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Regenerating Nature to regenerate Communities?

A first approach on a rural area: the case of the Union of Valconca's municipalities

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Introduction

This thesis is the culmination of a human and educational journey that has allowed me to explore themes to which I have always been deeply attached and then to try to "territorialise" them, i.e. make them concrete in a given place and time.

In particular, the concept of Sustainable Development has been investigated, starting from its theoretical assumptions, and then attempting to place them in a very specific local context: the Union of the Valconca municipalities. The main objective of the research was to identify sustainable development possibilities for rural areas..

To achieve this objective, a case study was carried out, analysing the main territorial dynamics through exploratory interviews with the community and then using the ecosystem services approach.

The choice of the "case study" was the result of the meeting and the collaboration, for a part of my PhD journey, with an agency of participatory strategic planning ("Piano strategico S.r.l"), which has enabled me to approach and look at the territory in a way that I couldn't have done alone. In particular, the collaboration with the project "Valconca Next - towards a strategic plan of Valconca" allowed me to take part in the initial campaign of "exploratory" interviews, intended as functional to the creation of a participate strategy of sustainable development for this territory and community.

In parellell, the theme of ecosystem services has been analyzed, from the theoretical principles to mapping techniques and biophysical assessment, ending with economic evaluations. From the different analyses of the study area, it has emerged that one of the most interesting and desirable perspectives for the immediate future of the resident communities, is that one resulting by the adoption of organic farming's practices. The adoption of these practices, together with a possible territorial reconfiguration into a "*bio-district*", would have repercussions on several levels in the area in question.

There is also an open debate in the literature on the contribution that these practices can make to climate change mitigation. It was therefore attempted, through a tool developed by FAO, to study the potential absorption of GHG gases induced by the adoption of organic and/or conservative agricultural practices.

The results confirm what was expected: organic and conservation agriculture practices can be one of the solutions for the mitigation of global warming. But not only that, carbon sequestration in soils has a number of 'systemic' benefits for agro-ecosystems and the community itself. Moreover, the creation of associations linked to quality agricultural supply chains can effectively contribute to preserving and in some cases regenerating the social capital of these territories.

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1. THE QUEST FOR SUSTAINABILITY AND THE ECOSYSTEM SERVICES APPROACH

The concept of Sustainable Development (SD) has now become a *mantra*, with respect to which everyone, from the single individual to the leaders of nations, cannot be indifferent. Taken literally, 'sustainable development" is development that can last over time, indefinitely (Dernbach, 1998, 2003; Lele, 1991; Stoddart, 2011, Mensah, 2019).
Sustainable development was the solution to the problems of environmental degradation discussed by the Brundtland Commission in its report "Our Common Future" (1987). The purpose of the Brundtland Report was to investigate the many concerns raised in the preceding decades, namely that human activity was having serious and negative impacts on the planet and that patterns of growth and development would be unsustainable if they continued unchecked. Key works that highlighted this thinking included Rachel Carson's "Silent Spring" (1962), Garret Hardin's "Tragedy of the Commons" (1968), Ecologist magazine's "Blueprint for Survival" (1972) and the Club of Rome's "Limits to Growth" report (1972). In the Brutland Report, sustainable development is defined as: "*the development that meets the needs of the present without compromising the ability of future generations to meet their own needs'*. From this definition and the literature on the subject, it is clear that the pursuit of sustainability cannot only be an environmental prerogative, but to be achieved, it must also include social and economic dimensions. It is possible to identify these three dimensions as interacting, mutually influencing subsets.

The capital approach to sustainability (Stern, 1997) allows for an even better definition of the idea of intergenerational equity, defined as the equitable distribution of resources between successive generations. In fact in order to act with a view to sustainable development, the capitals (on which development's capacities are based) should be held at least the same between one generation and the next (ibid.). Capital is one of the key points of economic theory (see for example Jansson et al., 1994 and Faber et al., 1995) and in its essence can be defined as a stock that can generate a flow of goods and/or services (Ekins et al, 2003). There are different types of capital from which goods and services are generated (often resulting from the interaction between them). The classical economics identifies three kinds of capital, that are land, labor and human-made capital; Ekins (Ekins, 1992) instead, refers to four kinds of capital, that is human, social, manufactured and natural (also called ecological or environmental) capital. Goodwin (Goodwin N., 2003), disaggregating more, identifies five kinds of capital, adding financial capital. Each of these stocks produces a flow of 'services', which serve as inputs into the productive process (Ekins et al, 2003).

Ecological economics distinguishes between strong and weak sustainability. The concept of weak sustainability, which comes from the work of Nobel Prize winner Robert Solow (Solow R.M., 1974, 1986, 1993) and John Hartwick (Hartwick J. 1977,1978) , is based on the assumption that "human-made capital" can replace "natural capital". On the contrary, in the concept of strong sustainability, these two types of capital are complementary but not substitutable. If the overall goal of sustainable development is the long-term preservation of the well-being of human beings and that the well-being of human beings is based on the benefits derived from different capitals and their synergies, then in weak sustainability is only the summation of these capitals that must be constant:

NATURAL CAPITAL + SOCIAL CAPITAL + HUMAN CAPITAL, ETC. = CONSTANT

So, for example, natural capital can decrease as long as it is replaced by the growth of one or more of the other capitals and the total capital remains unchanged. To give an application , it is possible to decrease forests, reserves of mineral materials, if this decrease in natural capital brings an increase in financial capital or built capital.

The strong sustainability principle, on the other hand, claims the “non-substitutability” of capitals, which can increase or at least remain constant over time to ensure the welfare flow required for human societies to thrive.

Both conceptions, if they are taken in a rigid or extreme manner, have operational limitations (Ferlaino, 2005). In fact, weak sustainability has been strongly criticized because it allows high replacements of natural capital, which is hardly plausible: natural capital provides basic-life support systems such as food, drinking water, clean air and a stable climate that are difficult to replace (Turner 1993; Barbier et al., 1994; Gutés,1996). On the other hand, even strong sustainability, if considered as the complete non-substitutability of capitals, is weak on the operational level, since “it is a platonic construction that, in its most extreme aspects, does not allow for social and economic change, but only the preservation of the existing or, worse, the pre-existing” (Ferlaino, 2005).

Therefore, from literature review, arises the concept of critical natural capital (CNC), as the portion of natural capital that must be maintained and preserved because it provides those goods and services that are not currently replaceable by other forms of capital. The CNC can be identified with ecosystems, species or processes that are ecologically, economically or socially important (Brand 2009, de Groot et al. 2003, Rounsevell et al. 2010) and it can include essential global ecological processes (e.g. carbon sequestration) but also locally significant cultural landscapes or ecological functions (purification of air and water).

1.1 Natural Capital and Ecosystem Services

Since the beginning of human existence on this planet, the development of human societies has been strongly linked to the use of natural resources stocks and the goods and services they provide.The entire stock of natural assets is called today “Natural Capital” and includes all the living organisms, air, water, soil and geological resources that contribute to providing goods and services that have direct and indirect value for humanity and that are necessary for the survival of the environment from which they are generated (Comitato Capitale Naturale, 2017).

Following the ecosystem approach promoted by the *Convention on Biological Diversity* (UN,1992) is possible to distinguish the assets of natural capital from biotic and abiotic components. Biotic components include all terrestrial and marine ecosystems, together with the flora and fauna they contain (biodiversity), while abiotic components are minerals, metals, fossil fuels, but also air, wind or solar power (Comitato Capitale Naturale, 2017). Like all other types of capital, the stock of Natural Capital produces a flow of services, for the present time and for the future, called *ecosystems services* (ES) (De Groot, 1992), such as climate regulation, water purification, protection from extreme events, the supply of material food and energy, but also cultural services such as the inspiration and pleasure originated by the contemplation of nature.

The modern concept of ecosystem services as indicated by Lele et. al (Lele S. et al. 2013) arised in the 1970s as 'environmental services' (Wilson and Matthews 1970), was re-named 'ecosystem services' in the mid-1980s (Ehrlich and Mooney 1983), and it gained really momentum from 1997 onwards with the works, among others, of Costanza and Daily (Costanza et al. 1997; Daily, 1997).

One of the most widespread and used definitions is still that one provided by the Millennium Ecosystem Assessment which defines ecosystem services as "the functions and products of ecosystems that benefit humans" (MA, 2005). Some other internationally recognized ways that are used to define ecosystem services, are: "the direct and indirect contributions of ecosystems to human well-being" (TEEB, 2010), "the contributions of ecosystem structure and function, in combination with other inputs, to human well -being "(Burkhard et al., 2012; Burkhard & Maes (Eds), 2017) and again" all the positive contributions, or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature "(Pascual et al ., 2017).

Table 1.1 *- Review of ES's definitions from different sources.*

Definition	***Reference***
"The benefits humans derive from nature"	Millennium Ecosystem Assessment, 2005
"The benefits that humans recognize as obtained from ecosystems that support, directly or indirectly, their survival and quality of life"	Vandewalle et al., 2009
"The capacity of ecosystems to do something that is potentially useful to people"	Haines-Young & Potschin, 2010
"The potential that ecosystems have to deliver a service which in turn depends on ecological structure and processes"	de Groot et al., 2010
"The contributions of ecosystem structure and function, in combination with other inputs, to human well-being"	Burkhard et al., 2012 Burkhard & Maes (Eds), 2017
"*All the positive contributions or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature*."	Pascual et al, 2017

The Cascade Model

A conceptual model useful for understanding the issue of ecosystem services is the “cascade model” (Haines-Young and Potschin, 2010; Potschin and Haines-Young, 2011, Potschin and Haines-Young, 2016). This model shows, through a flow diagram, the relationships between ecosystems and the human system (see figure 1.1).

Figure 1.1: *The cascade model (after Haines-Young and Potschin, 2010)*

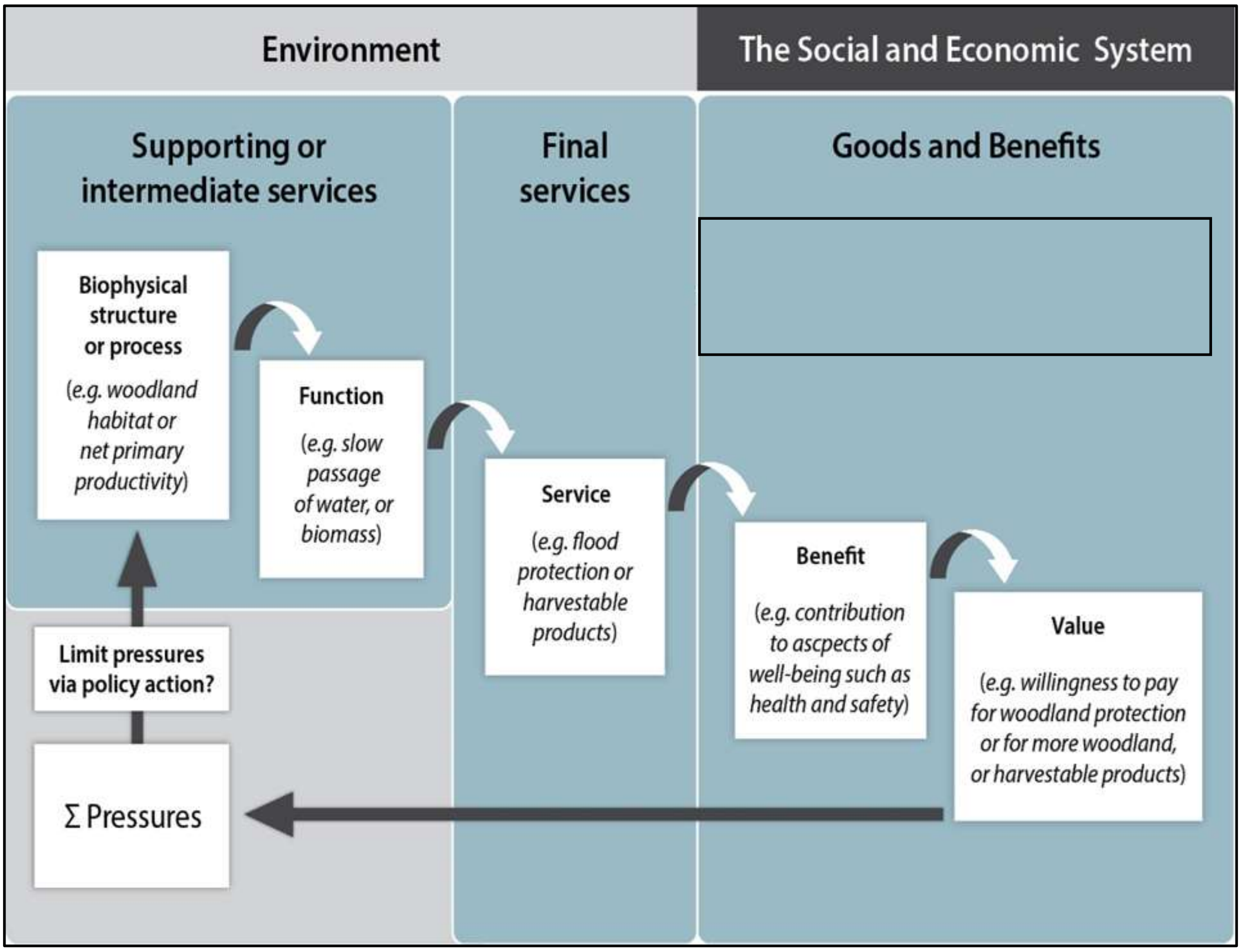


Figure 1.1: *The cascade model (after Haines-Young and Potschin, 2010)*

In this representation, ecosystem services are in the middle of the model, and represent the link between ecosystems, their properties and functions (left) and the human system (right).

Starting from the left in the figure, ecosystems are characterized by typical *structures* (type of habitat, i.e. woodland, wetland, grassland, etc.) and *processes* (i.e. primary productivity, nutrient cycling, soil formation), which generate the various *functions* of ecosystems. *Functions*, in this case, are those properties and processes of ecosystems that can be useful to humans, because they underlie the ability to provide a specific ecosystem service (Burkhard & Maes (Eds.) 2017).The state of ecosystems, the integrity of their structures and processes are decisive in the ability to provide functions and therefore ecosystem services (Maes et al., 2018). *Structures, processes and functions*, in this conceptualization, define the so called "*supporting or intermediary services*", that is a kind of ecosystem services that don't provide direct benefits to the human system, but support the provision of (final) ecosystem services.

The final *ecosystem services* (central box in Figure 1.1) therefore include those functions, coming from the structure and processes of ecosystems, which directly impact our socio-economic system and well-being and that generate *benefits* (Haines-Young and Potschin 2010).

Benefits depend on the type of service considered and may relate to health, ability to earn an income, protection from extreme events, water supply, etc.

It is possible to assign a *value* (monetary, moral, aesthetic or social) to these benefits. These values can be strongly dependent and conditioned by the historical-cultural context to which they refer (Haines-Young and Potschin 2010, IPBES 2019).

On the basis of these values, we usually act through actions and policies which can affect the state (structure and processes) of natural capital and therefore its ability to generate services (Burkhard & Maes (Eds.) 2017).

According to what has been expressed so far, it is clear that, if we don't recognize the services that nature offers us and don't assign them a suitable value, trying to emphasize their benefits for the society, we run the risk (and we are already running it widely, see for example the latest IPBES global assessment on biodiversity and ecosystem services (IPBES, 2019), to erode natural capital and the services deriving from it, beyond certain thresholds, in a way that the foundations of our prosperity on this planet could be seriously at risk.

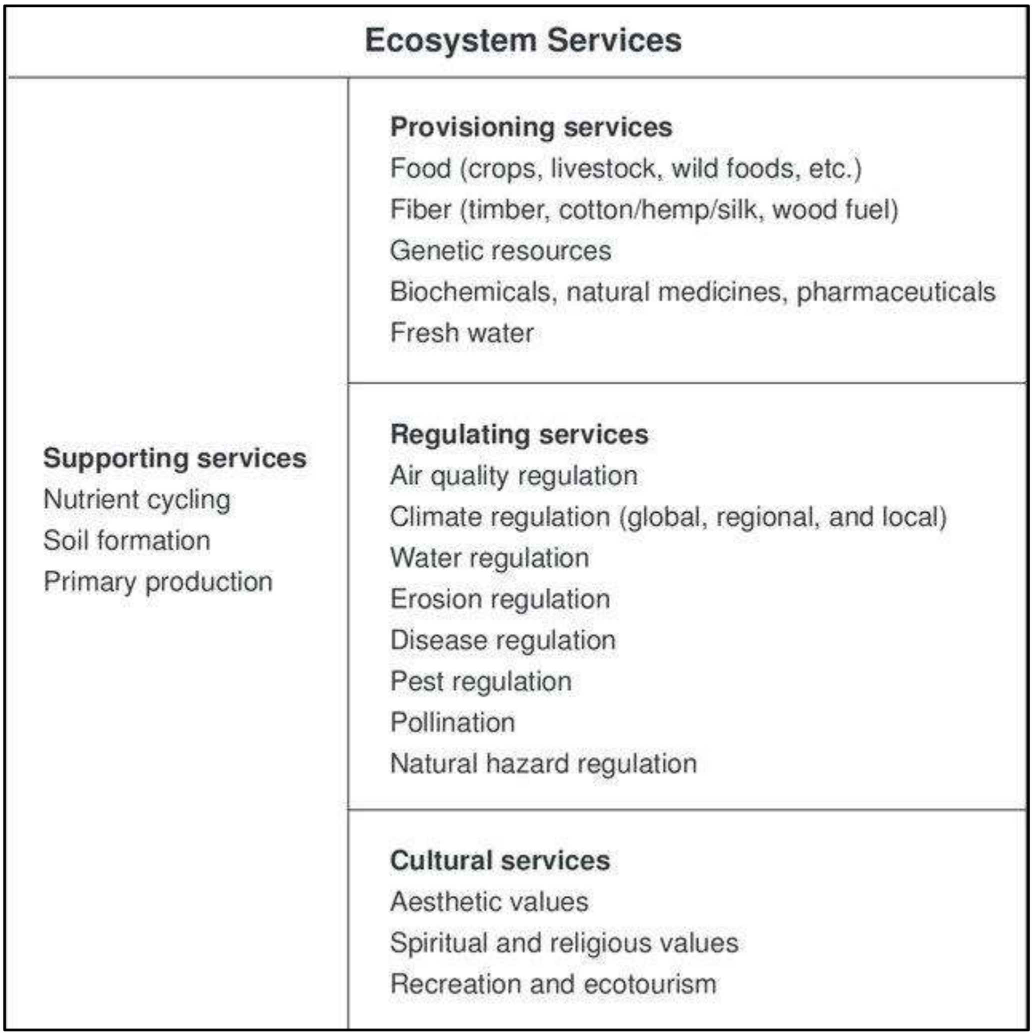
International initiatives and classification

The concept of ecosystem services and natural capital gained a lot of visibility at the international level with the "Millennium Ecosystem assessment" (MA, 2005; https://www.millenniumassessment.org/en/index.html). The work, supported by the United Nations, provides a comprehensive assessment of the state of natural capital and ecosystem services, underling the impacts by human actions but also the possible solutions for maintenance, restoration and sustainable use of natural resources.

