – red circle). The research team decided to merge such two steps as in Greece, the widespread use of crowdsourcing platforms is not so common yet and consequently, the majority of people has not discovered its benefits, something that entails limited trust and limited participation. This happens not only with crowdsourcing activities but also with many other attempts promoting participatory actions due to: a) the lack of awareness on issues concerning participatory planning and b) the absence of extensive participatory initiatives. Therefore, researchers along with some key stakeholders defined the problem and the goal to be pursued and decided to organize a face-to-face living lab in order to further analyse the issue at hand and seek possible solutions. The structure of the living lab is presented in Figure 3.

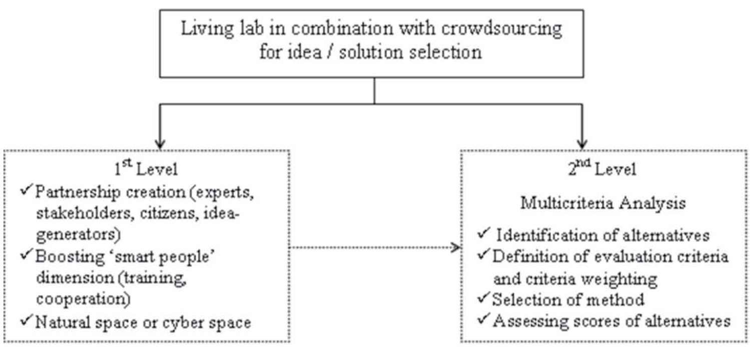
The living lab consisted of two separate sessions. The first one included: a) the creation of the partnership, b) an introductory discussion (exchange of opinions) on the problem under study and on the utility of crowdsourcing, living labs and MCDA in decision making and c) the training of participants on relevant methods and tools (GIS-based MCDA). The second session concerned the implementation of the evaluation process per se. The MCDA method selected, was the Weighted Sum GIS-based MCDA; a spatial MCDA method allowing for the visualization of alternatives and criteria and the exploration of spatial relations. The Weighted Sum tool was applied (ArcGIS software) in order to weight and combine multiple rasters under the framework of an integrated analysis (ESRI-ArcGIS online manual, 2019). Such tool allows for the overlay of several rasters based on a common measurement scale and weights each according to its importance (Tomlin, 1990). It is based on the

Figure 2. The adopted methodological approach



Source: Papadopoulou & Giaoutzi, 2017

Figure 3. The structure of the living lab



Source: Papadopoulou and Giaoutzi, 2017

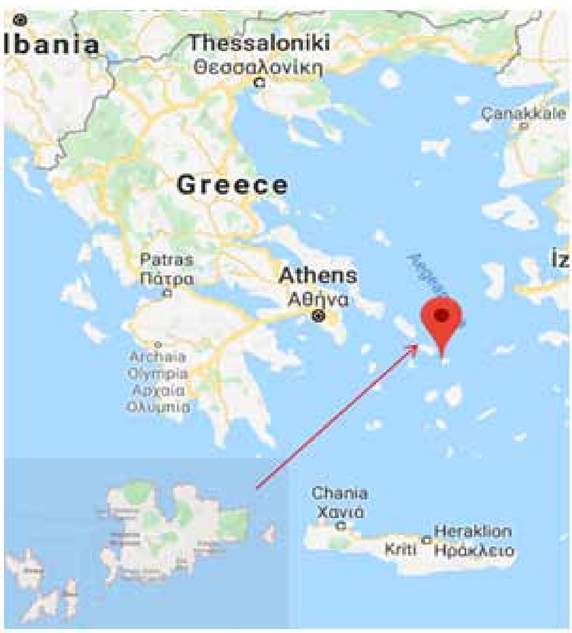
Weighted Sum algorithm where field values, having been determined for each raster, are multiplied by the specified weight. All rasters are summed and an output raster is created. The Weighted Sum tool operates only on raster data models and results in the creation of a map where high values represent the most suitable or desirable locations (Malczewski & Rinner, 2015). It should be mentioned that the MCDA process was performed under a participatory evaluation context as evaluation criteria and their weights were collaboratively defined.

