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Dominance–based Rough set approach for environmental sustainability of Man and the Biosphere program of "Etna river valleys"

Abstract

The studies and conventions, for several decades, highlight the importance of ecosystem services provided to natural resources and biodiversity for humanity and the need to lead towards their management towards a sustainable model. Agenda 2030 for Sustainable Development is a program of action for people, planet, and prosperity to September 2015 by the governments of the 193 UN member states and includes 17 Sustainable Development Goals (SDGs). The SDG 15 "Life on Land" is dedicated to Biodiversity, Forests, and Desertification and its goal is "Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss".

In Sicily (Italy), the Etna Park (established in 1987) promote the conservation of natural resources and biodiversity and the sustainable development of the territory, recognizing the environmental,and also the social and economic dimension of protected areas.

The institution of the "Biosphere Area" (UNESCO "MAB – Man And Biosphere" Program), is an opportunity to adopt sustainable development models in 'Etna system' for the regeneration of virtuous relationships between the cities and the countryside (food, tourism, renewable energy, waste, etc.), the redevelopment of the landscape, the rediscovery of local cultural identity and the relocation of the economy.

The research aims to provide, through the methodology of the "Rough Sets", a useful tool to support the strategic choices that stakeholders will be called to activate for the management of the complex environmental, cultural and economic mosaic that characterizes the BR "Etna river valleys".

Keywords: Man and Biosphere Programme UNESCO, Biosphere Reserve, Sustainable management model, Etna environment, Dominance-based Rough Set Approach (DRSA), UN SDGs, Biodiversity.

INTRODUCTION

Human action has completely transformed our planet and continues to transform it (IPCC 2018; Pearce et al. 1991; UN 2020a). To meet the growing global demand for goods and services, the balance between man and nature has been upset and ecosystems have lost their original characteristics, resulting in the continuous and uncontrolled process of exploitation of natural resources (Phillips and Borrini-Feyerabend 2009).This lack of a balance has led to the intensification of problems, such as pollution, global warming, desertification, deforestation, loss of biodiversity, and natural habitats (IPCC 2000; OECD 2018; Sturiale et al. 2020). Biodiversity - the diversity within species, between species and of species and ecosystems - is being degraded faster than at any time in human history and the last decades represent the historical period of greatest vulnerability of ecosystem services due to anthropogenic action (Millenium Ecosystem Assessment 2005). Globally, the risk of extinction of species has worsened by about 10% in the last three Decades. More than 31,000 species are threatened with the risk of extinction due mainly to the loss of habitats to be unsustainable agriculture, deforestation, unsustainable harvest and trade and invasive alien species (UN 2020a).

In September 2015 the 2030 Agenda for Sustainable Development was proposed as a program of action for people, the planet, and prosperity and signed by the governments of the 193 UN member states. It incorporates 17 Sustainable Development Goals (SDGs) into a major action program for a total of 169 'targets' and 231 indicators (UN 2015b). The SDGs are an urgent call for action by all countries - developed and developing - in a global partnership. Among these objectives, the SDG 15 "Life on Land", is dedicated to Biodiversity, Forests, and Desertification and aims to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (UN 2015a).

Many countries are adopting measures to conserve, restore and make sustainable use of natural resources (Ferretti et al. 2015), to explore nature-based solutions (EEA 2015) and to implement sustainable management plans of natural ecosystems (Bresso 1991; Pappalardo et al. 2015; Sturiale and Scuderi 2019). Nature is essential to achieving the integrated and indivisible SDGs. However, there are negative trends in the management of biodiversity and ecosystems that will undermine progress (towards 80% - 35 out of 44) of the poverty-related goals, hunger, health, water, cities, climate, oceans and land (SDGs 1, 2, 3, 6, 11,13, 14 e 15) (IPBES 2019). Several surveys and reports (IPBES 2019; Stafford-Mill et al. 2017; UNRISD 2017; UN 2020b) have shown that new governance models are needed to promote and implement sustainability at local, national and global level. New private sector investment frameworks are required to get SDGs up and running innovation, inclusive and adaptive governance approaches and agreements, multisectoral planning and strategic policy mix.

In The Italian territory, there is a remarkable wealth of diversified ecosystems and marked biodiversity. Over the years, Italy has been committed to protecting and enhancing this wealth by following a path that aims to manage and safeguard the natural areas and surrounding territories (Carbone 1999; Matarazzo et al. 2019). Our territory is full of protected natural habitats and urban areas surrounded by rural areas, which coexist and interact each other to ensure that each different ecosystem protects its highly biodiverse reality (Foti et al. 2018; Tempesta et al. 2018; Sturiale et al. 2020).

Sicily is characterized of territories particularly suited to rurality, able to produce many high-quality products (Scuderi et al. 2017). The peculiarity of its products also lies in the presence of old varieties and landraces, which are still today grown using sustainable methods and values. Among the many others, the river valleys of the Etna area are characterized by fertile soils and different microclimates linked to the presence of the Etna Volcano. The combination of all these factors has allowed the diversification and specialization of many crops, which still today identify their particular farming localities, such the pistachios of Bronte (POD), the blood oranges of Sicily (PGI), the hazelnuts of the Nebrodi, the strawberries of Maletto as well as many horticultural varieties in the Etna area (Sturiale et al. 2020).