The MA classification has been the first globally accepted categorization that provided a sound basis to launch ESs research and applications, despite the “lack of proper taxonomy” (La Notte et al., 2017). ESs are classified according to functional lines by using categories of:

- *Provisioning services* – food, materials and energy, which are directly used by people;
- *Regulating services* - the service that cover the way in which ecosystems regulate other environmental media or processes;
- *Cultural services* – the service that are related to the cultural or spiritual people's need*;*
- *Supporting services-* ecosystem processes and functions that support the other three types of services.

***Table 1.2** – The MA ecosystem services classification* (MA, 2005)



Ecosystem Services	
Supporting services Nutrient cycling Soil formation Primary production	**Provisioning services** Food (crops, livestock, wild foods, etc.) Fiber (timber, cotton/hemp/silk, wood fuel) Genetic resources Biochemicals, natural medicines, pharmaceuticals Fresh water
	Regulating services Air quality regulation Climate regulation (global, regional, and local) Water regulation Erosion regulation Disease regulation Pest regulation Pollination Natural hazard regulation
	Cultural services Aesthetic values Spiritual and religious values Recreation and ecotourism

Between 2007 and 2010 the international initiative - The Economics of Ecosystems and Biodiversity (TEEB, http://teebweb.org/), has taken place thanks to the iniziative by the European Commission and the German Federal Ministry for the Environment. TEEB added the economic perspective to the policy debate on ecosystem services: trying to identify the economic cost of the degradation of natural capital and ecosystem services. The work was attended by experts in many fields, from natural sciences to economic and political sciences.

TEEB classification of ESs builds on MA from which differs in the omission of Supporting Services. Instead, a new category known as Habitat Services are introduced to emphasise the importance ecosystems in providing habitat for migratory species (i.e. nurseries) and their role as genetic diversity protectors. The resulting categories are: *Provisioning*, *Regulating*, *Habitat Services* and *Cultural and Amenity Services*.

At the European level, the adoption in 2011 of the *EU Biodiversity Strategy to 2020* put the ecosystem services definitively on the political agenda. The strategy's purpose was stopping the loss of biodiversity and ecosystem services, and trying to restore them where possible. Th member states were also required to map and economically evaluate the ESs by 2020, according to action 5 of the strategy, which required to increase knowledge on the state of ecosystems and their services in the territories of the EU. In order to support this mapping *the Common International Classification of Ecosystem Services* (CICES) has been used. This classification was originally developed by the work for environmental accounting undertaken by the European Environment Agency (EEA) (Maes et al., 2014). The CICES (Haines-Young & Potschin, 2013) developed on MA and TEEB classifications, provides a hierarchical system evolved on several levels of detail and poses great emphasis on the ecological dimension (La Notte et al., 2017). CICES classification, whose last update ended in 2018, considers three categories: Provisioning, Regulation and Maintenance Services, and Cultural Services.

CICES describes these three categories of services using a five-level hierarchical structure. Each level is progressively more detailed and specific. An example of classification is provided below:

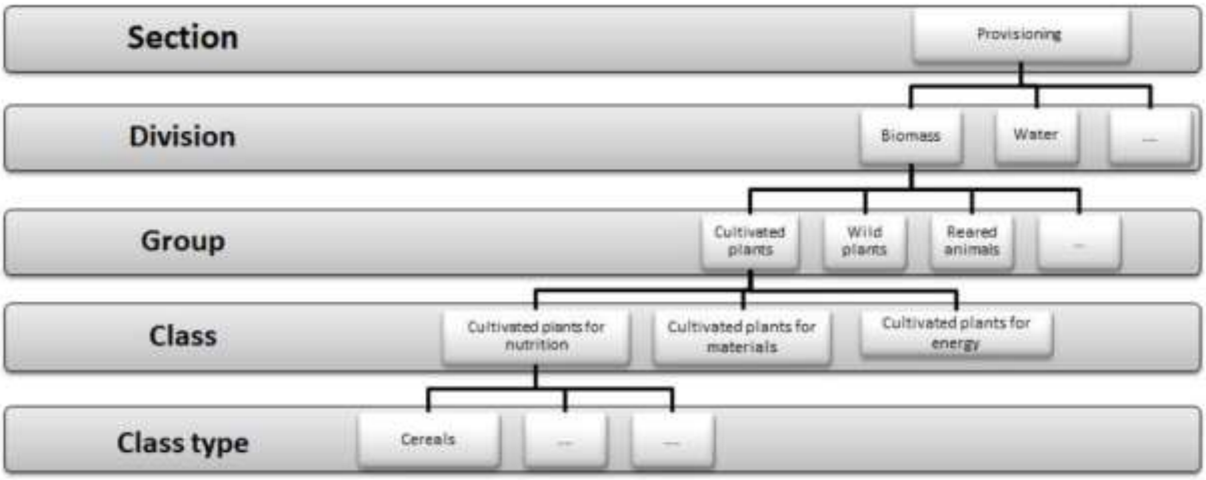


Figure 1.2: example of CICES classification structure (https://cices.eu/cices-structure/)

One of advantage of CICES is that it allows, within its classification, a comparison of the other types of classifications, including that of IPBES (see below). .

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services-IPBES, has been established in 2012 that is supported by four United Nations agencies : UNEP, UNESCO, FAO and UNDP and it is administered by UNEP.
IPBES wants to improve the science-policy interface on the issue of biodiversity and ecosystem services as well as the conservation and sustainable use of biodiversity, long-term human well-being and sustainable development.
Over the years it has produced several thematic reports and the first draft of the Global Assessment Report on Biodiversity and Ecosystem Services (IPBES, 2019) was made available in 2019.

The IPBES approach differs more from those mentioned above, the original wording of ecosystem services changes to Nature's Contribution to People (NCP) and the categories of ecosystem services are reclassified into three categories of NCP: regulating contributions, materials contribution and non-materials contributions.
These categories (in first analysis) can be associated respectively to regulating, provisioning and cultural services.

1.2 Ecosystem services and human well-being

The theme of human well-being (HWB) or of a "good quality of life" (in the IPBES framework) is closely linked to ecosystem services, in fact it can be considered the goal towards which the whole ecosystem services framework tends (Jax & Heink, 2016). HWB is a multifaceted concept but according with Gasper (Gasper, 2005) it can be divided into subjective and objective well-being: Indeed even though there are some dimensions (such as basic needs for food or shelter) which are always valid, many dimensions of HWB are dependent on place, culture, and history (Jax & Heink, 2016) and personal aspirations and values (MA, 2005; Diaz et al., 2015).

Ecosystems and their functions can offer a multitude of services that are of fundamental importance for human well-being (Costanza et al., 1997; MA, 2005; TEEB, 2010).

In the conceptualization of the Millennium Ecosystem assessment (MA, 2005), great emphasis is placed on Human Well Being (HWB) and on the contributions that ecosystems provide to this multidimensional concept and it is defined as the opposite of poverty, described as a "pronounced deprivation in well-being" (MA, 2005).

In the MA, the components of the HWB have been divided into four macro-categories which include: safety, primary goods, health and social relations; plus a fifth, triggered by the achievement of the previous four defined “freedom of choice and action”.

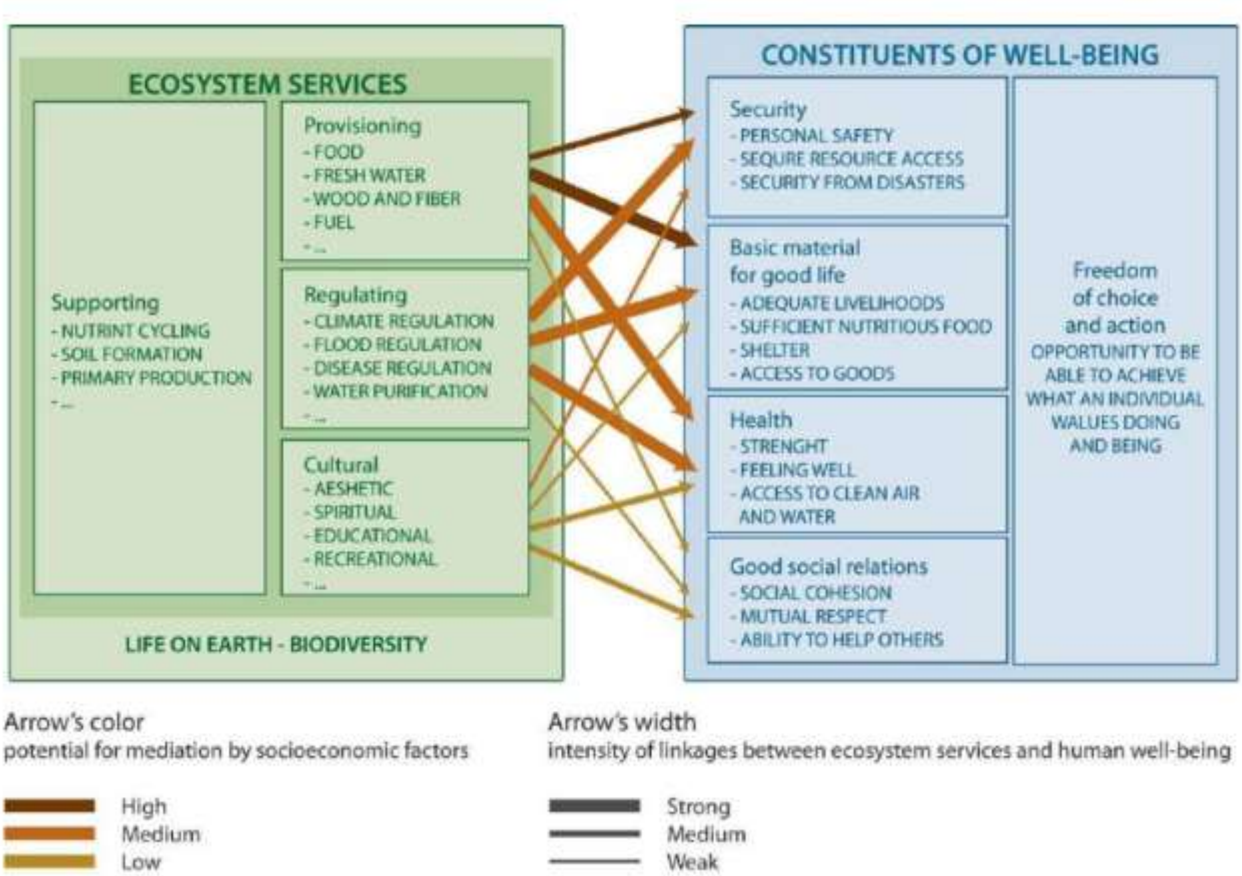


Figure 1.3: The links between ecosystem services and human well-being (MA, 2005).

In the figure, the arrows that connect the ES with HWB are differentiated on a chromatic level, depending on the capacity of the socio-economic system to mediate this connections (eg. compensating with technology a degraded ES).
The thickness of the arrows instead, specifies the degree of intensity with which the ES contribute to the HWB. The strength of the linkages and the potential for mediation differ in different ecosystems and regions. (MA, 2005).

BASIC MATERIAL FOR GOOD LIFE

The Millennium Ecosystem Assessment defines this category as "the possibility of having adequate and secure sustenance, including goods and income, sufficient food and water at all times, a shelter and the possibility of having energy for heating or cooling" (MA, 2005).

Income and employment

The earning that comes directly or indirectly from natural capital includes both the revenue from the sale of resources such as fruits and other food, timber, fuel wood, medicinals and materials for handicrafts or art (MA, 2005), and the revenue from the nature-based tourism, as well as payments that rural landowners might receive for ecosystem services such as preservation of watershed functions or carbon storage (IPBES, 2019).

The increase in supply services such as the production of agricultural crops, fisheries and forest products has been associated with a significant growth of local and national employment and economies (MA, 2005). In the areas where the productivity declines due to land degradation or fisheries overload, the impacts on local economies and employment could be devastating for the poor or those who rely on these services for income (MA, 2005; ODI, 2014).

Ecosystems also can provide regulatory services, that can protect people and goods from extreme events, reducing the health care and material damage costs. The cost of building new infrastructure, to protect against extreme events, can be saved by using wisely these regulatory services and nature-based solutions (Somarakis et al. (Eds), 2019). Urban green space helps mitigate health-related diseases thereby reducing health care costs (Smith et al, 2013).

Food

The production of food (and feed) on a global scale derives largely from the union of natural, human and built capital. So when it occurs that some components of human capital (knowledge, practices) and built capital (machinery, tools, etc.) combine with the natural capital component to generate the final ecosystem service (Fischer & Eastwood, 2016; Palomo et al., 2016) we can speak of co-production of ecosystem service. Historically, in fact, people have selectively bred some species, which have evolved separately from their wild relatives, and it that way they have set off the birth of agriculture and livestock, which have completely "reshaped human societies and their environment" (Stépanoff & Vigne 2018). This synergy between man and the environment has brought huge benefits over the years for the health and well-being of billions of people (MA, 2005; TEEB, 2018), with a constant reduction in malnourished people (FAO, 2017).

The amount of food produced has had a huge growth in the last decades, so much so that IPBES, (IPBES, 2019, Ch. 2.3) based on some estimates of the FAO (FAO, 2017), argues that the current volume of food produced annually would be enough to feed all the world population, including the extra population forecast for 2050 (9.5-12 billion). While food production is fundamental for the sustenance of human beings, at the same time it is one of the main drivers of environmental degradation, including the loss of biodiversity (IPBES, 2019, Ch. 2.3).

The natural component in turn is fundamental for the production of food. In fact, agro-ecosystems are extremely depending on supporting ecosystem services (formation, structure and fertility of the soil, nutrient cycle) (Power, 2010; Zhang et al., 2007) and on regulating ecosystem services (pollination, protection from diseases) (Power, 2010; TEEB, 2018).

For example pollinating insects influence food supply on a global scale, since crops dependent on pollinators amount to 35% by volume of total production (IPBES, 2016). Klein et al. (2007) found that 87 of 115 globally important crops benefit considerably from pollination, from a hypothetical maximum of 90% (i.e. melon, watermelon, pumpkin) to a minimum of 5% (i.e tomato) on the final yields. Globally, the value of this service has been estimated in a range between US $ 195 billion to US $ 387 billion annually, based on the estimation methodology and input data used (Porto et al., 2020).

HEALTH

The health of individuals is a product but also a determinant of well-being (MA, 2005).The changes in provisioning services (such as the availability of food and water, medicinal plants or biobased material for new medicines) and regulating services (which can affect the quality of air, water, the transmission of diseases and absorption of waste) have a very strong impact on health (MA, 2005). These contributions are threatened by changes in ecosystems, for example, according to a study of McMichael et al., In 2003, an 83% of medicinal goods had yet to be discovered from tropical vegetation (McMichael et al., 2003); while Miller et al., calculated that in 2011, over 600 new medicines could still be discovered from plants that had not yet been studied, much of which could be lost forever if biodiversity continues to decline (Miller et al., 2011). Ecosystem condition also has direct impacts on human health resulting from bacterial contamination, air pollution, and toxic algal blooms (Cox et al, 2003).

Green areas, especially in urban areas, can reduce the concentration of pollutants in the air (Liu & Shen, 2014; Nowak et al. 2006; Tzoulas et al., 2007) caused by traffic and domestic heating (primarily particulate matter), through the deposition of pollutants on the surface of trees and / or by stomatal uptake of gases (Niinemets et al., 2014). Air pollution is one of the main causes of premature deaths, especially in middle-income countries, and it has been estimated that around 6% per year (over 3 million) of deaths globally is attributable to this problem (GBD, 2017).

Changes in cultural services can also have a great influence on health: they are directly connected with the opportunities for inspiration, recreation, relaxation that have effects on both the physical and emotional state of people (MA, 2005). Access to nature, even if only through a window view, provides restorative experiences that can improve physiological and psychological health (Van Den Berg et al., 2007). Connection to nature and greenspace have been linked to healthy cognitive, physical and behavioral development, especially in youth and children (Hale et al., 2011).