DEVELOPMENT OF RESIDENTIAL AREAS IN MYKONOS: A LIVING LAB PERSPECTIVE

Historically Greece has experienced the lack of integrated spatial planning programmes and cadastre, officially regulating land uses. Along with the increasing demand for housing development, this resulted in an 'arbitrary' evolvement of residential areas that in many cases puts pressures on the environment. Except for the local population's housing needs, the tourist sector creates an additional demand for the development of tourist infrastructures and facilities especially in the case of islands. Tourism is a driving force for the Greek economy and supports in an extremely high degree the national GDP. Thus, special emphasis has been placed on serving its needs and improving the offered tourist services.

The Island of Mykonos: State of the Art

Aegean islands are an international tourist destination, attracting a high number of visitors every year. Moreover, there is a demand for summer/holiday residences by both endogenous and exogenous population. Mykonos is among the most popular Greek islands, ranked every year as one of the most preferred tourist destinations at a global scale. It attracts an extremely high number of tourists, especially during the tourist season (April-October). It is located in the Aegean Sea and belongs to the 'Cyclades' island complex (Map 1). Its area is about 86.125 km^2; its coastline is about 89 km (Municipality of Mykonos, 2019) and according to the most updated census data, its population is 10,134 inhabitants (Hellenic Statistical Authority, 2019). During the last twenty years the tourist development of Mykonos is tremendous, having already been started from 1960. Tourism is the dominant productive sector supporting local economy. Thus, a constantly increasing need for hosting facilities and infrastructures exists. The number of hotels and rental rooms has been multiplied at a high rate during the last decade while, a substantial demand for residential properties, mainly holiday residences, is taking place. Covering accommodation and housing needs is a critical challenge for the island due to: a) its limited space, b) the increasing housing demand, c) the pressures that housing sector puts on natural environment and d) the need to protect local identity:



Considering the aforementioned parameters as well as the potential of the island to be transformed into a living lab, an empirical study was carried out (October 2018) regarding the smart management of housing sector in Mykonos. Under this framework, the methodological approach presented above was implemented in the context of a case study. Stakeholders were engaged in order 'smart people' dimension to be strengthened, valuable knowledge to be elicited and preferences of the local community to be incorporated in the final result. A living lab was established, a crowdsourcing exercise took place and a participatory evaluation / spatial MCDA was implemented.

Preparation of the Empirical Case Study

The first (preparatory) step of our analysis included the identification of the problem and the formulation of the goal to be achieved. The problem concerned the effective management of housing needs in Mykonos and the respective goal referred to the sustainable development of residential areas in the island. The adoption of a smart approach for addressing such a problem seemed ideal as it may support the organisation of a living lab where relevant technologies, enhancing mutual understanding, participation, spatial analysis and visualisation, could be exploited and promote the smart perspective of the island.

The second step consisted of the organisation of the living lab. Possible participants were identified, and invitations were sent via e-mails to local stakeholders. Participants (totally 20) were separated into two main groups: a) experts on spatial MCDA and planning (2 participants) and b) local stakeholders. Among the stakeholders involved, were: representatives of local administration (4 participants), real estate groups (3 participants), citizens (inhabitants of Mykonos) (5 participants), tourist operators (3 participants) and representatives of environmental agencies (3 participants). The living lab consisted of two main sessions. The first (rehearsal) session concerned the training of stakeholders on issues related to spatial MCDA. Also, a broad discussion between stakeholders and experts took place in order to exchange experience on housing development. The additive value of crowdsourcing and living labs in seeking wide-accepted solutions was highlighted. The second session concerned the application of a field exercise where stakeholders, through crowdsourcing and GIS-based MCDA, evaluated the suitability of possible areas for housing development.