To valorize the peculiarities of the target area, a participatory endogenous development process has been initiated, through the future recognition as a Biosphere Reserve (BR), called "Etna river valleys"(Guarnaccia et al 2020). Within the newly established Reserve, this research uses the Rough Sets (RS) methodology and aims to provide useful tools to support the strategic choices of stakeholders. The area lends itself to a model of territorial development that supports small farms through the increase of agricultural production with good cultivation practices and the spread of the organic farming method (Foti et al. 2013). Additionally, in virtue of the naturalistic and landscape value of the area under study, virtuous strategies such as the establishment of exchange groups with the direct involvement of local producers and the innovative itineraries could be activated to broaden the demand for local products, improve their distribution and increase low impact forms of tourism (IUCN 2015; Mantić 2019, Salerno et al. 2013; Sturiale et al. 2020). In support of the economic activity present in the territory, the project is also to start the development of sustainable tourism. The area is already equipped with reception facilities, like hotels in inhabited centres and the countryside and rural tourism structures (Timpanaro et al. 2015). The creation of the BR could be considered among the targets indicated in SDG 15 "Life on Land", as its priority objective is to promote the conservation of biodiversity, biological resources, ecosystem and their sustainable use.

The research aims to provide, through the methodology of the "Rough Sets", a useful tool to support the strategic choices that stakeholders will be called to activate for the management of the complex environmental, cultural and economic mosaic that characterizes the BR "Etna river valleys".

The Biosphere Reserves: institution, objectives and developments

The Man and Biosphere Program (MAB), born in 1971, is an interdisciplinary program that aims at the conservation of biodiversity and biological resources and their sustainable use. It plays a dynamic role, by considering the territory as a place of experimentation of sustainable development aimed at improving the relationship between man and nature. Therefore, the BRs recognized by UNESCO demonstrate the possibility of generating well-being, thanks to the implementation of a sustainable development model, which environmental quality, quality of life, and occupational innovation of occupation (Butti Al Shamsi et al. 2019).

The constitution of the BR has objectives that coincide with some of the targets of SDG 15 "Life on Land". In particular, the targets: 15.1 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity 15.9 Integrate ecosystem and biodiversity values into national and local planning; 15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems (UN 2015b).

Since the institution of the first BR in 1976, the current World Network of BRs (WNBR) has grown, including now 714 sites in 129 Countries with a total area of over 600 million hectares (locations and numbers of BRs can be found on UNESCO's website: http://www.unesco.org/new/en/natural-sciences/environment/ecological-sciences/biosphere-reserves/) Although this, theBRs (brS) are still undervalued and underused and their roles and functions are not recognized and understood by the public and governments. Contrary to this trend, the present work stresses the importance of (BRs) as useful tools to boost the man-environment harmony and pass on to future generation's ways of acting, behaviors, and knowledge, which reflect a sustainable model of society. In these areas, effective and functional solutions must be implemented to convince the users of the territory of the goodness of the development process and to assure the maintenance in the long term thereof. According to the cornerstones of the establishment of these areas, the territory should be both economically productive and environmentally sustainable, safeguarding environmental resources and the related ecosystem services, traditional practices and products, artistic and cultural heritage (Reed 2019).

Over the years, the programme has been complemented by other documents and action plans, which have renewed the objectives to be pursued and highlighted global issues and new challenges. The following is a brief overview of the main milestones in the development of the MAB programme up to the 2017 youth movement.

the Seville Strategy (1995) which sets specific objectives, recommendations at national, international, and for each BR, and implementation indicators. It invites the interested parties to acquire all the relevant information elements and to assume a full commitment, both in the planning process and in the management and continuous monitoring of the BRS,

also through the creation of advisory bodies. The Seville Strategy adopted a two-pronged approach:

- creation of the innovative concept of reserve from the examination of past experience;
- identification of their three functions (conservation, development and logistical support) looking to the future.

The Strategy identifies the specific role of BRs in developing a new vision of the relationship between conservation and development.

the Statutory Framework of the World Network of BRs (WNBR) (1995) which establishes criteria, functions, and procedures for the designation of BRs and sets out the principles for their periodic review;

the Madrid Action Plan (2008), which, implementing the 2008-2013 MAB (Man and Biosphere Program) Strategy, reiterates the three great challenges of the 21st century: climate change, biodiversity loss, and urbanization; it stresses the strategic importance of involving all stakeholders to ensure the well-being of human populations and their development;

2015-2025 MAB Strategy (2015), defines strategic objectives, which are derived directly from the three functions of BRs and identified in the statutory framework of the WNBR and in the global challenge to climate change (Madrid Action Plan for BRs). They are:

1. Conserve biodiversity, restore and enhance ecosystem services, and foster the sustainable use of natural resources

2. Contribute to building sustainable, healthy and equitable societies, economies and thriving human settlements in harmony with the biosphere

3. Facilitate biodiversity and sustainability science, education for sustainable development (ESD) and capacity building

4. Support mitigation and adaptation to climate change and other aspects of global environmental change (UNESCO 2015)

the Lima Action Plan (2016), which, implementing the 2015-2025 MAB Strategy, establishes objectives, actions, and expected results; t pays particular attention to the achievement of the sustainable development goals and the implementation of the 2030 Agenda.