These benefits are moderately mediated by socio-economic circumstances. For example, economically advantaged people can replace some ecosystem services through the purchase of medicines or quality water, but are vulnerable to poor air quality (MA, 2005).

SECURITY

In the Millennium Ecosystem Assessment (MA, 2005), the category "security" includes safe access to basic resources, protection from natural disasters, and the safeness of people and goods.

Changes in regulatory services such as disease transmission, climate regulation and flood regulation have a strong influence on safety. Changes in supply services such as food and water also have a significant impact on security, as their degradation can lead to the loss of access to these essential resources. Changes in cultural services can affect security as they can contribute to the disruption or strengthening of social networks within society (MA, 2005). The presence of green spaces in urban areas is associated with a decrease in aggression, violence and crime (Branas et al., 2011; Garvin et al., 2013; Kuo & Sullivan, 2001). These benefits are moderately mediated by socioeconomic circumstances. The rich personshave access to some safety nets that can minimize the impacts of some ecosystem changes (such as flood or drought insurance). However, thiss kind of persons cannot completely escape from exposure to some of these changes in the areas they live in (MA, 2005).

GOOD SOCIAL RELATION

The natural environment has important influences not only on individual wellbeing, but also on social relations (Hartig et al., 2014). In the MA, the category of good social relations is associated with the presence of mutual respect, social cohesion and the ability to help others and provide for children (MA, 2005). Kuo and Sullivan have found that higher levels of community cohesion, prosocial behaviors and social interaction among neighbors, are linked to the presence of communal green spaces in urban areas (Kuo & Sullivan 2001b, Kuo 2011). A healthy natural environment also stimulates a sense of community, increasing the sense of pride and the common will of citizens to live in a better place (EPA, 1997).

Changes in ecosystems and in the availability of resources at the same time can cause conflicts between different stakeholders, particularly when a group suffers from restrictions on access to natural resources or the consequences of the destruction of ecosystems (or its functions) by others. (IPBES, 2019). Striking examples of these cases have been recorded and continue to occur in coastal fishing communities, arctic populations, traditional forest and pastoral nomadic societies (MA, 2005, IPBES, 2019).

FREEDOM OF CHOICE AND ACTIONS

Freedom of choice and action refers to the ability of individuals to control what happens to them and to be able to achieve what they value (MA, 2005). Freedom of choice is severely limited, if not completely cancelled , when the other components of well-being deriving from ecosystems fail. Socio-economic circumstances can strongly mediate the influence of changes in ecosystems on the freedom of choice and action. Rich people living in countries with efficient governments can keep hold of choice ‘s freedom even in situations of significant ecosystem change, while this is much more difficult for the poorest, for example, if the change in ecosystems leads to a reduction in income (Ibid). For example, it has been shown that the reduction in the supply of firewood and drinking water increases the time that must be dedicated to find them, consequently, and so it is took away from the time available for the study, employment and care of other family members (Ibid)

1.3. Mapping and assessing Ecosystem Services

What to evaluate and map?

Natural capital is providing essential services for human survival and well-being, while, on other hand, is suffering a degradation not seen before (Newbold et al., 2015, IPBES 2019). In order to locate and monitor these degradation processes and to be able to reverse them, it is necessary to estimate where and to what extent these processes are occurring (Maes et al. 2012). In Action 5 (Target 2) of the EU biodiversity strategy to 2020, the need to provide for the evaluation and the mapping of the state of ecosystems and their capacity to provide ecosystem services was clearly stated.

The evaluation of ecosystem services must necessarily starts with understanding what needs to be valued and mapped.

Burkhard and Maes (Eds, 2017) , relying on *cascade model* identify the different components that can be analyzed in a socio-ecological system.

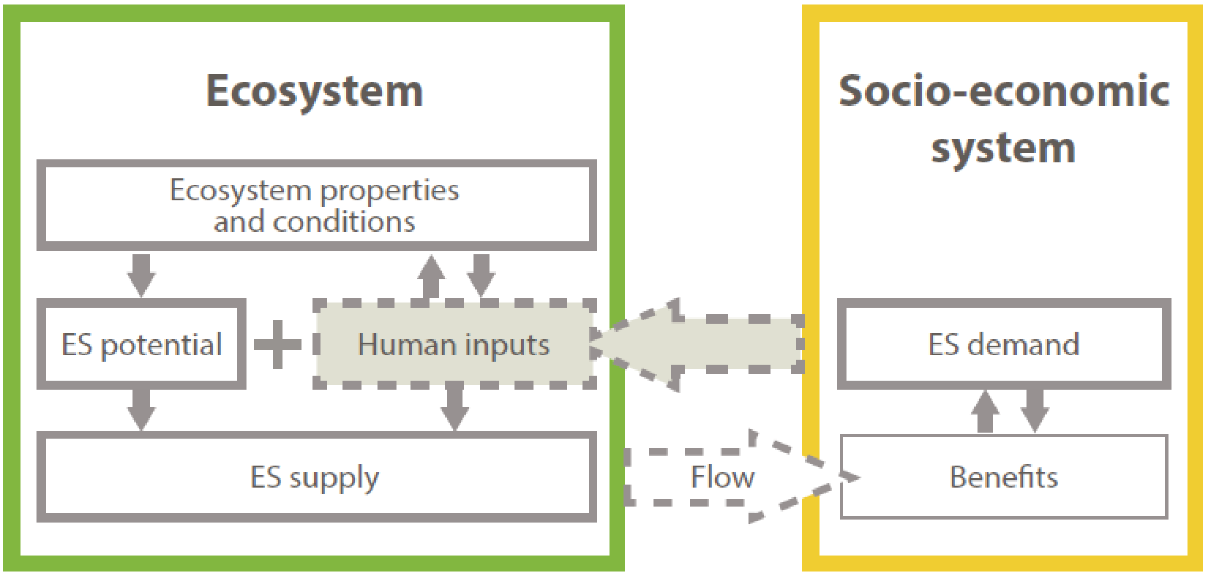


Figure : Evaluation and mapping aspect of ES.

Bold grey: subjects relevant for mapping; dashed: may be mapped; thin: additional aspects for which mapping could be developed (Burkhard & Maes (Eds.) 2017).

These components correspond to :

- *Ecosystem properties and condition*

  The specific structures and processes (properties) of the ecosystem, together with the state of integrity and health (condition).

  Ecosystem properties can be related to land cover/land use, climate condition, slope gradient, soil type, while ecosystem conditions are related to, for example, pollutant load and to the number of species present. The properties and conditions of ecosystems generate the potential or capacity of ES supply.

- *ES potential*

  It indicates the natural maximum capacity of ecosystem service provision, without the addition of human inputs, such as fertilizers, technologies and/or special management techniques. In this sense, ES potential (or capacity) indicates the amount of ES that can be provided or used in a sustainable way, based on ecosystem properties and conditions and current land use.

- *ES supply*

  Refers to the supply of a specific service, regardless of its current use, including some human inputs necessary to generate the service. Può essere valutato in un preciso momento nel tempo e dipende fortemente dal ES potential e dall’human co-production. Degli indicatori tipici per l’ES supply comprendono amount of carbon stored in soil and vegetation, relative reduction in noise or pullutants or yields of crops.

- *ES flow*

  ES (or set of ecosystem services) actually used in a particular area and in a particular time. Driven by a demand for a specific service, the ES supply is turned in a ES flow. If the flow is limited by a reduced ES supply, the ES potential may be affected, leading to over-use of the capacity to generate the service, to the degradation of natural capital, or to an unsatisfied demand for the service.

- *Es demand*

  Defining ecosystem services is possible because there is a demand associated with them by the human population (Fisher et al 2009).

  Demand in this case can be defined as ecosystem services need from the part of individuals, from some particular stakeholders and from the whole human society (Burkhard & Maes (Eds), 2017). This demand associated, for example, with a specific area depends on many factors: the number of inhabitants, cultural-dependent desires, the types of productive activities and the different possibilities with which this demand can be satisfied. The demand associated with regulatory ecosystem services often goes unnoticed or is taken for granted (Burkhard & Maes (Eds), 2017). From the industrial revolution to today, the demand for ecosystem services has hugely grown, and it is necessary to study in depth the relationship between the supply of ecosystem services and their demand (Marino et al, 2021). Infact this balance between supply and demand for ES has a direct relationship with human well-being and some issues such as sustainability and resilience (Villamagna et al, 2013). On the basis of these balances, it is possible to build an "ES footprints", similar to the concept of ecological footprint (Wackernagel, 1997, Burkhard, 2017).

How to evaluate and map?

The different components described above can be evaluated and subsequently mapped using different methods (Kasparinskis et al., 2018).

The assessment methods can be classified into:

- Biophysical methods
- Socio-cultural methods
- Economic methods
- Expert-based quantification

Biophysical methods are the most used, especially for the left side (also called "supply side") of the cascade model. In contrast, the components of the right side (or "demand side") of the cascade model, i.e., benefits and values, are most often measured with social or economic methods (Burkhard & Maes (Eds.) 2017).

2.2.1 Biophysical methods

A biophysical quantification is the measurement of an ES in biophysical units, as per example the amount of carbon sequestered and stored by vegetation, amount of grains produced, amount of pollutants filtered. Biophysical methods rely primarily on indicators, proxies and *models*.

Indicators and proxies

Indicators represent a complex phenomenon and provide information that supports the interpretation of the state, of the changes and of trends in the supply of an ecosystem service for example (Layke et al., 2012; Maes et al., 2016). Moreover, the intrinsic characteristics that a good ecosystem service indicator should have got, are (Brown et al., 2014):

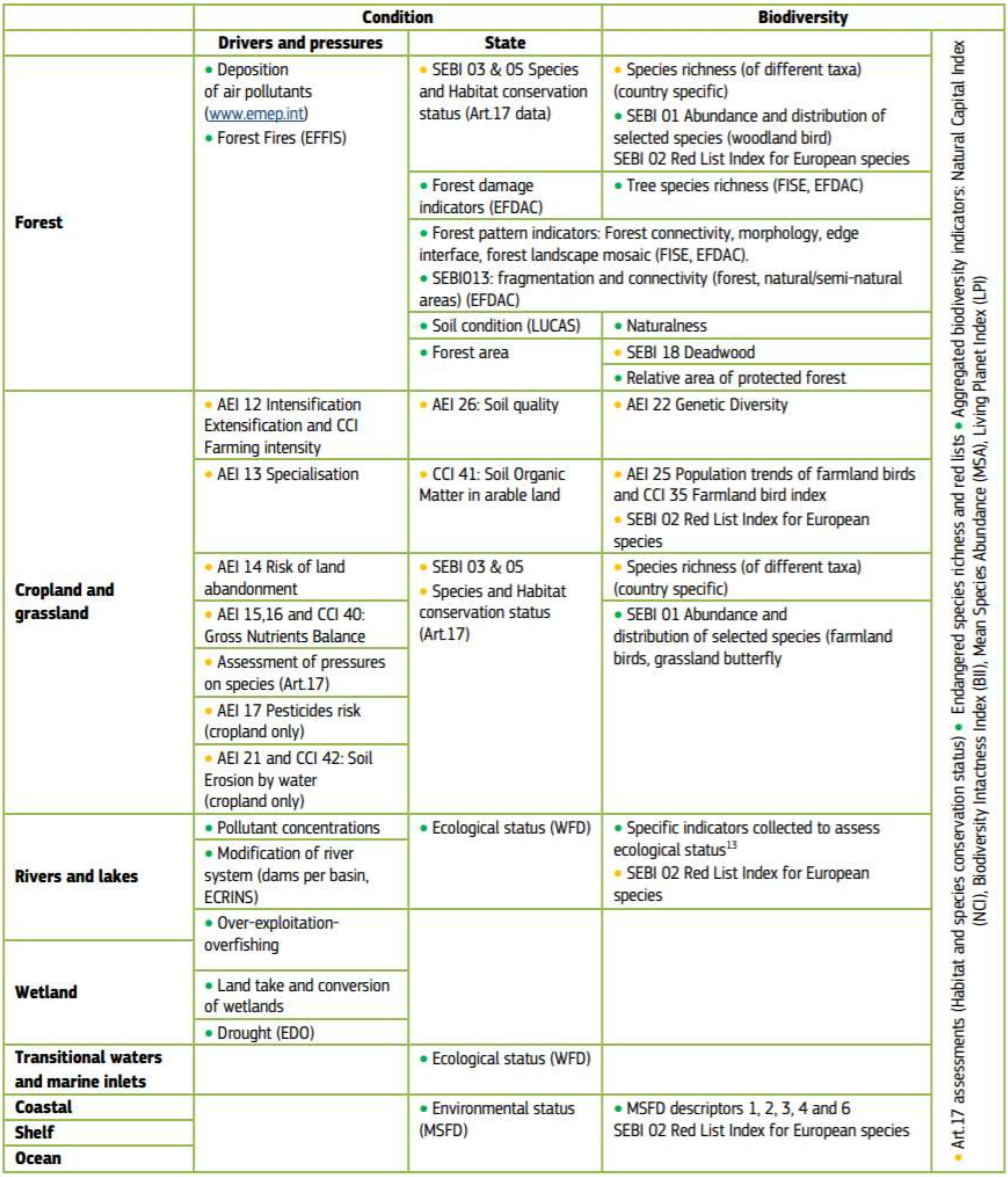
- Relevance, to assessment necessities;
- Clearness, for the conceptual interpretation of the data;
- Usefulness, for the scope of the assessment;
- Scientific strength, relating to reliability and verifiability of the used data;
- sensitivity to changes;
- Convenience and affordability.

As several indicators can be used to measure a single ecosystem service, the choice of a specific one should reflect the purpose of the analysis, the target audience (e.g. journalists, policy-makers, scientists, etc.), the spatial and temporal scale, data availability and the position on the ES in the cascade model (i.e. supply or demand) (Burkhard & Maes (Eds) 2017).

If it is not possible to identify a direct measure of the ES that we want to investigate, it is possible to use variables that approximate or indirectly measure the ES. In this case we can speak of proxy indicators.

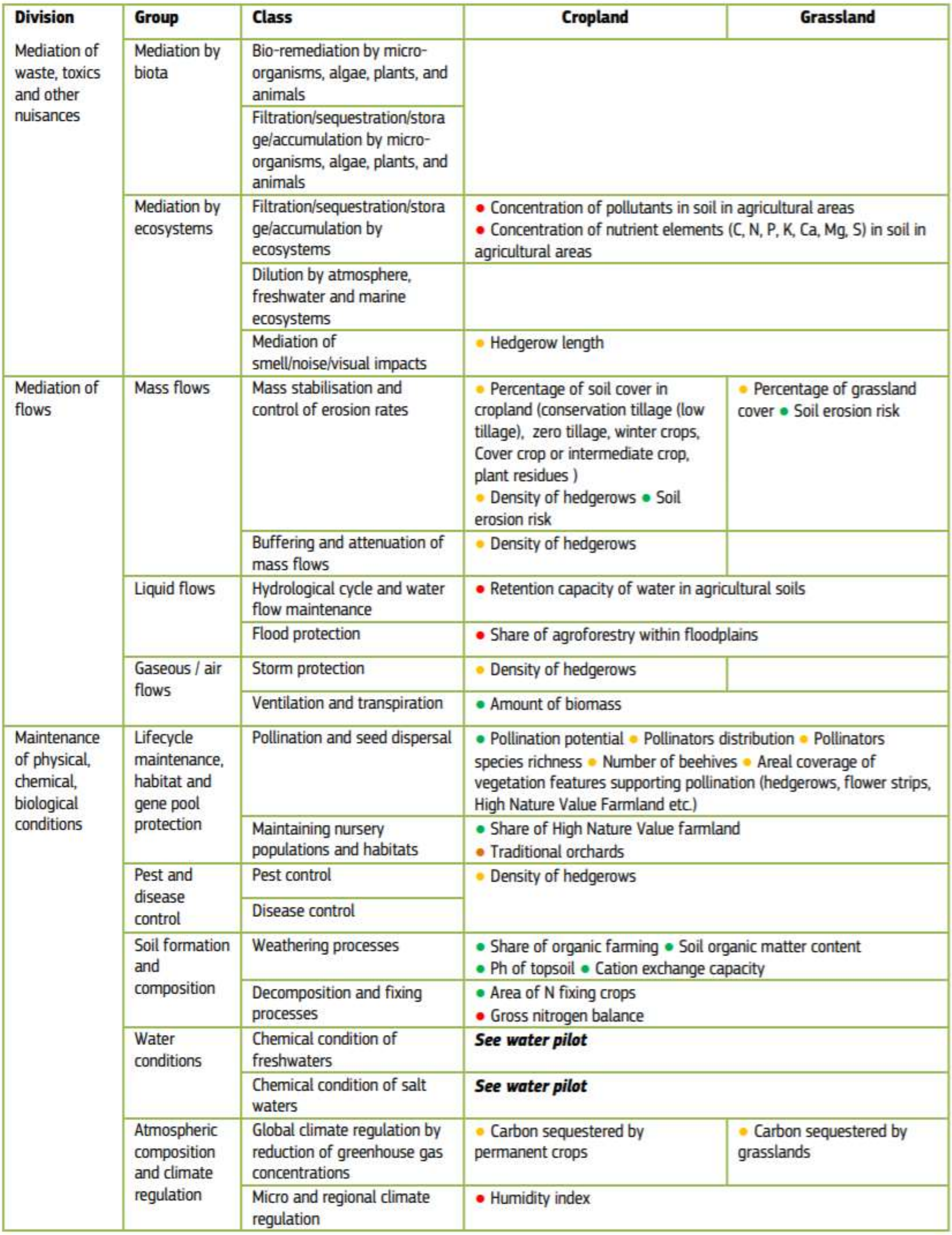
Some indicators that can be used to estimate the state of ecosystems and the supply of ecosystem services, are provided at the European level, and they can be found in the second technical report of the MAES initiative (Maes et al. 2014)). The following indicators are coherent with the CICES classification.