Implementation of the Empirical Case Study

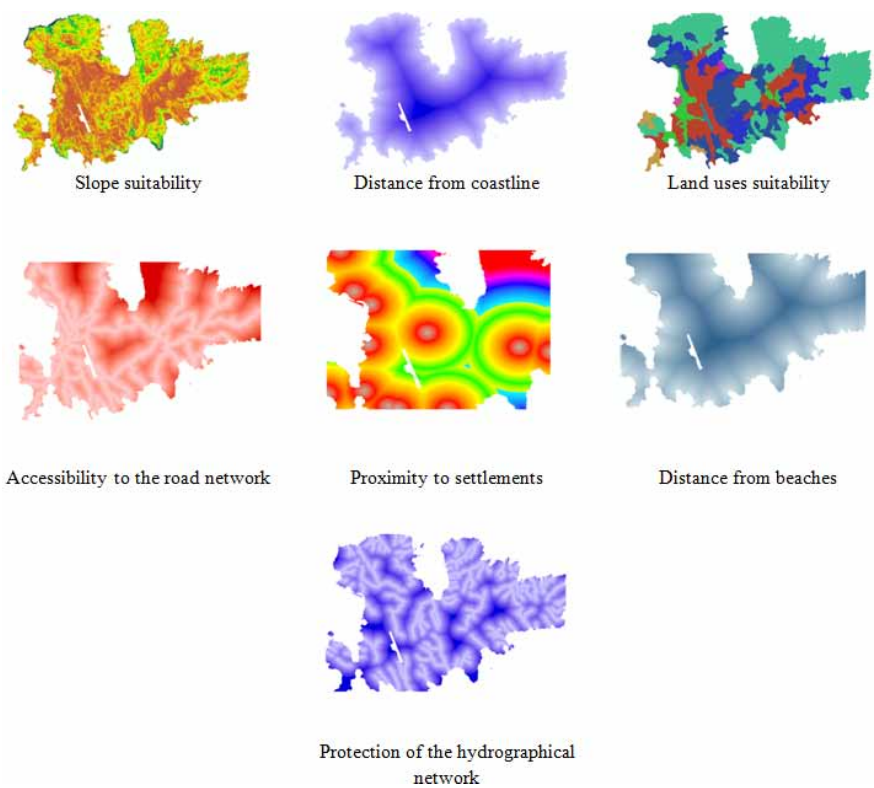
The implementation of the empirical case study in the living lab followed. An introductory session took place where several issues such as existing and future housing needs; reported problems; impacts of residential areas on natural and cultural resources; gained experience, and future perspectives of the housing sector were discussed. In the sequence, experts trained the participants on the functionality of GIS-based MCDA and the stages through which spatial MCDA evolves (see Figure 1).

The training aims included the clarification and thorough explanation of the concepts: alternative solutions, evaluation criteria and weights, alternatives' scores, spatial analysis, spatial variability of alternatives and criteria, selection of the most suitable alternative. The additive value that MCDA offers when solving complex spatial problems was also delineated. Furthermore, the Weighted Sum method was presented to stakeholders as well as the functionality of the respective tool in ESRI's ArcGIS software. The Weighted Sum was selected as a popular, simple and easy to be used by non-experts method. Its functionality as an overlay analysis tool in a GIS environment was clarified and the steps of its implementation were explained to the engaged stakeholders. Issues like possible alternative sites, representation of criteria by the respective map layers, criteria-layers of varying importance and its 'translation' into criteria weights, map layers overlay and synthesis of a final decision map were discussed during the training session in an effort stakeholders to get familiar with spatial MCDA and the application of the Weighted Sum tool. The correspondence of participants was satisfactory. They carefully listened to the instructions given by experts, they took notes on the several theoretical and practical aspects analysed and they asked for further explanations each time they felt that they had missed something.

In the sequence (second session of the living lab), the field exercise started. The whole area of the island was available to stakeholders for experimentation. Each stakeholder had a personal computer and could explore alternative locations by interacting with a web map. They could express their preferences as to possible locations and explain why they preferred some of them and why they excluded others. No limitations as to the possible areas were set at this stage. The goal of this preparatory stage was firstly to explore the state-of-the-art and secondly to elicit information that could feed the next step, that of evaluation criteria definition. Many of the stakeholders, keeping in mind the existing legislative framework and the need to protect the environment, understood that residential areas should have a distance from the coast, the hydrological network and sensitive ecosystems. Also, they preferred regions close to the sea and existing settlements.