It's presented as a matrix, structured according to the Strategic Action Areas of the MAB Strategy 2015-2025, and includes targeted outcomes, actions and outputs that will contribute to the effective implementation of the strategic objectives contained in the MAB Strategy. It also specifies the entities with prime responsibility for implementation (States, MAB National Committees, UNESCO Secretariat, BRs, etc.), together with time range and performance indicators (UNESCO 2016).

the 2017 MAB Youth Forum, the initiative, first announced at the World Conservation Congress in Lima, offered young people the chance to become actors in the MAB programme, in the special territories where they live, and ensure the sustainable development of their communities, in line with the Lima Action Plan.

Within the institutional structure of the MAB, of particular importance is the Statutory Framework of the WNBR, that defines BRs as ".areas of terrestrial and coastal/marine

ecosystems or a combination thereof, which are internationally recognised within the framework of UNESCO's Programme on Man and the Biosphere (MAB), in accordance with the present statutory framework". It describes the criteria, zoning, and functions that a reserve must possess. The article no. 3 indicates, in particular, three equally important and interdependent functions that the BRs must pursue:

conservation of genetic resources, species, ecosystems, landscapes;

sustainable socio-economic development;

logistical support to encourage and support research, surveillance, training, and environmental education activities.

Furthermore, in article 4 of the statutory framework seven criteria to which the BRs must meet are indicated. Four out of seven criteria refer to the natural characteristics of the territory, which must: include a mosaic of ecological systems representative of the main biogeographical regions, including a graduated series of human interventions; be important for the conservation of biodiversity; offer the possibility to study and demonstrate sustainable development approaches at the regional level; have adequate dimensions to satisfy the aforementioned 3 peculiar functions.

Three criteria, instead, refer to perimeter and management. The first one deals with dividing the territory into zones that support the three main functions of the BRss. The zones differ according to the level of sensitivity of the ecosystem and the anthropization of the area and are divided into:

one or more central areas, core zones, which consist of territories, protected under specific laws and regulations, suitable for long-term safeguarding, following the conservation objectives of the BRs, of sufficient size to meet these objectives, and in which only research and zero impact activities are allowed;

one or more buffer zones,surrounding or bordering the central areas, in which only activities compatible with conservation objectives can be carried out, including environmental education, ecotourism, monitoring, and scientific research;

one or more transition zones surrounding or bordering the buffer zones, where sustainable use practices are encouraged and developed; it is the part of the reserve where all the activities that allow economic and human development, socio-culturally and ecologically sustainable are allowed.

The other two criteria refer to the management of the BR: the second wants to ensure the involvement of public and private entities of the territory in the conception and implementation of the functions of the reserve, while the third onedeals with the launch of resource management mechanisms and human activities in the buffer zones, the definition of a management plan for the Reserve, the designation of authority to implement the plan, the initiation of research, monitoring, education and training programs.

In addition to the indicated criteria, the Statutory Framework of the WNBR asks states to develop and apply national criteria, specifically tailored to the characteristics of their territories.

METHODOLOGY

Case Study: the Biosphere Reserve "Etna river valleys"(request proposa)

The BRs have kept alive realities destined for land neglect or anthropization, adopting agricultural and cultural strategies to ensure a sustainable future for both man and nature (Van Der Berghr et al. 1997).

Italy's participation in the MAB program has made available a model to follow for the promotion of ethical and cultural activities and values linked to environmental conservation and education, sustainable use of resources, and good practices traditionally employed in the country (Foti et al. 2019). In this way, a significant boost to the Italian Network of BRs, both in numerical terms and in terms of management capacity, as well as in the renewed interest of local communities in the issues and objectives related to sustainable development has been achieved. The active participation in national and international events, such as the Euro MAB network, has made it possible to create important relationships and exchanges and to reconsider the role that the MAB Program can play, in synergy with other International Conventions, in achieving the Sustainable Development Goals of the UN.

The first enrolments in the MAB program of Italian reserves date back to the 1970s and relate to areas whose conservation is aimed at maintaining and safeguarding biodiversity. The first to be registered, in 1977, were the 'Collemeluccio-Montedimezzo' and 'Foresta del Circeo'State Natural, managed by the State Forestry Corps, followed, in 1979, by 'Miramare' one, established as a Marine Nature Reserve by Ministerial Decree of 12.11.1986, and entrusted to WWF Italy, for a total of 19 sites scattered throughout the Italian territory.

The establishment of a BR in Sicily called 'Terre della Biosfera: le valli fluviali dell'Etna' ("Etna river valleys") is a local project carried out by the members of the 'Terre della Biosfera' association with the 'Verdi Bronte' association, the German foundation 'Manfred Hermsen Stiftung' and the tour operator 'Natour Sicily'. The candidacy of the "Terre della Biosfera – le valli fluviali dell'Etna" forbecoming a BR has as its main purpose the conservation of the biodiversity of the territory, with particular consideration for the areas outside the protected areas and its peculiar landscape (Butti Al Shamsi et al. 2018).

The ambitious project aims to create a point of contact in an area large and diverse as that envisaged, which includes two provinces (Catania and Messina), three regional natural parks (Nebrodi, Etna and Alcantara), four natural reserves (Fiume Fiumefreddo, Bosco di Malabotta, Forre laviche del Simeto, Oasi di Ponte Barca on the Simeto river), and also incorporates and connects numerous SCIs (Sites of Community Importance) and SPAs (Special Protection Areas) of the European Network 'Natura 2000' (Directive 92/43 / EEC "Habitat").