An example for indicators that can be used for both ecosystem status and ecosystem service provision is provided below. For a full version of the indicators, see Maes et al. (2014). To the indicators below, Maes et al. assign a progressive color from green to red, based on the joint characteristic of i) availability of the indicator at the European level ii) ability of the indicator to convey information to the policy making.



	Condition		Biodiversity	
	Drivers and pressures	**State**		
Forest	• Deposition of air pollutants (www.emep.int) • Forest Fires (EFFIS)	• SEBI 03 & 05 Species and Habitat conservation status (Art.17 data)	• Species richness (of different taxa) (country specific) • SEBI 01 Abundance and distribution of selected species (woodland bird) SEBI 02 Red List Index for European species	• Art.17 assessments (Habitat and species conservation status) • Endangered species richness and red lists • Aggregated biodiversity indicators: Natural Capital Index (NCI), Biodiversity Intactness Index (BII), Mean Species Abundance (MSA), Living Planet Index (LPI)
		• Forest damage indicators (EFDAC)	• Tree species richness (FISE, EFDAC)	
		• Forest pattern indicators: Forest connectivity, morphology, edge interface, forest landscape mosaic (FISE, EFDAC). • SEBI013: fragmentation and connectivity (forest, natural/semi-natural areas) (EFDAC)		
		• Soil condition (LUCAS)	• Naturalness	
		• Forest area	• SEBI 18 Deadwood	
			• Relative area of protected forest	
Cropland and grassland	• AEI 12 Intensification Extensification and CCI Farming intensity	• AEI 26: Soil quality	• AEI 22 Genetic Diversity	
	• AEI 13 Specialisation	• CCI 41: Soil Organic Matter in arable land	• AEI 25 Population trends of farmland birds and CCI 35 Farmland bird index • SEBI 02 Red List Index for European species	
	• AEI 14 Risk of land abandonment	• SEBI 03 & 05 • Species and Habitat conservation status (Art.17)	• Species richness (of different taxa) (country specific)	
	• AEI 15,16 and CCI 40: Gross Nutrients Balance		• SEBI 01 Abundance and distribution of selected species (farmland birds, grassland butterfly	
	• Assessment of pressures on species (Art.17)			
	• AEI 17 Pesticides risk (cropland only)			
	• AEI 21 and CCI 42: Soil Erosion by water (cropland only)			
Rivers and lakes	• Pollutant concentrations	• Ecological status (WFD)	• Specific indicators collected to assess ecological status[13] • SEBI 02 Red List Index for European species	
	• Modification of river system (dams per basin, ECRINS)			
	• Over-exploitation- overfishing			
Wetland	• Land take and conversion of wetlands			
	• Drought (EDO)			
Transitional waters and marine inlets		• Ecological status (WFD)		
Coastal		• Environmental status (MSFD)	• MSFD descriptors 1, 2, 3, 4 and 6 SEBI 02 Red List Index for European species	
Shelf				
Ocean				

Table 1.3 *Indicators to asses condition and biodiversity of ecosystems (Maes et al., 2014)*



Division	Group	Class	Cropland	Grassland
Mediation of waste, toxics and other nuisances	Mediation by biota	Bio-remediation by micro-organisms, algae, plants, and animals		
		Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals		
	Mediation by ecosystems	Filtration/sequestration/storage/accumulation by ecosystems	🔴 Concentration of pollutants in soil in agricultural areas 🔴 Concentration of nutrient elements (C, N, P, K, Ca, Mg, S) in soil in agricultural areas	
		Dilution by atmosphere, freshwater and marine ecosystems		
		Mediation of smell/noise/visual impacts	🟡 Hedgerow length	
Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	🟡 Percentage of soil cover in cropland (conservation tillage (low tillage), zero tillage, winter crops, Cover crop or intermediate crop, plant residues) 🟡 Density of hedgerows 🟢 Soil erosion risk	🟡 Percentage of grassland cover 🟢 Soil erosion risk
		Buffering and attenuation of mass flows	🟡 Density of hedgerows	
	Liquid flows	Hydrological cycle and water flow maintenance	🔴 Retention capacity of water in agricultural soils	
		Flood protection	🔴 Share of agroforestry within floodplains	
	Gaseous / air flows	Storm protection	🟡 Density of hedgerows	
		Ventilation and transpiration	🟢 Amount of biomass	
Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	Pollination and seed dispersal	🟢 Pollination potential 🟡 Pollinators distribution 🟡 Pollinators species richness 🟡 Number of beehives 🟡 Areal coverage of vegetation features supporting pollination (hedgerows, flower strips, High Nature Value Farmland etc.)	
		Maintaining nursery populations and habitats	🟢 Share of High Nature Value farmland 🟠 Traditional orchards	
	Pest and disease control	Pest control	🟡 Density of hedgerows	
		Disease control		
	Soil formation and composition	Weathering processes	🟢 Share of organic farming 🟢 Soil organic matter content 🟢 Ph of topsoil 🟢 Cation exchange capacity	
		Decomposition and fixing processes	🟢 Area of N fixing crops 🔴 Gross nitrogen balance	
	Water conditions	Chemical condition of freshwaters	***See water pilot***	
		Chemical condition of salt waters	***See water pilot***	
	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	🟡 Carbon sequestered by permanent crops	🟡 Carbon sequestered by grasslands
		Micro and regional climate regulation	🔴 Humidity index	

***Table 1.4**: Indicators for regulation and maintenance services supply delivered by agro-ecosystems (Maes et al., 2014).*

Biophysical model

When it is not possible to use more direct methods, such as field surveys or indicators and proxies, some other models, often computer-based can be used. These models, based on input data that relate to the socio-ecological context try to simulate the socio-ecological reality investigated as closely as possible, but always with a certain degree of approximation (Burkhard & Maes (Eds) 2017).

These models are very useful because they allow to simulate a change in the parameters considered (land cover and land use, source and/or intensity and/or type of pollution, climate, etc.) and obtain results otherwise difficult to explore. They also offer often the opportunity to get a graphical output of the results and they are useful especially for regulatory services, where direct data are often time and resource consuming.

Finally, they can be very helpful for decision makers when there is a need to understand the connection between nature, the ecosystem services it provides, and the possible impacts on quality of life (IPBES, 2016).

1.4 Agroecosystems and ecosystem services

Agriculture is a dominant form of land management at global level, and agricultural ecosystems cover nearly 50 per cent of the habitable surface of the Earth (FAO, 2019).

At European level, In 2015 agricultural land is estimated to cover 42% of the total surface area (Perpiña Castillo et al., 2018).

Agroecosystems can be defined as ecosystems that have been strongly manipulated and altered by human action with the aim of establishing agricultural production (Gliessman, 2006). Although altered by human influence, agroecosystems basically respond to the same processes, structures and characteristics as natural ecosystems, and therefore rely on and simultaneously provide important ecosystem services (Power, 2010).

Humans have always valued these ecosystems largely on the provisioning services they offer, and these massive portions of land are designed and managed to ensure the supply of food, fodder and fibre (MA, 2005; Zhang et al., 2007, Power A., 2010).

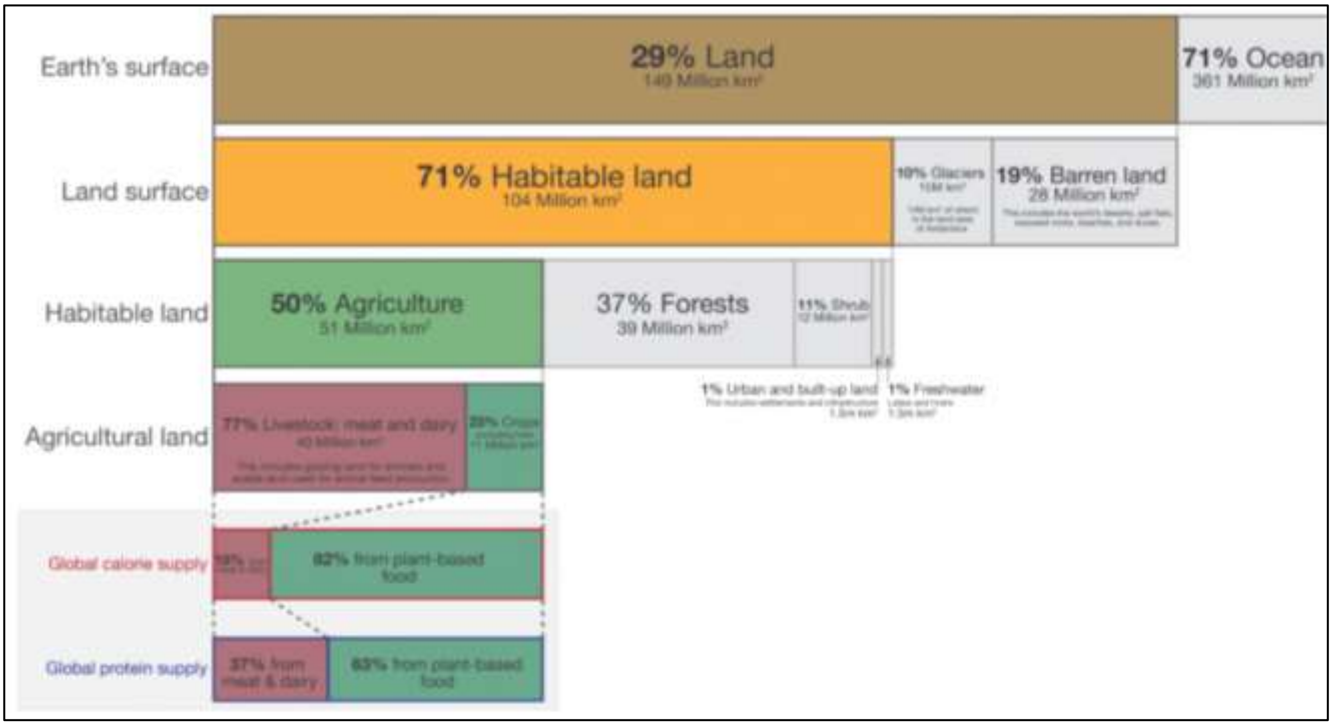


Figure 1.4: *Distribution (%) of the earth's surface (Source: Our world in data elaboration on FAO 2019)*

ES DEMAND

For the production of provisioning services, agro-ecosystems are dependent on an inflow of ecosystem services that can also be derived from the less humanised and managed portions of land (Power A., 2010; Zhang et al., 2007).

Agro-ecosystem support services include those related to soil formation, structure and fertility, nutrient cycling and crop genetic diversity.

Regulating services include pollination, protection from pests and diseases (provided by natural enemies that move into agro-ecosystems from natural vegetation) and purification of water flowing to agricultural systems (Power, 2010, TEEB, 2018).

ES SUPPLY

Agro-ecosystems, in addition to needing ES and providing provisioning ES (see above) can provide other ES such as local and global climate regulation, habitat for biodiversity, pollination, nutrient regulation , pest and disease control or scenic beauty and recreational opportunities (MA, 2005, Power, 2010, TEEB 2018).

The degree to which these ES are provided is closely dependent on the types of agricultural practices used and landscape management (Power, 2010, Zhang et al., 2007).

Management practices also influence the potential for 'disservices' from agriculture, including loss of habitat for conserving biodiversity, nutrient runoff, sedimentation of waterways, and pesticide poisoning (Zhang et al. 2007).

These disservices, or negative impacts, can be significantly reduced through appropriate management practices.

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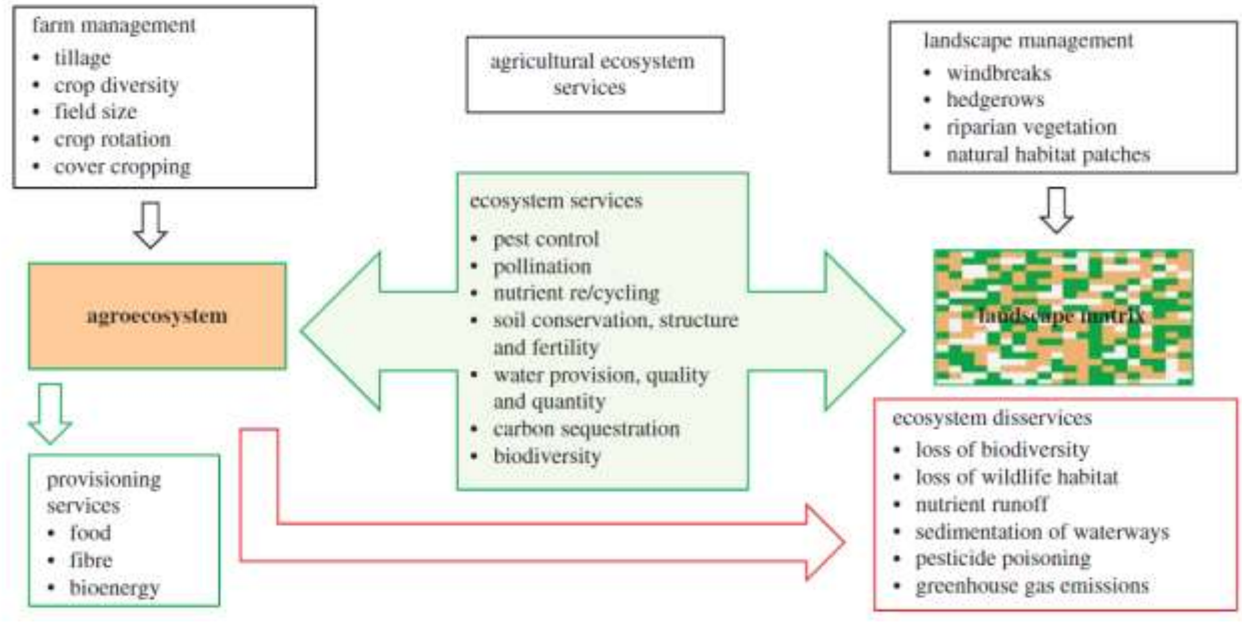


Figure 1.5*: Impact of farm and landscape management on the flow of ecosystem services and disservices (Power, 2010).*

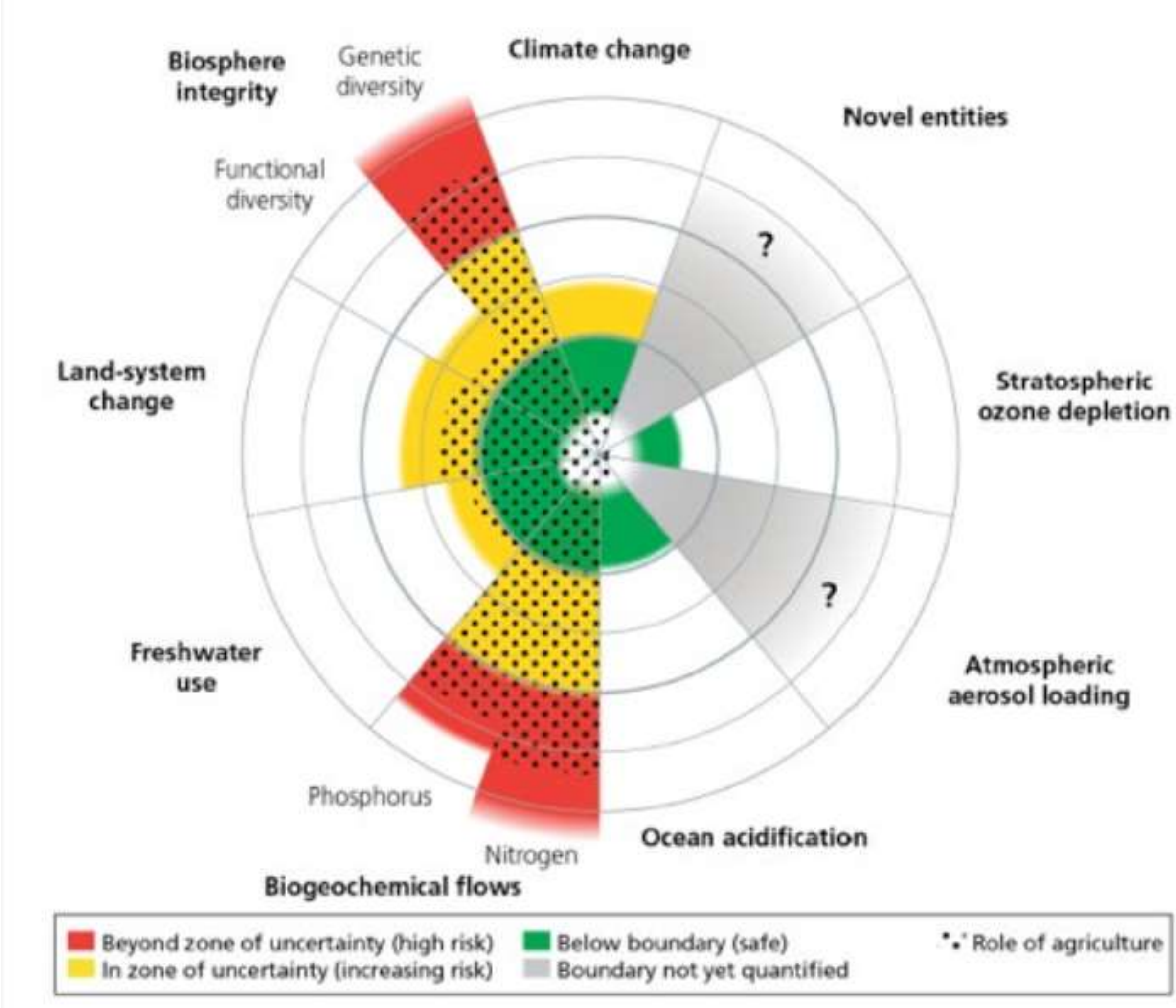


Figure 1.6*: Estimate of agricolture's role in the status of the nine planetary boundaries (Campbell et al. 2017)*

The increase in global population (and therefore in demand for food) has led to intensive agricultural practices, which mostly maximise provisioning services at the expense of other ecosystem services, particularly regulating and supporting services.