Then, the crowdsourcing exercise followed. At this stage, stakeholders were asked to define possible evaluation criteria on the basis of which, alternative locations would be assessed. Coordinators/Experts highlighted that emphasis should be given to the protection of natural resources, the limitation of pressures put on them, the development of a sustainable residential pattern in the island and the satisfaction of existing housing needs. Each stakeholder made a list of criteria and provided it to the rest. After a discussion, experts along with the stakeholders decided to keep seven criteria: a) distance from the coastline, b) slope suitability, c) accessibility to the road network, d) proximity to settlements, e) distance from beaches, f) protection of the hydrographical network and g) land uses suitability. Such criteria were proposed by the majority of stakeholders and a high level of consensus was attained during the debate on which criteria should be finally considered. Each criterion was 'translated' into a map layer (Figure 4) and the spatial MCDA process began. Living lab coordinators and stakeholders implemented together and step-by-step the Weighted Sum overlay analysis on ESRI's ArcMap software. Each participant applied it to a personal computer following the instructions given by experts.

Figure 4. Criteria - Layers



Firstly, they loaded all criteria-layers on ArcMap. It should be mentioned that all relevant layers had been pre-processed by experts in order to: refer to the same projection and Euclidian distances to be defined where necessary. All criteria were represented as layers of raster format.

Before defining weights and running the Weighted Sum tool, values of each layer had to be reclassified to a common scale of 0 to 10 where '10' corresponds to the most favourable sites of each layer and '0' to the less favourable ones. Indicative values are presented in Table 1 for the layer 'land uses'[1].

Table 1. Reclassified values for the criterion-layer 'Land Uses'

Land Use	Code	Reclassified Value
Continuous urban fabric	1.1.1	9
Discontinuous urban fabric	1.1.2	9
Airports	1.2.4	1
Sport and leisure facilities	1.4.2	1
Non-irrigated arable land	2.1.1	4
Complex cultivation patterns	2.4.2	2
Land principally occupied by agriculture with significant areas of natural vegetation	2.4.3	4
Natural grasslands	3.2.1	7
Water bodies	5.1.2	1

Accordingly, for criterion 'slope suitability', flatter locations were preferred to the steepest ones; for criterion 'proximity to settlements', sites close to existing settlements were more favourable, and; for criterion 'protection of the hydrographical network', locations next to streams were not among the most preferred. In the same way, reclassified values were defined for all layers-criteria by both experts and stakeholders after discussing the relative importance of each location (alternative sites included in all layers-criteria).

The final step of Weighted Sum implementation concerned the definition of criteria weights. Criteria weights were defined in such a way so that their sum to be equal to 100 (Table 2). 'Land uses suitability' was defined as the most important criterion, followed by: 'distance from coastline' and 'distance from beaches' (criteria of equal importance); 'accessibility to the road network'; 'slope suitability' and 'proximity to settlements' (criteria of equal importance); 'protection of the hydrographical network'. The most suitable locations should simultaneously satisfy all of them to the highest possible degree.

Table 2. Criteria weights

Criterion	Weight
Slope suitability	13
Distance from coastline	15
Land uses suitability	18
Accessibility to the road network	14
Proximity to settlements	13
Distance from beaches	15
Protection of the hydrographical network	12
Sum	**100**