The candidacy project of the "Terre della Biosfera – le valli fluviali dell'Etna" envisages a zoning in three parts of the area under study to allow the achievement of the conservation of natural resources and sustainable development (Figure 1).

The 'core' area, which is the area with the highest naturalistic value, includes the south-western portion of the Nebrodi Regional Park, the Regional River Park of the Alcantara

River, the Oriented Nature Reserve of Fiumefreddo (CT), Sites of Community Importance (SCIs)and Special Protection Areas (SPAs)of the EuropeanNatura 2000 network and the sources, high valleys and courses of the Simeto and Alcantara rivers. The area thus designated would simplify the management, which already falls into the remit of the respective managing bodies, through management plans and use regulations (Matarazzo et al. 2019).

Actions envisaged by the project for the "core" area are:

conservation of highly natural places and natural habitats not used by man;

protection of rare and endemic plant and animal species;

research and monitoring;

environmental education.

The "buffer" area, which surrounds the core one and protects it from excessive negative anthropic interventions through the reduction of all those activities with a strong ecological impact, is characterized by those territories that are destined for redevelopment. Its role is that of a buffer between the anthropic impact and environmental protection: in some cases, these zones share the same environmental value of the "core"areas, in others,they present anthropic activities, like intensive agricultural and pastoral ones, which can result in a high risk for the environmental sustainability.

The actions foreseen by the project for the "buffer" area are:

creation of ecological corridors;

support for systems of sustainable use of forest resources;

conservation of the fragmented agricultural structure and support for ecological agriculture;

promotion of typical local products;

environmental education and sustainable development;

training and updating on the sustainable use of the territory and enhancement of local traditions.

The "transition" area is characterized by a strong anthropic presence, both at a demographic level since it includes the inhabited centres, and at the economical level due to pursuit of activities, like agriculture, tourism, and small industry ones.

The actions envisaged by the project for the "transition" area are:

tourism enhancement of the area, through information, advertisement, organization, and interconnection of the tourist offer;

improvement of local transport infrastructures;

creation of a brand for products from the BR;

promotion of local crafts and traditions;

environmental education and organization of public awareness events.

The overall vision of the proposed MAB "Terre della Biosfera – le valli fluviali dell'Etna" reserve entails the progressive transformation of the Etna river valleys into a large ecological corridor between the three neighbouring regional parks (the Nebrodi regional park, the Alcantara river park and the Etna Regional Park)and results in the proposal of a model of

economic development that respects natural resources, landscape aspects, with particular reference to the landscape and traditional agricultural activities.

The theory of Rough Sets

Thetheory of "Rough Sets", (RS) introduced by Pawlak in 1977 (Pawlak, 1997) as a powerful data analysis tool, was later subjected to in-depth analysis and methodological changes to be applied in multicriteria decision-making problems of classification, choice and ranking,also in the presence of purely ordinal data (Greco et al. 1996, 2001; Matarazzo et al. 2018).

The methodology is theoretically based on the hypothesis that with each object in a given universe U is associated information, expressed using some attributes that describe the aforementioned objects (Greco et al. 2001). If, for example, the objects are farms that aim to reduce negative externalities on the ecosystem, the information is represented by the production specialization, the cultivation method, etc. Objects characterized by the same description in terms of the considered attributes are regarded as indiscernible (or similar) about the available information (Pawlak 1997).

The indiscernibility relation constitutes the mathematical foundation of the classical theory of RS, intended like the bricks ("granules") with which knowledge of reality is built (Greco et al.1996; Matarazzo et al. 2019; Słowiński et al. 2015).

Each set of indiscernible objects is called elementary set and represents an atom ("granule") of the knowledge of the universe. Any subset X of the U universe can be defined in terms of granules, or in a precise way, as union of elementary sets (as in classical set theory), or in an approximate way. In the latter case, the subset can be characterized by two ordinary sets, called lower approximation and upper approximation. A rough set X is defined through the aforementioned approximations, which coincide in the case that X is an ordinary set; the difference between lower and upper approximation represents the boundaryof the rough set X (Greco et al.2001; Pawlak 1997).This approach leads to an approximate representation of reality characterized by the "granularity" of knowledge, similar to the concept of "sharpness" in image theory, which constitutes the key concept of the theory of RS.

The lower approximation of X is constituted by all the elementary sets included in X, whose elements therefore certainly belong to X; the upper approximation is given by all the elementary sets that have a non-empty intersection with X, whose elements can belong to X. The elements that belong to the boundary of X cannot, therefore, be characterized with certainty as to their membership in X, using the information available. According to the approach of the rough set, therefore, a concept described in an imprecise way can be replaced by a couple of precise concepts, namely its lower and upper approximations (Greco et al. 1996).

The peculiarity of rough sets consists in dealing with an imprecise representation of reality due to the granularity of knowledge, a consequence of the indiscernibility between objects having the same description ("granules") (Greco et al. 2001).