To make up for this deficit in regulatory and support services, human inputs are added, such as fertilisers and pesticides, which, however, above certain thresholds, can lead to other problems for human and ecosystem health (groundwater pollution, eutrophication of water, etc.), In addition, practices such as excessive tillage and monocultures can reduce ecosystem services related to soil carbon uptake, erosion control and soil formation, leading to a general degradation of agricultural soils, with consequent losses in fertility and productivity, lower income for farmers and increased risk of food insecurity.

In the light of this evidence, it is increasingly urgent to rethink food production systems and steer them towards more sustainable practices, such as agro-ecological practices.

1.4.1 Climate regulation and agro-ecosystems

Climate change

The adaptation and mitigation measures's failure to the climate change along with the linked exceptional meteorological events, have since the last few years been at the first position of the list of *global risks* for the survival of the human species compiled annually by the World Economic Forum (WEF) (WEF, 2021) .

Depsite that, in 2013 the CO2's concentration in the atmosphere has exceeded 400 parts per million (ppm) and the Mauna Loa observatory (part of the *Scripps Institution of Oceanograph*y) has recorded a peak of 417.9 ppm in June 2020 (https://keelingcurve.ucsd.edu/). These similar CO2's concentrations have been recorded on earth 3 million years ago, when the temperature was 2-3 ° C warmer and sea level was 10-20 meters higher than now (WMO, 2018).

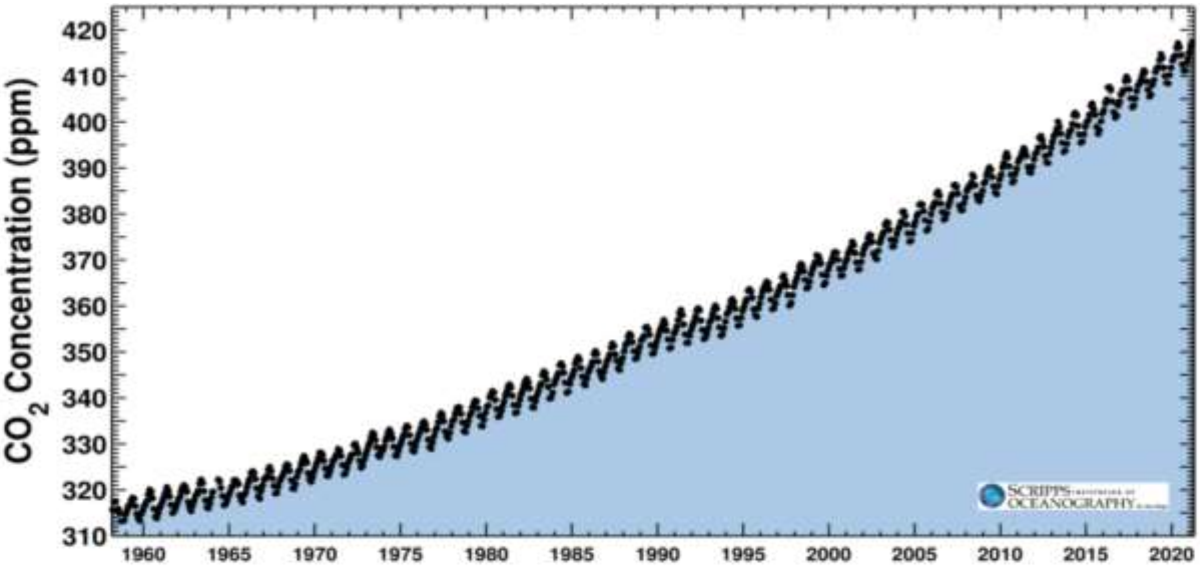


***Figure X**: Carbon dioxide (CO2) concentration at Mauna Loa observatory (https://keelingcurve.ucsd.edu/).*

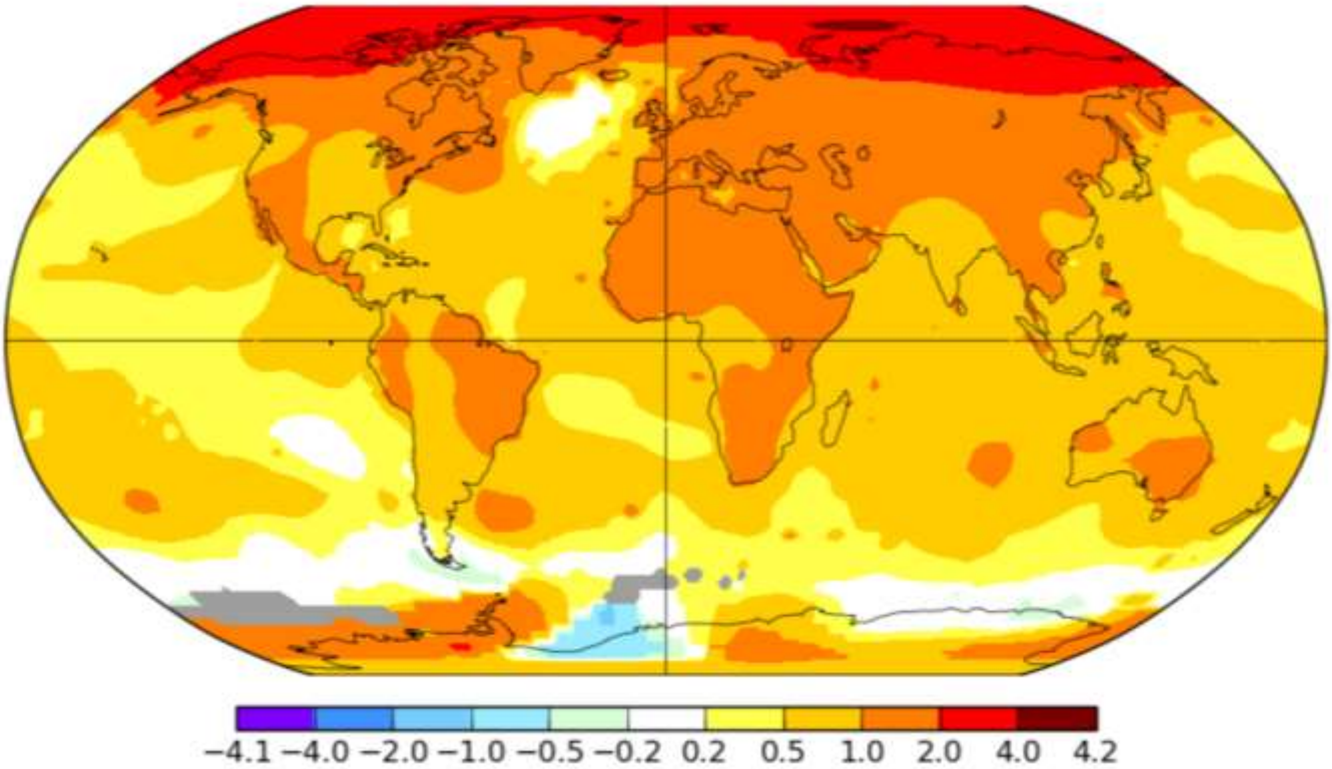


Figure 1.7: Average surface air temperatures from 2010 to 2020 compared to a baseline average from 1951 to 1980 (Source: NASA,https://data.giss.nasa.gov/gistemp/maps/index_v4.html).

Although the climate has its own natural variability , the global impact of human activities in the last decades is unprecedented (IPCC, 2013) and 97% of the meteorological scientists agree with the anthropogenic causes of climate change (Cook et al., 2016) . The main driver of climate change is the greenhouse gas's emission (GHG), in particular carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) , that is mainly due to the combustion of fossil fuel for energy consumption the additional contribution of the agricultural and manufacturing sector. On the other hand, the changes of land surface, in particular the deforestation, also take a part in the increase of additional GHG emissions , and above all they reduce the potential CO_2's absorption by forests.

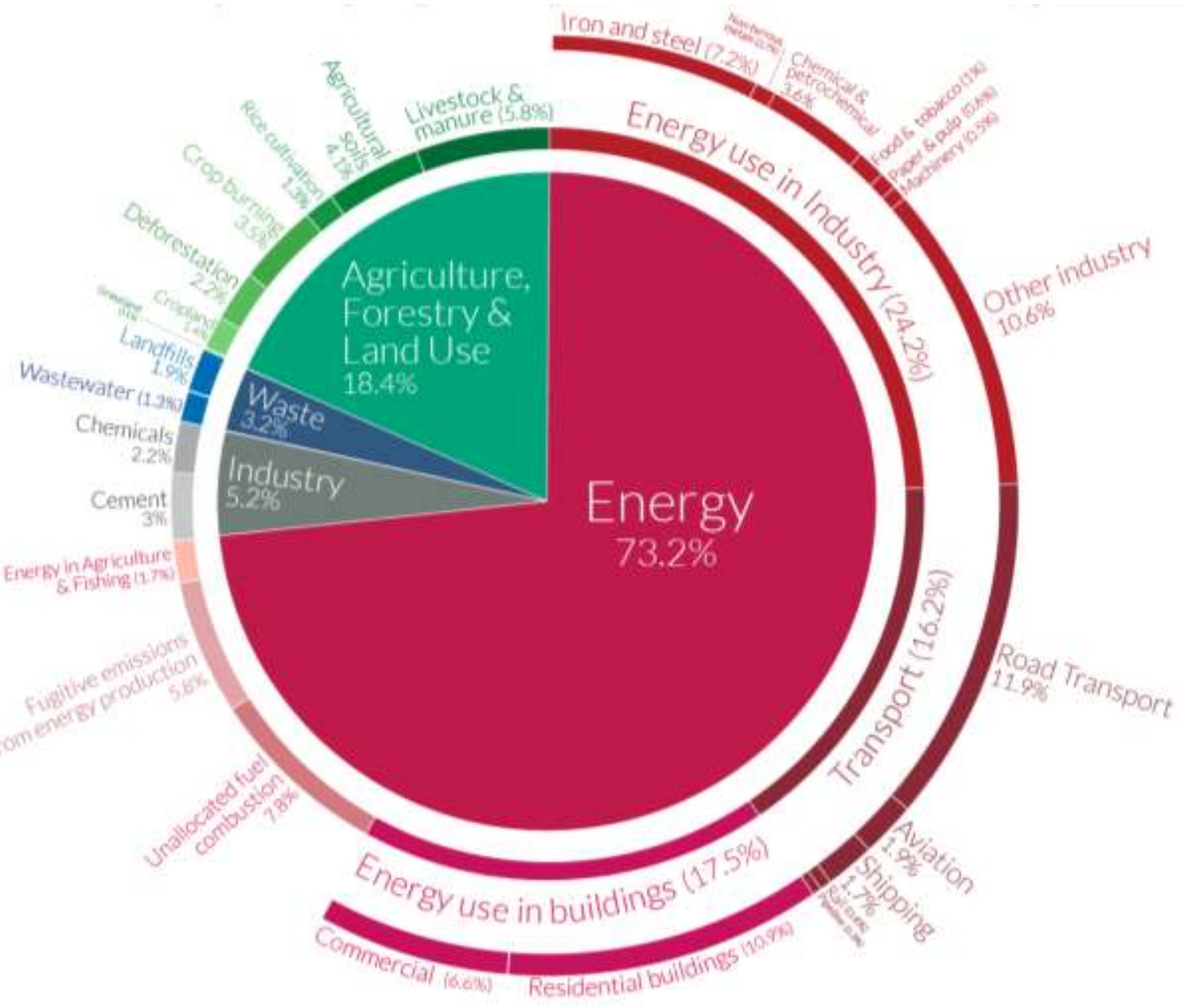


***Figure 1.8**: CO2eq emission sectors (elaboration by OurWorldinData.org on the World Resource Institute (2020)*

Climate regulation by the ecosystems

The earth's climate is regulated by the ecosystems thanks to their action of sequestration and storage of carbon dioxide (CO_2) (IPCC, 2006). The terrestrial ecosystems and soil collectively contain more carbon than the atmosphere itself (Lal, 2008).

In particular the vegetation, thanks to the photosynthetic process absorbs CO_2 from the atmosphere, storing the carbon in the biomass (epigeal biomass, hypogeal biomass and organic dead matter) and in the soil, and so it contribuite to climate regulation and climate change mitigation (ibid.)

This regulating ecosystem service is one of the most recognized and studied (Stern 2007, IPCC 2006, Pagiola 2008, Canadell & Raupach 2008, Hamilton et al. 2008, Capoor & Ambrosi 2008, Anderson-Teixeira et al, 2012).

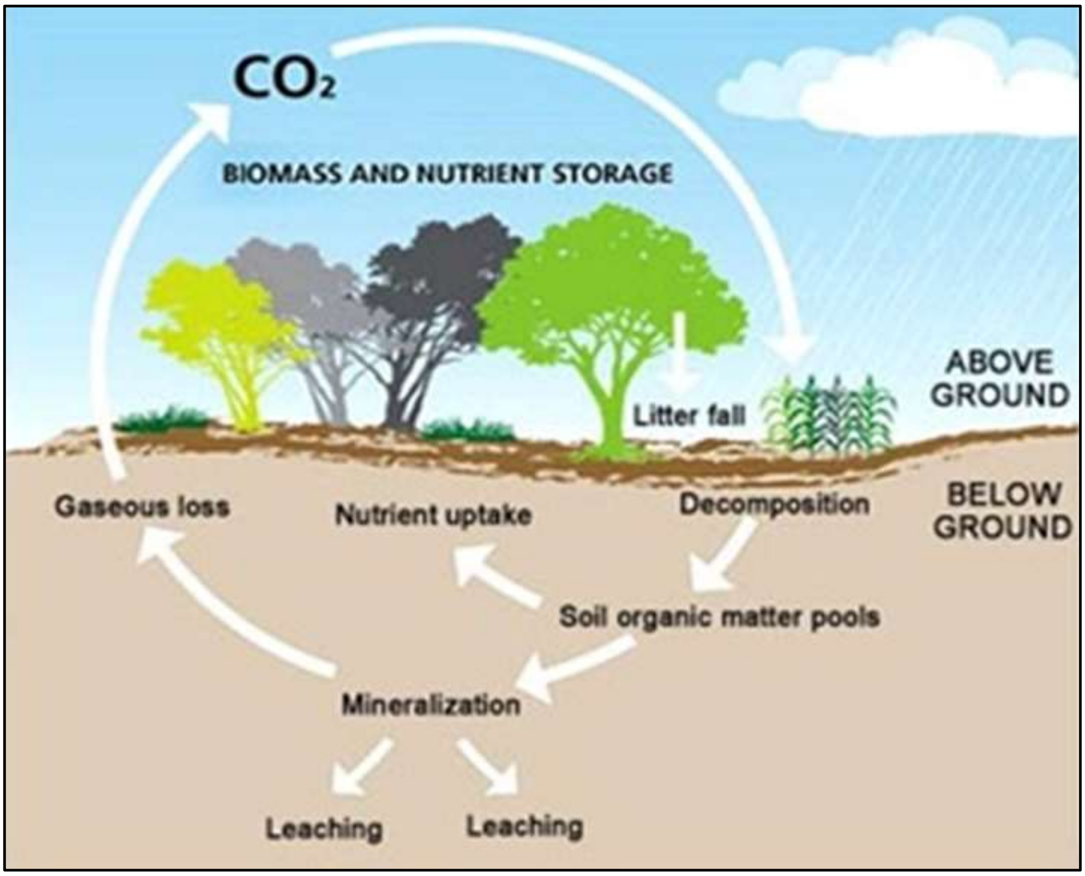


Figure 1.9 *- Example of the global climate regulation service by terrestrial ecosystems (Derrington, 2017)*

Human activities have influenced and keep still to influence, often negatively, this ecosystems's ability of climate regulation. In particular through the conversion of woodland into agricultural areas or cities. (MA 2005, IPBES 2019). This reduces the potential for sequestration and increases the concentration of CO_2 in the atmosphere. Globally, deforestation and forest degradation keep still growing at an alarming rate: a forest's loss rate of 10 million hectares per year has been estimated between 2015 and 2020 and the main driver of this change is the development of agricultural areas (FAO & UNEP, 2020). In Italy this trend is reversed, forests have been gaining space for years at the expense of agricultural areas that are no longer cultivated (INFC 2005; INFC 2015).

In order to decrease the concentration of GHG and in particular of CO2, it is possible to act i) on the reduction of anthropogenic emissions into the atmosphere and its causes, ii) by increasing the potential for carbon sequestration by terrestrial ecosystems. Through reforestation (including urban) and sustainable forest management, it is possible to increase the potential of CO2 sequestered each year from the atmosphere. There are also agricultural practices such as conservative agriculture or climate smart agriculture (see e.g Hobbs et al, 2008, Lipper et al, 2014, FAO, 2018) that can reverse these degenerative processes, in particular by increasing the organic carbon content in the soil.