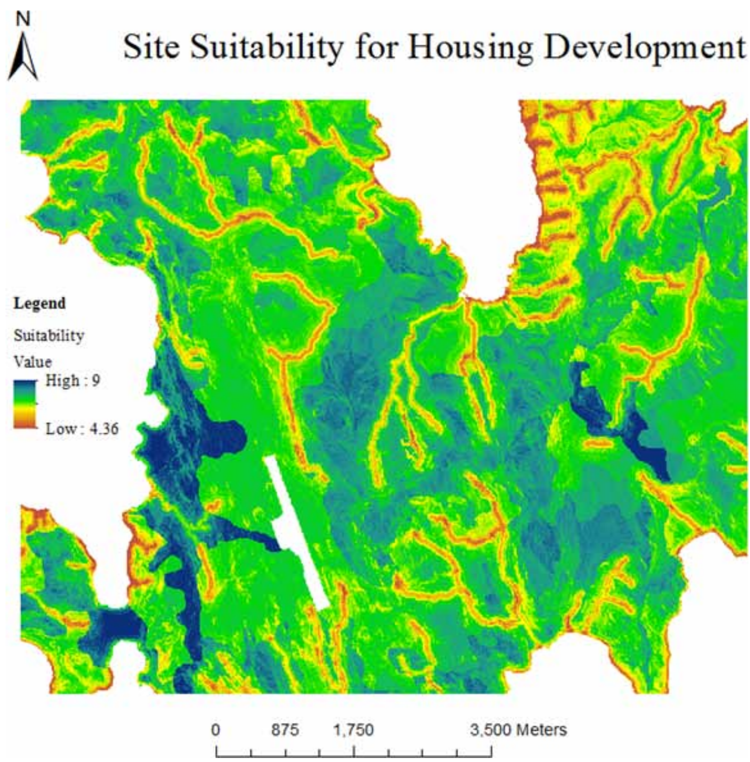
Criteria weights were collaboratively defined. Indeed, the contribution of stakeholders was of utmost importance as they have a clear perception of the local peculiarities. They all agreed that 'land uses suitability' is the most important criterion when it comes to housing development. Along with the support of experts, the rest of weights were also defined.

Then, the Weighted Sum algorithm was applied, and the final decision map was produced after the aggregation of layers, representing the evaluation criteria and containing all possible suitable locations. A sensitivity analysis was also performed in order the results to be tested as to possible changes of criteria weights (weights of the four main criteria). No remarkable deviations were noticed in the final outcome.

Analysis of Results

As depicted on the decision map (Figure 5), the alternative locations have been classified according to their suitability for housing development. Suitability was measured with the support of an arithmetic scale of 0 to 10 (the same scale used during the reclassification stage). The highest value (10) represents the most suitable sites while the lowest value (0) represents totally unsuitable areas.

Figure 5. Site suitability decision map



According to the results, there are no totally unsuitable areas but there are areas with very low suitability. The most suitable sites are mainly into or around the existing settlements. The most unsuitable sites are next to the streams and the coastline. Moreover, a coloured bar is also used for ranking the possible locations and making the final results more comprehensible. According to this coloured bar, sites in red and yellow are areas of low suitability; the 'green' sites are of intermediate suitability while, the most suitable locations for the development of residential areas are those in blue.

After the completion of the field exercise, two main fieldwork-related questions addressed to participants. The first one concerned the assessment of the outcomes (quality of outcomes, level of satisfaction). The second one referred to the assessment of the proposed methodology and its potential to support land use management issues and the design of effective spatial solutions.

Regarding the outcomes, in general, stakeholders said that they were realistic, and they could be used as supportive material during decision making processes. Environmentalists agreed that the proposed pattern of housing development was rather ecologically friendly but they would prefer a more limited expansion of the housing sector. Tourist operators and real estate representatives mentioned that not only the 'deep blue' but also the 'blue-green' areas may be seen as possible sites for the development of housing and tourist infrastructures. They explained that according to the current trends, it seems that accommodation needs will be further increased in the future and the sector of real estate is expected to strongly support the income of Mykonos. However, they agreed that a compromise solution between environmental and economic goals should be pursued. Local authorities and citizens highlighted that it is important to prevent the uncontrollable expansion of the building sector and its development should strictly follow the terms and conditions set by the relevant legislative framework. They were satisfied by the results provided by the field exercise and added that, residential areas' development should be done under the principles of sustainability in order natural environment and local identity to be protected as they constitute the prevailing comparative advantages of Mykonos.