Before proceeding with the application of the theory of RS to multicriteria decision-making problem at hand (ordinal classification, called sorting), related to the use of natural resources in protected areas and, in particular, to the compatibility between the exercise of agriculture and the protection of the ecosystem (Norgard 1984; Sturiale et al. 2020), the main concepts of the adopted methodology are explained below.

As above recalled, the classical theory of RS defines indiscernible two objects that have the same description in terms of the attributes considered. The indiscernibility relation is reflexive, symmetrical, and transitive and, therefore, it is an equivalence relation. If the universe U is divided into classes, two indiscernible objects should belong to the same class, otherwise, they would be inconsistent with respect to this relationship. To be able to face all the multicriteria decision-making problems, the indiscernibility relation is replaced by the dominance relation: object a dominates object b if a is at least as good as b with respect to all the considered criteria; therefore this binary relation, thus defined, is reflexive and transitive (partial pre order). In this way a new RS approach, called Dominance-based Rough Set Approach (DRSA) has been built; it presupposes that the domain of each considered attribute is preferentially ordered, thus allowing to explicitly take into consideration the preferences of the Decision Maker (DM) also if they are qualitative, expressed in ordinal scale (Matarazzo et al. 2019). The attributes are then called criteria. Even the decision attribute (assignment class) satisfies ordinal properties, and, therefore, we have a partition of objects into classes ordered according to a certain preference. The addressed problem of sorting precisely consists of the assignment of each object to an increasing or decreasing union of decisional classes, predefined by the DM.

The preference model obtained from the DRSA analysis is still presented in the form of decision rules (Greco et al. 2000) in the form "if ..., then ...", where the premise (the conditional profile) represents a sufficient condition for an object to be assigned to a union of ordered classes (decision profile). Each rule is expressed in ordinary language, in terms of evaluations of the objects with respect to a subset of the criteria considered. The syntax of these rules in the DRSA is very rich and is of the type: "if the evaluation of x with respect to the criterion c_i is at least (at most) equal to v_i, ... and with respect to the criterion c_j is at least (at most) equal to v_j, and .., then x must be assigned at least (or at most) to class c_k ".

The conditional and decisional profiles respect the fundamental dominance principle: one profile dominates another profile if all the evaluations of the first profile are not worse than the evaluations of the second profile with respect to the criteria considered. The constraint of monotony requires that, if the conditional profile of one decision rule dominates the conditional profile of another rule, then the decision profile of the first rule must also dominate that of the second. In other words, if object a dominates object b with respect to the considered criteria and b is assigned to a certain class Y, then a must be assigned to a class Z not preferentially inferior to X. This principle of dominance allows representing the semantic correlation between criteria and decision classes. It is important to underline that the dominance relation does not require a priori specifications of (subjective) criteria importance, since it an objective relation. It may happen that some decision rules do not

respect the principle of dominance, even if supported by some (actual) examples found in the sample considered. These rules are inconsistent with respect to the principle of dominance, but they and the examples on which they are based must not be considered simply as a mistake of DM in assigning certain objects to a certain decision class and be eliminated; instead, they must be identified and presented as uncertain rules, which provide doubtful knowledge.

A set of rules (Greco et al., 2000) is complete if it covers all the objects of the decision table, reassigning the consistent objects to their original classes and the inconsistent ones to the union of classes that refer to that inconsistency. Objects that satisfy both the premise (conditional part) and the conclusion (decision part) of a rule constitute its support. Any complete and non-redundant set of rules is called minimal.

The decision rules can explain the decisions related to an object of the decision table and help the DM to make decisions regarding new objects that satisfy the conditions expressed by some rules, thus suggesting an appropriate intervention strategy to the DM.

A particularly interesting aspect of the RS lies in the ability to select a subset of attributes and/or criteria, called reducts, which alone can express all the knowledge contained in the decision table considered, without deteriorating its quality. Therefore, short, easy understandable and certain decision-making rules can then be obtained even using only the criteria of any one of these reducts.

The minimal sets of decision rules constitute the most concise and non-redundant representation of the knowledge inferred from the decision table containing the sample of examples. In the following, some minimal sets of certain rules of the sorting problem at hand will be presented, with particularly easy and clear syntax. Each time the conditional part of the chosen decision rules will consist of only one or two conditional criteria (rules of length "one" or "two" respectively); the set of rules will be able to cover all the objects considered, that is to explain the assignment of the objects to the different decision classes.

The concepts described above constitute the fundamental points of the classical theory of RS and of the subsequent methodological modifications (DRSA) to be able to apply it to multi-criteria decision-making problems of choice, ranking, and sorting. For further information, please refer to the authors (Greco et al. 2001, 2005, 2010; Slowinski et al. 2015) who dealt with the RS methodology and described how to consider the ordinal properties of the criteria and the preferences of the DM and how to apply DRSA also to support choice and ranking multicriteria problems.

Survey design

This study proposes the application of rough set theory to a complex and multifunctional system to be analysed, such as the BR "Etna river valleys", focusing on environmental issues related to the enhancement and use of environmental, cultural and economic resources that characterize the BR "Etna river valleys". This methodology supports decision rules that can help define strategies for the management of different economic activities that are compatible with both environmental protection and ecosystem maintenance.