Soil as a carbon pool

The soil is a carbon pool: it can act both as a carbon sink and as a carbon source, accumulating or releasing carbon (IPCC 2006). In particular, the soil is the terrestrial pool with the highest carbon content, about 2500 Pg1 to 1-m depth (where con Pg = Petagram = 109 tonne) (Batjes 1996), 3.3 times the atmospheric pool (760 Pg) and 4.5 times the biotic pool (560 Pg) (Lal, 2007; Lal, 2008; Stockmann et al., 2013).

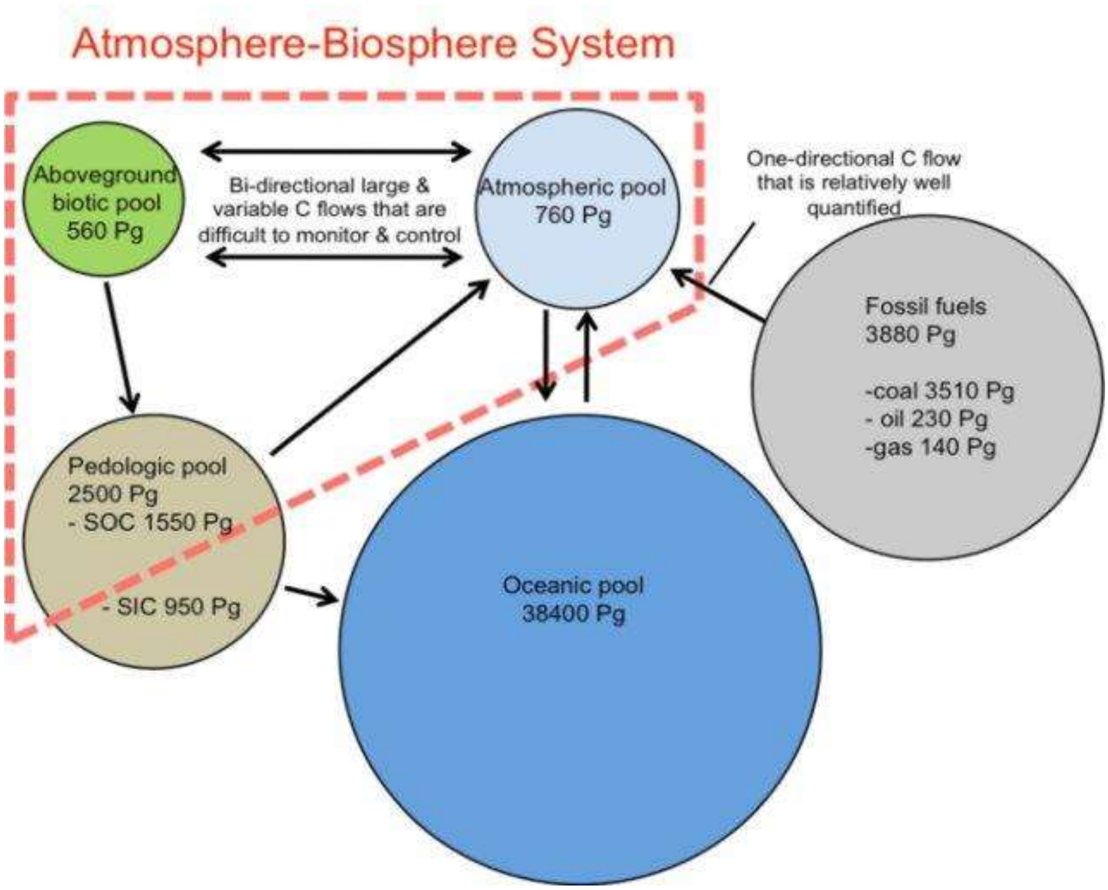


Figure 1.9: Gloval carbon pools and associated flows (Lal, 2007)

The carbon contained in the soils is in organic form, the soil organic carbon (SOC) , and inorganic, the soil inorganic carbon (SIC). SOC is the most easily measurable fraction of soil organic matter (SOM), which includes all the elements that make up the organic component of soils and not just the carbon fraction (Griffin & Edwards, 2020; Lal, 2008).

Although the relationship between SOM and SOC changes according to the type of vegetation cover, depth, degree of decomposition and other factors (see Jain et al. 1997; Périé & Ouimet 2008; Pribyl 2010), it is conventionally assumed that the SOM contains approximately 58% SOC, using the Van Bemmelen conversion factor (SOM = 1.724 SOC). The SOM is made by (i) debris of plants and animals at various stages of decomposition (from fresh residue, passing through active decomposing fraction up to humus, the stabilized organic matter) (ii) soil microbes and other fauna (iii) substances synthesized through microbial and chemical reactions (Lal, 2007) (see figure 1.10).

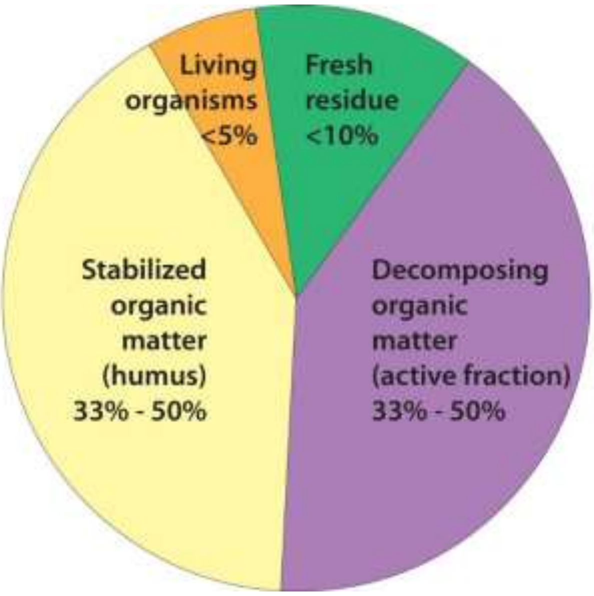


Figure 1.10 *– Composition of soil organic matter (SOM) (soils.usda.gov)*

The organic matter's contents fluctuates from less than 1% in the desert soils, to average values between 1% and 15% in the forest soils, especially in the mountain environment, and to more than 90% in peat.

Increase Soil Carbon Sequestration

The increase in soil carbon sequestration can occur in different land uses, including forestry, grazing land and cropland, through some different practices (Smith 2012). According to a study by Smith et al. (Smith et al. 2019) the practices that can increase carbon sequestration include:

- changes in land use, in particular towards ecosystems that absorb more carbon (e.g. reforestation);
- management of vegetation, including use of cover crops and improved rotations;
- nutrient management, e.g., type, timing, and precise application of fertilizer;
- reduced tillage intensity;
- optimized irrigation management, in particular in arid condition.

Some of the practices listed above are attributable to the Conservation Agriculture (CA). CA aims to preserve and to increase organic matter in the soil, and so, among other benefits, it can contribute to the reduction of CO_2 emissions in atmosphere (FAO, 2015; Hobbs, 2008; Kassam et al., 2009).

Conservation agriculture is based on three basic principles (FAO, 2015):

i) *Minimum soil disturbance, implemented by the practice of no-till seeding.*

In this case a split is opened in the ground by a specific equipment, and the seed is placed inside that split: no mechanical preparation of the seedbed occurs.

Conventional plowing, indeed, by breaking the structure of the soil accelerates the release of carbon from soil to the atmosphere, with the loss of associated functions and the increase of GHG concentration (Reicosky & Saxton, 2007).

ii) *permanent soil organic cover (at least 30 percent) with crop residues and/or cover crops*.

Organic soil cover can be obtained by using crop residues, or if the time lag between harvesting one crop and planting the next is too long, through cover crops.

These procedures can bring some advantages:

- they are an additional source of organic matter (and therefore of SOC) which is assimilated into the ground;
- increase the recycling and availability of nutrients (especially phosphorus and potassium);
- the evaporation of moisture from the ground decreases,and this can bring to greater water infiltration;
- soil microorganisms increase, at different depths, by producing different exudates, (FAO, 2015)

iii) *species diversification through varied crop rotation (and/or sequences and/or associations) involving at least three different crops.*

Crop rotation is an agronomic technique with a centuries-old history, which consists in varying the species grown on the same plot .
This practice can bring different benefits, including (FAO, 2015) like:
- a greater diversification of the soil biota, due to the different organic exudates released by the roots, which in turn make the nutrients available again (by recycling them) for the plants.
- a phytosanitary function, the mono-succession of crops, in fact "load" the soil with specific pathogens that can attack the plants in the following crop cycle.

Rotating crops promotes a reduction in crop-specific pathogens, ensuring that the following crop is not affected by the pathogens accumulated in the previous culture cycle.

Other benefits of soil carbon sequestration

Increasing the content of organic matter in soils and therefore of SOC, is not only important for the purpose of CO2 sequestration. The content of organic matter in soils, in fact, is an indicator of the soils's quality and of the health(Lal, 2016; Reeves, 1997) and it conditions many functions associated with it (Brevik et al., 2015,).
The increase of organic matter (and so the SOC), due to the improvement of the solis's functions, has direct repercussions on ecosystem services (the nature's functions that are useful to the people) generated by soils, and so it plays a very important role for the human well being (Keesstra et al. 2016).
The SOM supports the production of biomass (Soussana et al., 2019), the filtering, the storage and the transformation of nutrients and of water, and also it reduces the erosion (Keesstra et al., 2012). SOM in soils also tale advantages to the biotic part, increasing the biodiversity and vitality of the soil biota (Smith et al., 2019).

All these benefits also have an impact on society. In the figure below (fig.1.11), for example, it can be seen that the increase in soil carbon, and thus organic matter, has repercussions on specific soil functions that provide specific ecosystem services (in the figure Nature

Contribution's to People, followiong the innovative IPBES framework). By bringing benefits to human societies, ecosystem services can also be linked to the Sustainable Development Goals (UN, 2015).

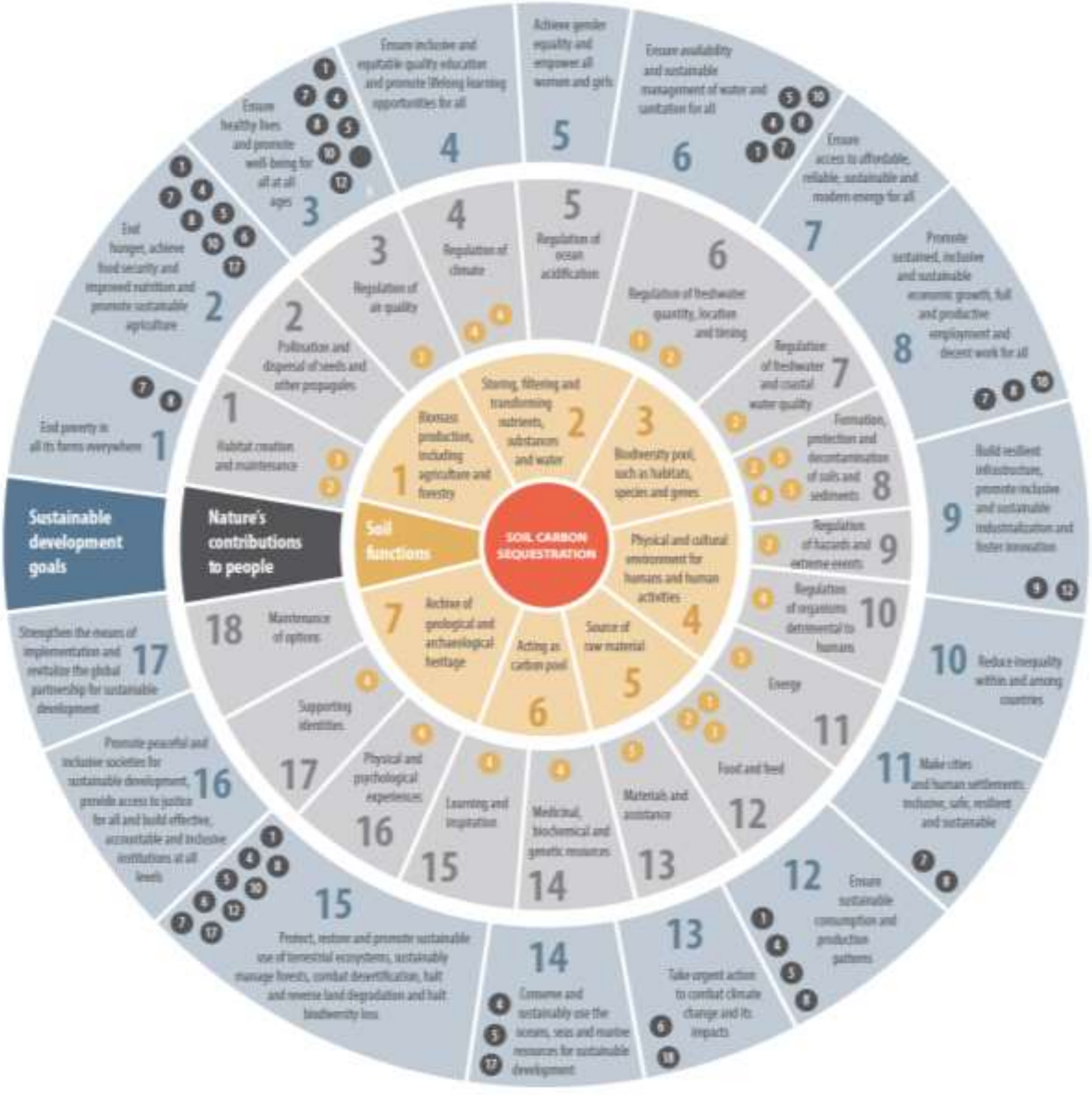


Figure 1.11 *Impact of soil carbon sequestration (SCS) on soil functions, on Nature's contribution to people (NCPs) and on the SDGs.*

An economic evaluation: the social cost of carbon

The social cost of carbon represents the economic value associated with the damage induced by the additional emission of one ton of carbon dioxide (tCO2) (Stern 2007, IPCC 2006). The calculation of the social cost of carbon (SCC) is controversial and complicated (see Weitzman 2007 and Nordhaus 2007), but it has been calculated countless times (see Tol, 2011 for a review), using different assumptions and quantified in costs with a very wide range. , from US $ 10 to US $ 1000 (IAWG 2016, Anthof and Tol, 2013, Moore and Diaz 2015, Nordhaus 2013). Generally the values of the SCC taken as a reference globally are those calculated by the American Environmental Protection Agency (Epa) which has estimated a cost of US $ 12, US $ 42 and US $ 62 per tCO2 emitted in 2020 for 5, 3 and 2.5% discount rates, respectively (IAWG, 2016). One of the latest evaluations by some expert economists and climatologists (Pindyck 2016) estimates the value within the range of US $ 150–200 for tCO2.

These assessments are estimated on a global scale and do not take into account the different effects that climate change can have on different geographical and socio-economic contexts. For these reasons Ricke et al. in 2018, they proposed for the first time a country level social cost of carbon (CSCC) that takes into account the differentiated impact of climate change at the national level (Ricke et al., 2018) (see Figure 1.12).

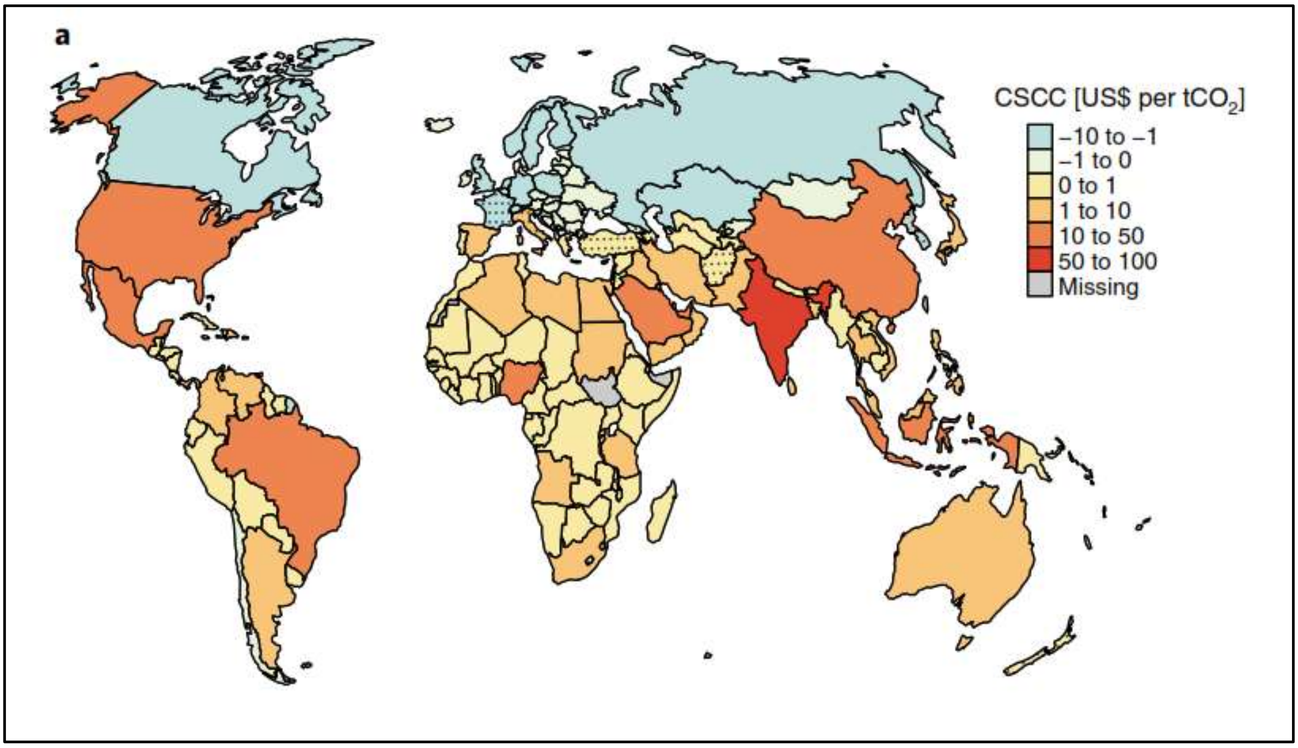


Figure 1.12 *- Spatial distribution of median estimates of the CSCCs computed for the reference case of scenario SSP2/RCP6.0, BHM-SR and a growth adjusted discount rate (ρ =2%, μ = 1.5) . Stippling indicates countries in which BHM damage function is not statistically robust (from Ricke et al, 2018).*

The highest average value of CSCC is obtained by India (US $ 86 for tCO2), followed by the United States (US $ 48 for tCO2) and Saudi Arabia (US $ 47 for tCO2). The average value for Italy is between US $ 1-10 per tCO2, while Former Soviet Union, Canada and Northern Europe have negative CSCC values because their current temperatures are below the economic optimum (Ricke et al., 2018)

Definitely, the CSCC measure is important for several reasons: it can highlight the difference in the regional impacts of climate change but also lead to ethical considerations on international relations linked to this global public good.