Considering the adopted methodology, stakeholders felt really excited by the added value that participatory workshops and technology can put in the decision-making process and the design of spatial plans. They underlined that they enriched their knowledge due to the exchange of views and discussions took place among stakeholders and between stakeholders and experts. They also understood the need to involve multiple criteria when making decisions for spatial planning as they reflect multiple perspectives and priorities that should be kept in mind. The biggest challenge for them was the implementation of spatial MCDA by using GIS technology as they gained new knowledge, they got familiar with such a tool and they perceived its usefulness when analysing spatial problems. GIS helped stakeholders to better comprehend the problem and its dimensions due to its analytical and visual capabilities. Crowdsourcing gave them the chance to propose their own solutions and explore those proposed by the rest of participants. Indeed, the majority of them mentioned that after the crowdsourcing exercise, they were more aware of the criteria that should be considered when it comes to housing development. As to the living lab, they fully agreed with the whole concept as it: a) supports innovation production through collaborative actions, b) helps non-experts to indulge into new technologies and get familiar with their use, c) reinforces knowledge diffusion and d) strengthens the smart dimension of their community. Finally, stakeholders mentioned that they are willing to actively participate in decision making processes and co-shape the future development of 'their' island. They are also working on the smart transformation of Mykonos and the development of smart solutions in the energy, mobility, water and waste sectors as they believe that such orientation brings the potential for a more effective and rational exploitation of the available resources.

DISCUSSION

The evolvement of smart cities and communities represents a prevailing and popular pattern of urban development, promoting the exploitation of technology and innovation in order to improve standards of living and serve citizens' needs. A critical number of metropolitan areas and cities worldwide have embraced such a smart perspective and outstanding efforts have taken place towards their smart transition.

The concept of 'smartness' is also gaining traction in the case of rural regions and islands, as an alternative option for dealing with local problems and peculiarities. In this context, issues related to precise farming and agriculture, efficient use of the available resources (e.g. land, energy, water), climate change mitigation, sustainable tourist development and management of digital divides are considered under a 'smart rationale'.

In Greece, the majority of islands face the challenge of managing the pressures put in natural resources by the tourist sector. Mykonos is a representative example, being a worldwide tourist destination and attracting a huge number of tourists every year. Land use regulations and coverage of accommodation needs represents a great challenge for the island, especially during the summer.

In this paper, the investigation of suitable areas for future housing development in Mykonos was presented through the implementation of a methodological approach that builds upon the concept of 'smart people' and engages the smart and participatory dimensions. The adopted approach presents similar characteristics to a series of methodologies having been applied for the management of issues related to spatial and participatory planning in smart cities and communities. Schuurman, Baccarne, De Marez, & Mechant (2012), after conducting a crowdsourcing exercise in order to elicit citizens' opinions on how ICTs could improve the quality of their daily life, recommended that a combination of crowdsourcing with living labs could stimulate citizen-driven innovation and provide better results. 'ParticipAct living lab testbed' for smart cities is another case joining crowdsourcing and living labs for collecting data from citizens' smartphones, through crowd sensing campaigns (Cardone, Cirri, Corradi, & Foschini, 2014). Other examples come from de Faria Ribas (2015), dealing with a mixed crowdsourcing-MCDA approach for selecting nuclear power plant technology; Nalmpantis et al. (2019), concerning the assessment of ideas for public transport through the utilization of crowdsourcing and MCDA (AHP); Ståhlbröst & Lassinantti (2015), focusing on the contribution of crowdsourcing in the different stages of a living lab, etc.

Similarly, the approach applied in the current analysis, represents an attempt to engage crowdsourcing, living labs and participatory evaluation in order to strengthen stakeholders' participation in a decision-making process, concerning the allocation of residential areas in 'their' island. It also encourages the use of modern technologies like GIS. The systematic application of such technologies and tools highlights the benefits that a smart participatory approach may bring when solutions to existing problems are sought.

Finally, the whole concept of this analysis is related to prior research regarding the smart transition of islands and the smart management of specific problems met in such regions. Under this framework, the case of Mykonos may be seen as an indicative example of a small island, building its smart profile through the enhancement of 'smart people' dimension, the adoption of modern technologies for managing existing problems and the elimination of digital divides.