Information was collected through the administration of a special questionnaire, face-to-face interviews, with 100 farms located in the area under analysis

The questionnaire, submitted to a sample of farms located in the territory of the Biosphere Reserve MaB Terre della Biosfera le valli fluviali dell'Etna (Sicily), aimed to collect the level of knowledge of good agricultural practices for the conservation and protection of biodiversity as well as the criticalities and problems of farmers and their degree of satisfaction and adherence to the funds of the Common Agricultural Policy (CAP).

The questionnaire was structured into three sections with a total of 65 questions:

- section 1 - questions about company activities;
- section 2 - questions about contributions received from the European Union;
- section 3 - questions about good practices for the conservation of biodiversity.

The questionnaires were distributed through the intervention of third parties, trained to facilitate the compilation of the same by the farmers. The interaction between "multiplier" and respondent allows, in fact, to win more easily the trust of the respondent, to optimize the process of detection and to submit more complex questions.

The questions were of different types

- open questions;
- closed questions;
- graded questions.

In questions comprising several options, the user could choose between "little," "low," "medium," "high," and "very much" on a five-mode Likert scale. The choice to apply a five-point scale versus a seven-point scale was made to avoid excessive ambiguity for farmers. Responses were analyzed respecting as much as possible the original structure of the questionnaire and according to the main aspects of interest of the project. The results were represented in graphic form and commented on. It should also be noted that since the questions are not mandatory, the response rate varies for each individual question.

According to the characteristics and the crops of the territory, the following four homogeneous areas have been considered: "Paternò", "Bronte", "Mojo Alcantara" and "Piedimonte Etneo". Each area includes various municipalities, and theirnames derives from the prevalence of territoryover the otherswhich exist in the same zone. The nomenclature is, therefore, used only to identify the area.

The crops consideredwere: dried fruit, citrus fruits, orchards, vineyards, olive groves, vegetables and cereals, and forage. Thus, as described in the general methodology, each category was evaluated according to the following criteria:

a1 (role of sustainability in the territory)
a2 (influence on the landscape)
a3 (pollution due to conventional agriculture)
a4 (ecosystem improvement with organic farming)
a5 (profitability of crops)
a6 (influence of hydrogeological systems)
a7 (ability to maintain biodiversity)

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The evaluation of the single criteria for each crop was made using a qualitative scale on five levels: low, medium-low, medium, medium-high, high. To make the analyzed data immediately readable, the qualitative judgments were encoded in a numerical scale, but all the analysis was carried out rigorously through the DRSA on the original ordinal data, and not on the forced transformation of them into numerical values. This too is a peculiarity of the method used. The table below shows theen codings numbers of the qualitative scale provided by the interviewees (Fig. 2).

RESULTS AND DISCUSSION

This study was carried out during 2020 by administering a specifically defined questionnaire, with face to face interviews with 100 farms located in the area under analysis The survey target is represented by active agricultural entrepreneurs and supporters of the Terra della Biosfera project. The distribution by gender of the sample interviewed: there is a predominance of men 85%, and only 15% of the sample consists of women. The distribution by age group confirms that the sample is mainly composed of adults between 18 and 60 years old, while agricultural entrepreneurs over 60 years old are only 17% of the sample. This figure confirms that young people are also interested in the area. With regard to the level of education of the farmers interviewed, 38% of the sample has a secondary school diploma, 26% a university degree, 15% a secondary school diploma and 12% an elementary school degree.

Farmers are, in fact, the key stakeholders of this European policy, which through the financial support of the first and second pillar also aims to contribute to business development and income stabilization. Farmers themselves are also the ones who, if properly involved, supported and trained, can develop their ecological knowledge and provide ecosystem services and other benefits for the environment and society.

It is widely known, in fact, the impact of the current food system that, from field to table, is responsible, according to the IPCC, for about 21-37% of total greenhouse gas emissions. The largest contribution to this estimate comes from agricultural production, with crop and livestock activities and changes in land use, such as deforestation and peatland degradation. These data are also partly the result of a process, still in progress, of abandonment of traditional agricultural methods: the latter, unlike the model of industrial agriculture, oriented to increase production through the use of monocultures, fossil fuels and chemical inputs, are generally based on ecological principles, able to ensure soil regeneration, conservation of biodiversity and production of healthy and nutritious food for the community.

Interesting results were obtained from the elaboration through the DSRA of the data that emerged from the questionnaires administered.

The overall decision table was divided into 4 different tables, one for each area concerned and investigated. Each table is composed of 7 rows and 9 columns: while each row corresponds to a specific crop ("object") examined, the first 7 columns correspond to the decision criteria taken into consideration described above, and the eighth column (decision)

consists of the assignment, made by the interviews of each crop to one of the three classes of merit identified (high, medium, low In this way, tables briefly describe the different qualitative levels of each crop as perceived by the decision-makers, in light of the particular points of view of the study, and justify their assignment to a union of classes.

On the basis of the data collected by the questionnaire and taking into account that the data available relate to a sample of only 100 farms, the number of crops (7) in each table is equal to the numbe rof conditional criteria, and therefore the reducts that can be obtained are numerous and not very significant. In our opinion, it is therefore more interesting in the study at hand to search for the decision rules, which, more concisely and exhaustively, effectively describe the different situations obtained for each area. Different minimal sets of decision rules have been chosen, requiring that the conditional part contain the fewest possible number of criteria, i.e. that the rule be as short and clear as possible.