In fact, in a totally cooperative world, the states could internalize costs, adopting the global social cost of carbon for their emissions. In a "non-cooperative world", on the other hand, the states could ignore the international consequences and internalize only the costs that correspond to to domestic damages, and , in this way , they could decrease the price of the issues and presumably increasing them (as in the case of the past Trump administration)

Ultimately, the CSCC measure is important for several reasons: it can highlight the difference in the regional impacts of climate change but also lead to ethical considerations on international relations linked to this global public good.

In fact, in a totally cooperative world, the states could internalize costs, adopting the global social cost of carbon for their emissions. In a "non-cooperative world", on the other hand, the states could ignore the international consequences and internalize only the costs that correspond to to domestic damages, and , in this way , they could decrease the price of the issues and presumably increasing them (as in the case of the past Trump administration).

1.4.2 Main critical issues in rural communities

Rural areas make up half of Europe and account for about 20 % of the population. Yet most of them are among the least privileged regions in the European Union (EC, 2020). Even in rural areas, sustainable development takes on a multidimensional character, aiming to increase the quality of life of inhabitants while preserving and restoring natural capital (Bleahu, 2005). Rural communities are subject to certain inequalities compared to urban communities, which are not only reduced to a generally lower income (EC, 2020; Satterthwaite D. 2007). First of all, as they are often predominantly based on the primary sector, they are directly affected by environmental changes (climate change, biodiversity loss, erosion, hydrogeological disruption), especially in low- and middle-income countries (Mihai and Iatu, 2020). On the other hand, they face in many cases the lack (or lower density) of essential services such as transport, health care and education services, as well as lower employment opportunities (Ibid). These elements are often the cause of the rural-city migrations witnessed and still witnessed today, which do not always lead to an improvement in the quality of life of those who decided to leave (Pelorosso et al., 2011; Tacoli et al., 2015). The abandonment of rural areas poses serious risks for the food security of the territories, but also for the loss of historical-cultural heritage, including that of traditional knowledge. For these reasons, even in the recent 2030 agenda, and specifically in Target 11, there is a clear indication of pursuing a better balance between the development of cities and rural areas (UN, 2015 - Target 11.a). The main EU policies that contribute to improving the living conditions of rural communities are The EU Cohesion Policy (https://ec.europa.eu/regional_policy/en/2021_2027/) and Common Agricultural Policy

(CAP) (https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy_it). Furthermore, in May 2020, the European Commission published the Farm to Fork Strategy (https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_it), specifically designed to transform the European agri-food system towards a more sustainable, resilient and equitable system for rural communities.

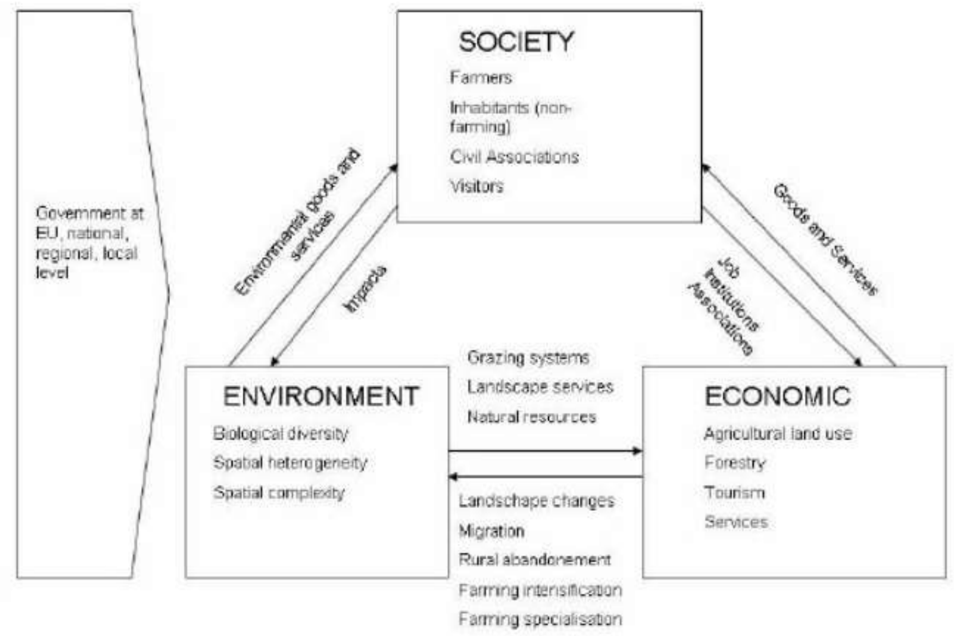


Fig – Components of the rural socio-ecological system and the involved stakeholders. The boxes represent the components, the arrows the interactions beetween these (Source: Schouten 2009).

2. MATERIALS AND METHODS

2.1 Setting the scene: the case study

In order to investigate possible scenarios for sustainable development in rural areas, in this paper we have focused on the analysis of a case study. In particolur, we focused on eight municipalities, geographically located in the Conca valley. The Conca valley is an area circumscribed by the Conca river, and it extends over the Rimini's district in Emilia-Romagna region and Pesaro and Urbino's district in the Marche region. That eight municipalities are therefore included in the local administrative territory of Rimini district and occupy a total area of 161 km2 (approximately 16,000 hectares), for a total of 28,292 inhabitants as of 1 January 2019 (ISTAT, 2020).

Since 1996 these towns have formed "The Union of Valconca" (UV), an association of municipalities, legally recognized and classified as a local authority, aimed to associated exercise of functions and services (TUEL - art. 32, paragraph 1 of Legislative Decree no. 267/2000).

The eight towns of the study area are:

- Gemmano
- Mondaino
- Montefiore Conca
- Montegridolfo
- Montescudo-Monte Colombo
- Morciano di Romagna
- Saludecio
- San Clemente

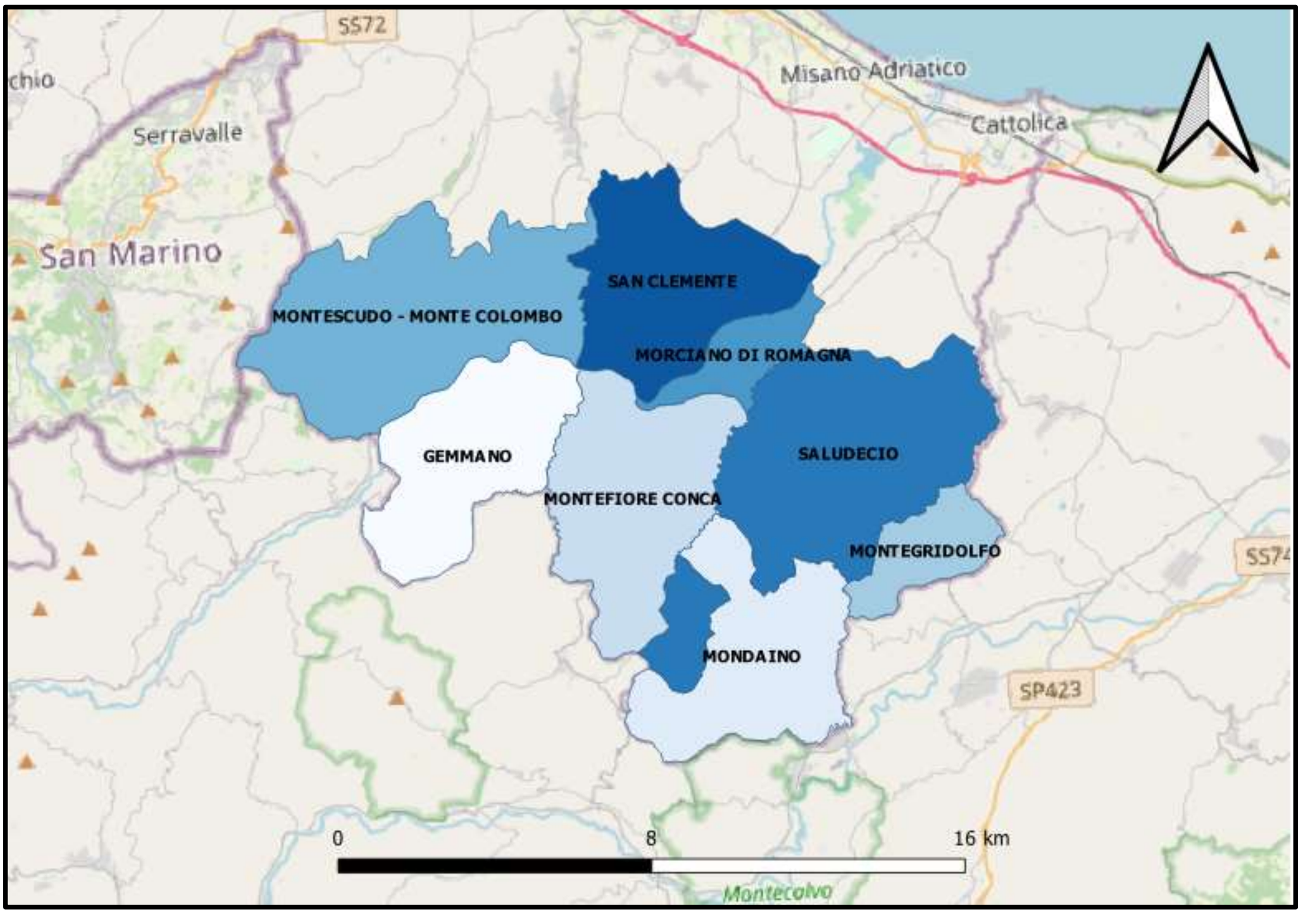


Figure 2.1*- Map of the administrative boundaries of the municipalities of the Valconca Union*

The UV’s municipalities are classified, in the context of the application of the 2014-2020 rural development program (Regione Emilia Romagna, 2016) , as a rural areas with intensive and specialized agriculture. In addition, 7 of this municipalities are included in the "disadvantaged non-mountain areas", with the exception of San Clemente, and for this reason they receive compensatory payments (70euro / ha of UAA). This last classification, updated in June 2020, is to be considered proposed due to natural and other specific constraints defined by directive 75/268 / EEC and by EU regulation No. 1305/2013, annex III.

The eight municipalities, instead, are not classified as “inner areas” due to the lack of the requirement relating to a significant depopulation, calculated for the time period from 2001 to

2011 (even if they have other two requirements relating to the distance from the major city poles and the percentage of elderly people out of the total population.) The Conca Valley's municipalities are part of the Local Action Group (LAG) called “Valli Marecchia e Conca” (see https://www.vallimarecchiaeconca.it/).

Territory and environment

The UV’s area is a quite extended territory but not so much populated (177 inhabitants / km2, compared to 393 inhabitants / km2 of the provincial average) (Camera di Commercio della Romagna, 2020) and it still definitely keeps a rural character.

The UV is distinguished by small towns and medieval villages built along the ridges of the hills that are extended between the coast (site of more populous and well-known towns such as Cattolica, Riccione and further north Rimini) and the Tuscan-Emilian Apennines. Just in a very few cases the hills exceed 400 meters above sea level (Gemmano, Montescudo) and gradually decrease towards the plain.

The agricultural areas, that are mainly addressed to the cultivation of cereals, forage, olive groves and vineyards, intertwine with the more natural spaces and wooded and bushy spots. The Conca river, from which the entire valley takes its name, rises on Monte Carpegna (Marche county) and flows for 47 km, crossing, among others, the cities of Montecolombo, Morciano di Romagna and Saludecio, to then flow into the Adriatic Sea.

About 2,700 hectares of territory (about 15% of the territory's total area) fall within protected territory, including:

- The Onferno Nature Reserve, in Gemmano (about 270 hectares);
- The protected natural and semi-natural area of the Conca (about 2472 hectares falls within the territory of the UV) which includes the riverbed of the Conca river and a bilateral territory to it;

- The Rio Melo ecological rebalancing area (about 15 hectares) in Montescudo-Montecolombo.

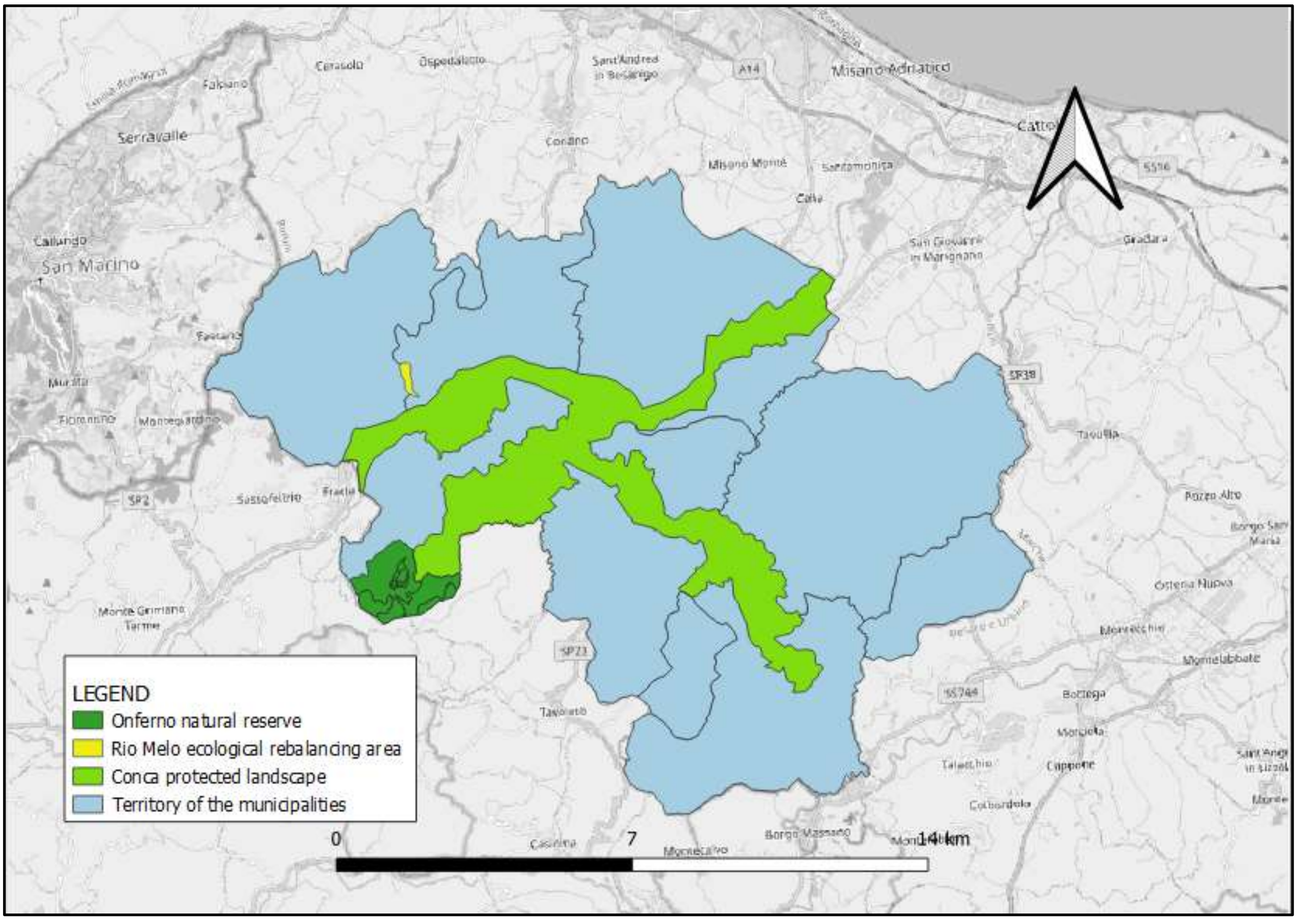


***Figure 2.2**: Protected areas in the Valconca municipalities (own elaboration on regional cartographic data)*

According to the European classification in *bio-regions* (areas with similar ecological characteristics) this territory is a part of the continental bio-region (MiTE, n.d); while according to the Italian classification in *eco-regions* (same principle of bio-regions but specific for the Italian territory) it belongs to the temperate division, Apennine section (ISTAT, 2020). The average annual temperature (calculated in the reference period 1991-

2015) is 13 ° C, while the average annual rainfall amounts to 838 mm (Antolini et al., 2017). Compared to the previous thirty years (1961-1990) there is an increase both in the average temperature (+ 1.1 ° C) and in the precipitation (+ 35 mm) (Ibid.).