CONCLUSION

The constant increase of urban population and the need to minimize the impacts of several problems in urban areas call for the undertaking of decisive actions and informative decisions in order to improve quality of life in contemporary cities. Rural and insular regions are also facing pressures due to: climate change that will strongly affect agricultural activities and food production, the increasing tourist development, the need for a more sustainable management of energy and water resources, etc. The adoption of ICTs and the establishment of smart communities, not only in urban but also in rural areas and islands, have already created a new reality where technology is used in a critical number of functions of modern cities and communities. Smart specialisation corresponds to the particular needs and problems of each region and sets the necessary preconditions for their confrontation. Moreover, technological advancements facilitate the sustainable development of cities, the exploration of effective solutions and the improved management of available resources. Smart cities and communities constitute a dominant trend of urban and rural development that will continue to evolve in the future along with technological evolution.

A critical dimension of smart communities is that of 'smart people'. The concept of 'smart people' implies the inclusion of citizens/stakeholders in decision making processes and innovation creation as they form city's identity while also being the main users and consumers of technologies and resources. Their active participation in problem solving is of exceptional importance as, on the one hand they are the final 'receptors' of the adopted solutions while on the other hand, they may enrich the process by offering knowledge and experience, emanating from their daily life.

Crowdsourcing and living labs are two robust tools that mobilize the massive participation of stakeholders and crowd during the investigation of solutions and innovation production. Such practices strengthen the creation of broad collaborative schemes working towards the accomplishment of common goals. Consequently, crowdsourcing and living labs enhance 'smart people' dimension by offering citizens the chance to co-shape the smart dimension of 'their' city.

This article focused on the role that crowdsourcing, living labs, participatory evaluation and GIS-based MCDA can play for developing residential areas in the island of Mykonos. In this context, the management of such an issue in a living lab environment was attempted. Participants were representatives of local authorities, citizens, tourist operators, real estate agencies and environmental organisations who assessed possible locations for housing development through a crowdsourcing exercise and the adoption of spatial MCDA methods and tools. The whole venture was completed in two meetings where a training session and a filed exercise took place.

The scope of the adopted approach was the deeper exploration of possible sites for housing development and the assessment of the additive value that participative actions and exploitation of modern technologies can offer when solving problems in small insular communities. The participation of relevant stakeholders was critical as they are the final 'receptors' of the designed spatial interventions while they also offer their gained experience and knowledge. The outcomes of such an approach intended to contribute to the better management of available resources, the enhancement of efforts aiming at the 'smart transition' of Mykonos and the inclusion of all interested parts so that 'smart people' dimension to be reinforced. Crowdsourcing allowed for gathering possible criteria that should be satisfied when housing development activities take place; the living lab promoted the use of relevant technologies; participatory evaluation contributed to the collective assessment of alternative solutions, and; GIS-based MCDA supported the spatial analysis of the problem and the visualisation of outcomes through the creation of a decision map.

Results showed that such a perspective is very welcomed and desirable by local communities as they are interested in exchanging views, enrich their knowledge and express their preferences regarding the future development of 'their' city/region. Moreover, they got aware of several modern technological tools supporting decision making processes. The empirical study confirmed that not only large metropolitan areas and big cities but also smaller communities, such as islands, have the potential to be transformed into smart regions and exploit the advantages of technology. Under this framework, improved decision-making behaviours can be achieved and more robust decisions can be taken, intending to the efficient use of resources and the establishment of sustainable future development patterns through the smart management of local problems.

All in all, the current analysis indicated that: participatory approaches provide better results due to the additive value of 'local knowledge'; local communities are willing to get involved in decision making processes, aiming at the confrontation of existing problems; living labs contribute significantly to the enhancement of 'smart people' dimension, the upgrading of local skills, the elimination of digital divides and the familiarization of local communities with modern technologies; collaborative actions strengthen the design of wide-accepted solutions, and; the smart transition of islands, through the extensive use of technology and the inclusion of citizens in smart initiatives, brings the potential to support the sustainable management of local natural and human assets.

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ENDNOTE

[1] Land uses were defined according to Corine Land Cover categorisation and respective layers were used.

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