Tables 1-4 correspond to the decision rules for each area investigated. In these tables, each row contains a rule, the next seven columns refer to the different criteria considered andthe last column, indicates the objects, called support, that satisfy the corresponding rule, and therefore justify the assignment to a decision class, according to the preferences expressed by the farmers. Note that, of course, "≤ medium" means "low or medium", and "≥ medium" medium or high.

For example, the above-described rule 1from Tab. 1 (Paternò area), using the natural language will be expressed as follows: "If A4, that is the improvement of the ecosystem with organic farming, is at least medium-high, then the cultivation is classified high ". This means that, if a new crop reaches at least level 4 with respect to criterion A4, then it will be considered high and, therefore, assigned to the highest quality level among those considered. The same rule has as support objects 2, 3, 5, i.e. the corresponding crops, i.e. citrus fruit, orchard, olive grove. From the point of view of decision support, we have therefore to draw farmers' attention to the ecosystem improvement with organic farming, since this practice in that area allows to reach the highest qualitative level of the decision classes. In a similar way, we can obtain decision support from the other decision rules.

Rule 2 can be expressed as follows: "If A4, that is the improvement of the ecosystem with organic farming, is at most medium, and A5, that is the profitability of crops, is also at most medium, then the cultivation is classified at most medium, with the supporting objects 4, 6, 7, i.e. vineyards, vegetables and cereals and forage.

We observe that in the Paternò area (tab.1) there are only two classes of assignment (high and medium) expressed by the farmers, since no cultivation has been attributed to the low class. Therefore, in this case and only in this case, the assignment "at the most medium" is equivalent to saying "medium".

Looking at Tab. 5,it is also clear that in the Paternò area there are numerous dominance relations (7) between the different types of cultivation. Thus, for example, the first line points out that cultivation 1 (dried fruit) dominates cultivation 4 (vineyard),indicated by "1"in the cell at the cross first row, fourth column; from the second line, that cultivation 2 (citrus fruits) dominates 3 (orchard), 4 (Vineyard), 6 (vegetables), 7 (cereals and forage), etc.

As noted above, if a dominates b means that a is at least as good as b with respect all considered criteria. Dominance relations Tables 5 and 6 are antisymmetric: for example. the cell at the cross fourth row, first column in Table 5 indicates "-1", that is cultivation 1 (dried fruit) is dominated by cultivation 4 (vineyard).

Moreover, from tab. 2 it is evident, among other things, that in Bronte area the criterion A7 (ability to maintain biodiversity) is able to explain by itself the assignment of crops to the "low" and "at least medium" classes, as well as the "medium" evaluation on this criterion is able alone to discriminate against only the aforementioned decision classes. It is also interesting to note that the criteria A3 (conventional agricultural pollution) and A4 (ecosystem improvement with organic agriculture) were implicitly considered by the experts to be unimportant in planning decisions (class assignment) in the area of Bronte, Moio Alcantara and Piedimonte Etneo, since no one of these criteria is present in decision rules of corresponding Tables 2, 3, 4.

Conversely, Tab. 3, which is related to the Moio Alcantara area, shows the high discrimination capacity of the A2 criteria (influence on the landscape) and A5 (profitability of crops), each of which alone can justify all the assignments and discriminate the different assignment classes. In a similar way, A5 criterion (profitability of crops), alone justifies all the assignments and discriminates the different assignment classes in "at most medium" (low or medium) and "high" in the Piedimonte Etneo area (Tab. 4).

Finally, it should be noted that the most frequent criteria in the decision rules reported in the presented tables are the criteria A2 (influence on the landscape) and A5 (profitability of crops). This last criterion is present in the conditional part of decision rules of all areas and therefore can be considered the most important took into consideration by the farmers of the aforementioned territorial and consequently of strategic importance for future planning. In contrast, it should be noted that criterion A3 (pollution due to conventional cultivation) is not present in any decision rule inferred, and that criteria A1, A4, and A6 are present each one only in one of the considered areas.

Once again, we emphasize that decision-making rules,as noted above, are of great support in making decisions. In fact, they in particular: a) provide by their support a traceable justification of the assignments to the decision classes; b) offer useful operational information about action on criteria to be improved, showing discriminatory threshold values necessary to advancethe allocation of crops in the decision classes.

The results highlight the barriers that determine the non-participation of farmers in the financial proposals promoted by the funds of the I and II pillars of the Common Agricultural Policy, specify the needs and expectations of respondents towards these economic-financial instruments and verify the level of exercise of good agricultural practices for the conservation of biodiversity. The following emerge clearly

- the willingness of the farmers interviewed to make their own contribution to biodiversity conservation;

- the presence in the area of farms that habitually apply good agricultural practices;

- the urgent need for companies to be supported in the promotion of their products on the market;
- the request for reduction of bureaucratic and administrative burdens related to access to funding measures;
- the need to diversify the areas of support and the criteria for access to funding according to company size, type of production and type of territory;
- the need for periodic and systematic communication and training of the agricultural and rural population on the contents and aims of European, national and regional policies on agriculture, food and the environment;
- the importance of providing institutional communication campaigns that illustrate the role of agriculture in preserving the environment and the different types of initiatives that can be classified as "good agricultural practices", so as to activate a greater degree of sensitivity of the population (demand subjects) towards these important functions of agriculture so that a "premium price" can be recognized.

Through the evaluation of the results of the questionnaire, the workgroup intends to contribute to the debate on the launch of the new regime of the CAP 2021/2027, so that it can be truly aligned with the European Green Deal and the Biodiversity and Farm to Fork strategies, but above all responsive to the needs of small farmers. In fact, the main CAP subsidy paid per hectare distorts the production model in favor of larger farms and landowners, who are not necessarily farmers. There is a need to create new perspectives for small family farms, which, in the face of a very important role in protecting and enhancing the territory, receive much less support than large "industrial" farms.

In this context, identifying what good agricultural practices are already adopted by farmers in the study area and what challenges need to be addressed to help them operate in a manner favorable to biodiversity, without jeopardizing the profitability and competitiveness of their economic activity have become the key objectives of the project. The development of agroecological practices on a large scale, together with the enhancement of local food products and short, traced and distinctive supply chains allow, in fact, to counteract the various phenomena of environmental degradation mentioned above and to revitalize rural territories.

CONCLUSIONS

Countries are adopting measures for the conservation and sustainable management of natural resources. They are adopt legal mechanisms to ensure the use of ecosystem services, to protect biodiversity, to implement sustainable forest management plans. But the latest progress report on the implementation of Agenda 2030 (UN 2020a) calls on all Countries to do more and calls for immediate action and a fundamental transformation of our relationship with the Earth, to halt the loss of biodiversity and protect ecosystems for the benefit of current and future generations.

With reference to SDGs 15, there have been multiple actions and interventions by States, which have led to an increase in protected areas from 2000 to 2018 precisely to protect the

biodiversity and to ensure the long-term and sustainable use of natural resources. But critical areas still exist and the risk of species extinction has worsened by almost 10% over the last 25 years, while land degradation has affected one fifth of the land on our planet (2 billion hectares) and the lives of 3,2 billion people, driving species to extinction and intensifying climate change (UN 2020a,b).

The area investigated, "Terre della Biosfera – le valli fluviali dell'Etna" ("Etna river valley"), established as the "Biosphere Area" of the UNESCO "MAB - Man And Biosphere" Programme, represents an opportunity to adopt sustainable development models in the "Etna system". In particular, it could promote the regeneration of virtuous relations between the city and the countryside (food, tourism, renewable energy, waste, etc.), the requalification of the landscape, the protection of biodiversity, the rediscovery of local cultural identity and the relocation of the economy, in line with SDGs 15.

The research has shownthat, taking into account many different criteria, the territory in question "Terre della Biosfera – le valli fluviali dell'Etna"("Etna river valley") represents a very active territory from the agricultural and production points of view, with the consequence that the prevalent interest is devoted to the criterion of profitability, according to the results of our analysis. Interesting is the high evaluation that is given to the landscape aspects of the territory for potential future tourist developments (Parco dell'Etna 2020; Scuderi et al 2021). The environment, there is limited attention to the pollution of conventional agricultural production, although there is a certain interest in organic farming. This data shows that there is stil little awareness of the environmental benefits offered by organic farming. Policy makers should therefore take adequate measures to better orient local farmers toward bio-agriculture. The Sicilian Region is still far from adopting an environmental model that is completely sustainable, but adopting the necessary measures and tools, it could become the ideal destination for tourist flows that wish to combine fun and the optimal use of natural resources (Spadaro et al. 2020).

The DRSA methodology well fits with the purpose of the research, allowing in such a rather heterogeneous scenario to: consider also purely qualitative data; express the decision rules in terms of syntax particularly rich; have an easy reading of these latest even for non-experts, as they are expressed in natural language; represent effective decision support that the rules can provide to the decision-maker for future territorial planning analyses and, finally ,provide the justification of each decision rule, showing the supporting objects. Moreover this approach does not require the specification of any technical parameters, such as subjective importance weights, assuming as the only model of preferences some decision examples provided by the decision maker.

Therefore, the application presented in this study could be an example of best practice as methodological support for SGD policy.It is very flexible implementation in terms of input data and the easy understandable results represent interesting features, very useful on this kind of studies that consider analysis of different dimensions.

In conclusion, the area defined as "Terre della Biosfera – le valli fluviali dell'Etna "("Etna river valleys") presents characteristics of uniqueness that must be protected, in relation to

its remarkable naturalistic value and the presence in the territory of social, economic, and environmental values that lead back to the principle of sustainability in terms of diversity within species, between species and of species and ecosystems. This development and conservation model can be seen as a part of the ambitious Sustainable Development Goal (SDG) n. 15 "Life on Land", which aims to "sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss". The proposed methodological approach could support local institutions and individual farmers in the choice of strategic actions to activate in order to achieve some of the goals set out in SDGs 15, especially in protected areas, where the relationship between nature and man can become critical and, if not managed in a sustainable way, can cause loss of biodiversity and ecosystem services.

The MAB programme aims to contribute to achieving the Sustainable Development Goals and implementing the 2030 Agenda for Sustainable Development both within biosphere reserves and through the global dissemination of sustainable development models that have been realised through local experiences in biosphere reserves. These universal goals must continue to be pursued and Countries must focus on not only growth, but also even more on inclusion and equity, combating climate change, protecting biodiversity and environmental sustainability.

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