Demography

The study area shows a demographic trend (Fig. X) that is mainly growing both in the long term (2002-2019) and in the medium term (2009-2019). In more recent years (2014-2019), on the other hand, a fluctuating trend has been recorded, with a population declining from 2015 to 2017 and recovering in the last two years (2018 and 2019) recorded (ISTAT, 2020), with a total population at the 1st January 2019 equivalent to 28,292 people.

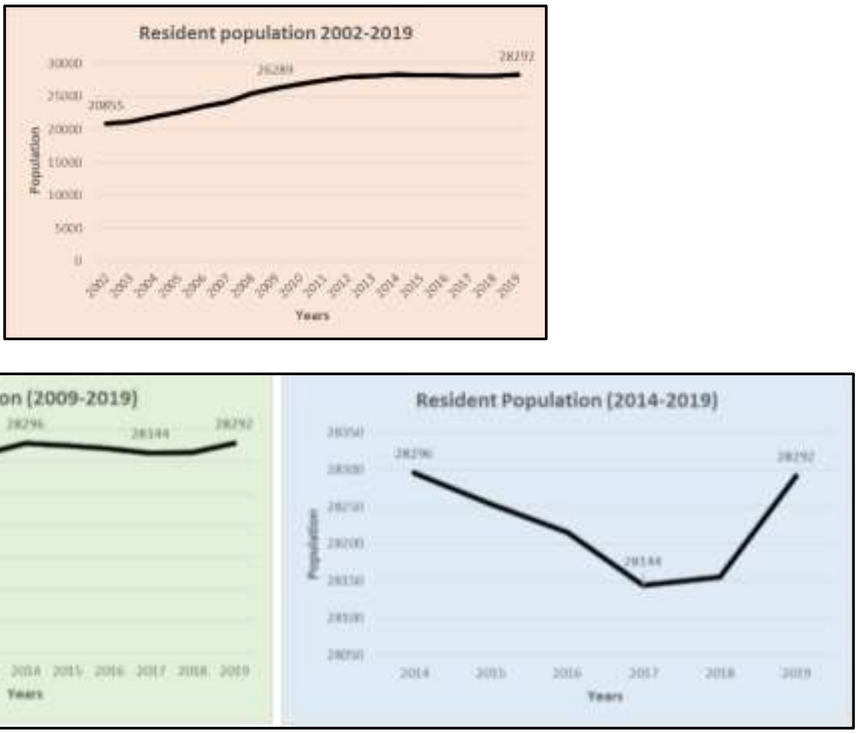


***Figure 2.3**: Demographic trend in the long, medium and short term (Own elaboration on ISTAT, 2020)*

During the years of demographic decline, for the first time since 2002, there has been both a negative *natural balance (*births - deaths) (minus 76 units, in the years between 2015 and 2018), and a *migratory balance* (registered in the civil registry from other cities or from abroad - (minus) deleted from civil registry for other cities/ abroad) net negative (minus 255 units in the years between 2014 and 2016 (Fig. X) (own elaboration on ISTAT, 2020).

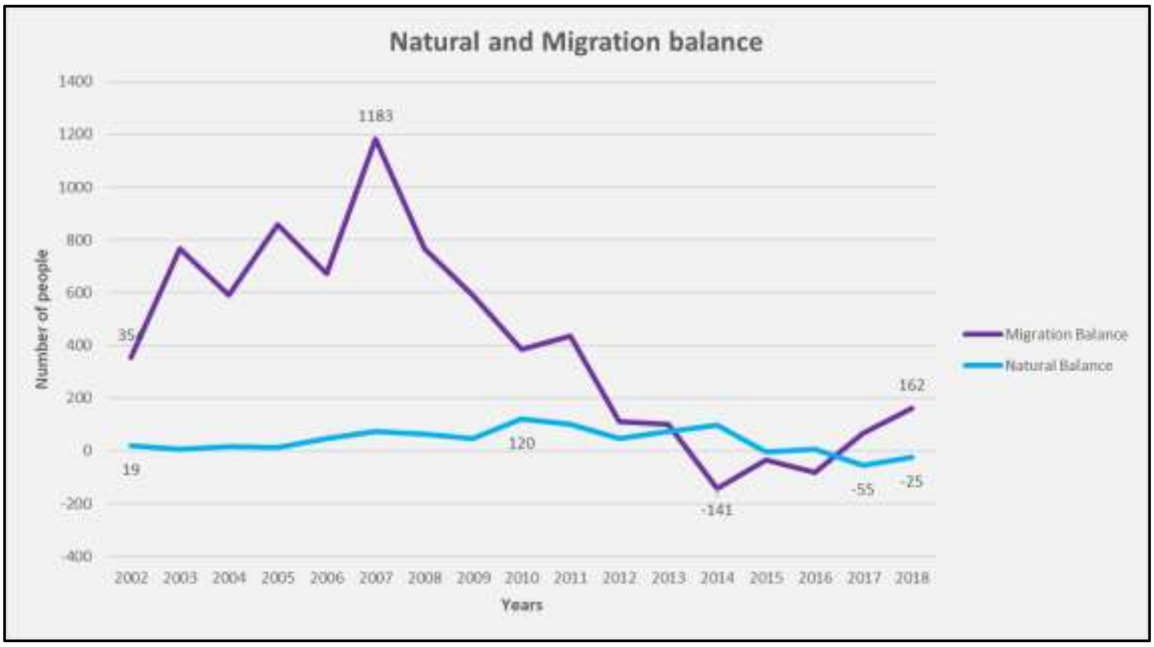


Figure 2.4: *Natural and migration balance in the 2002-2018 period in the study area (Own elaboration on ISTAT, 2020)*

According to what has been just reported, it can be deduced that in the long and medium term the population of the Valconca Union has grown (average variation 2% and 1% respectively) but the decline (even though not preponderant and accompanied by a recent recovery) recorded from 2014 to 2018, together with the observation of the natural and migratory balances, both negative for the first time since 2002, it could be a warning on regards the leaving from this territory by people.

Local economy

In 2019, 2.383 companies were active in the area, 29% of which in the trade sector, 22% in the construction sector, 21% in services, 17% agriculture and fishing and 12% manufacturing and industry activities (Camera di Commercio della Romagna, 2020 on ATECO classification). The enterprises employ 6,394 employees with an average of 2.7 employees per company (lower than Italy's average that settles at 3.7) (Ibid).

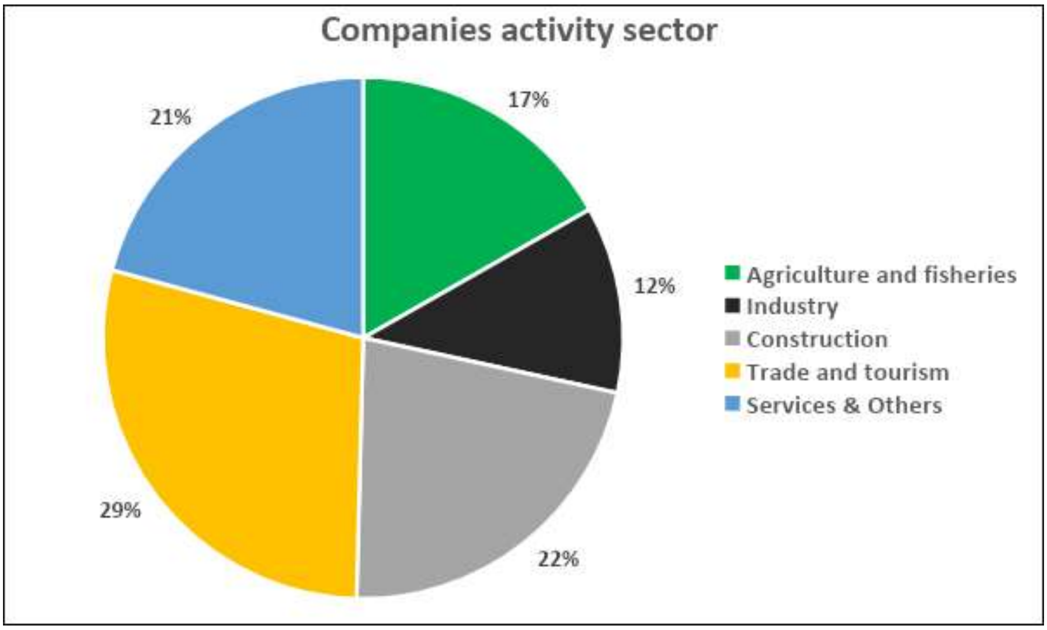


***Figure 2.5**: Composition of active companies by macro-sector of activity (own elaboration on Camera di commercio della Romagna, 2020)*

In the last 5 years, the total number of the active companies has dropped on average by 4% (0.3% compared to 2018), the largest decrease has been recorded in the construction sector (-10.3%), followed by agriculture and industry (-4.8 %), trade and tourism (-2.3%) , only the service sector's companies have been recorded an increase (+ 2.5%).

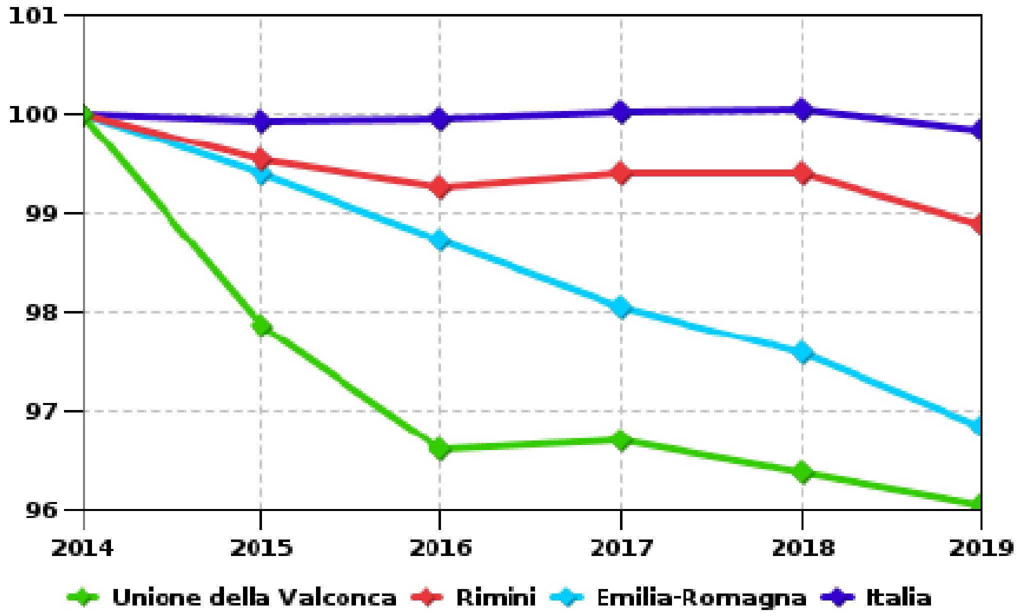


Figure 2.6*- Trend (%) of the active enterprises in the Valconca Union, province of Rimini, Emilia Romagna region and Italy (Camera di commercio della Romagna, 2020).*

In addition to this negative trend of active enterprises, a relevant fact is the average income per taxpayer in the Conca Valley (17,929 euro in 2019), which is lower than the provincial (19,692), regional (23,432) and Italian (21,244) average (Camera di commercio della Romagna, 2020).

2.1.1 Community interviews

In this section we report the first results of some interviews to the communities (8 mayors and 25 stakeholders) carried out in collaboration with the agency “Piano Strategico Srl” (http://www.agenziapianostrategico.it/chi-siamo/) within the framework of the Valconca Next project (funded by the Emilia Romagna region, https://www.osservatoriopartecipazione.it/scheda-processo/1521).

The general objective of the project was the construction of a participated strategic plan for the sustainable development of the territory.

My role in the first phase of the project was to:

- Support in the creation of the interview (in particular, in adding the contents of question 3, while the structure of the interview is based on a model already used by Strategic Plan Srl.)
- accompaniment to the administration of some interviews on site;
- transcription and subsequent analysis of the interviews recorded on digital media.

The interviews were administered with the aim of encouraging the participation of local actors in identifying criticalities and strengths of the territory in a sustainable development perspective. The project was suspended during the worsening of the Covid 19 pandemic, in March 2020, and then completed in early 2021 by the Piano Strategico Srl.

Structure of the interview and and choice of respondents

The structure of the interview is based on a model previously adopted by the “Piano Strategico Srl”, but integrated as much as possible, in the part relating to closed questions, with the themes considera by the 2030 Agenda (UN, 2015).

The interviews infact are composed of 2 initial open-ended questions aimed at investigating the problems (question 1) and strengths (question 2) of the territory from a sustainable development perspective. Question 3 consists of a series of closed multiple-choice questions (a maximum of 3, questionnaire style) aimed at highlighting the priority issues (divided into macro-categories: territory, environment, welfare and services, mobility, economy and culture) to consider for sustainable development of the territory.

The interview presents 3 further questions which are not currently considered in this analysis. The integral interview template is included in the appendix.

The interviews were administered to the 8 mayors of the Valconca municipalities, who were asked to indicate other territorial stakeholders to be interviewed. The interviewed stakeholders were asked to indicate other stakeholders to be interviewed (*Snowball Sampling* technique, see for example Johnson, 2014).

Administration

The interviews were administered directly to mayors and stakeholders at municipal facilities, private residences, or public gathering places in their respective municipalities. The answers of the interviewees were noted down directly on the paper version of the interview and at the same time recorded, so that the information noted could be checked later and in many cases supplemented.

Results

With the aim of framing the problems and potential of the local context under investigation, some results of the interviews are reported below. For a more complete view of the project process and results see https://www.osservatoriopartecipazione.it/scheda-processo/1521.

In general, the results reveal a territorial situation that, in terms of the socio-economic component, fairly closely follows the major problems that the scientific literature also reports for rural areas. (Bleahu 2005; Burja, 2014, Mihai and Iatu, 2019; Schouten et al., 2009; Sobczyk, 2014).
In fact, in a nutshell, European rural areas are mostly accumulated:

I) by a general trend of depopulation;

II) a more or less marked lack of essential and non-essential services;

III) average per capita income and employment opportunities are lower than in more urbanised centres.

In particular, by analysing more deeply the answers given in questions 1 and 2 it is possible to contextualise and in some cases identify the perceived causes of the main criticality (or priority for action) clearly highlighted in the answers to question 3.
We have chosen to present the answers of the questionnaires differentiated between those given by the mayors (8 in total) and those given by the stakeholders (25 in total), in order to highlight possible differences (but which are not covered now in this work). In the comments, the answers given in questions 1 and 2 are analysed with reference to the macro-issues highlighted.

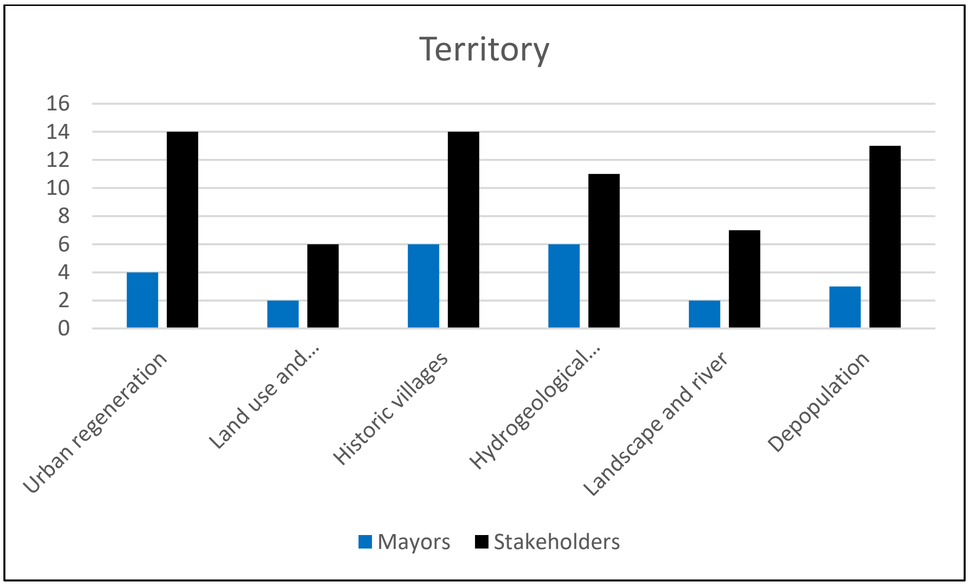


Fig 2.7 - Histogram of the preferences expressed in question 3 (territory macro-theme) by the mayors and stakeholders interviewed

Preferences expressed by both mayors and stakeholders clearly indicates that particular attention should be paid to historical villages valuing them and preventing them from being abandoned, as is happening in some cases. Depopulation is perceived as a problem especially for stakeholders and mayors of the innermost municipalities. In this regard many interviewees reported the following as the main causes of depopulation: the lack of job opportunities ("*There are no job opportunities for young people who leave, we need to create opportunities for them to stay*") and of essential services such as mobility ("*we need to invest in transport, otherwise people will leave*"). In many cases, there is also evidence of an essentially passive community life ("*as a village it is a dormitory, you don't live community life*"), balanced by sporadic social events during traditional village fairs. The problem of hydrogeological instability (and erosion) is felt, particularly by the mayors of the eight municipalities ("There is a big problem with erosion").

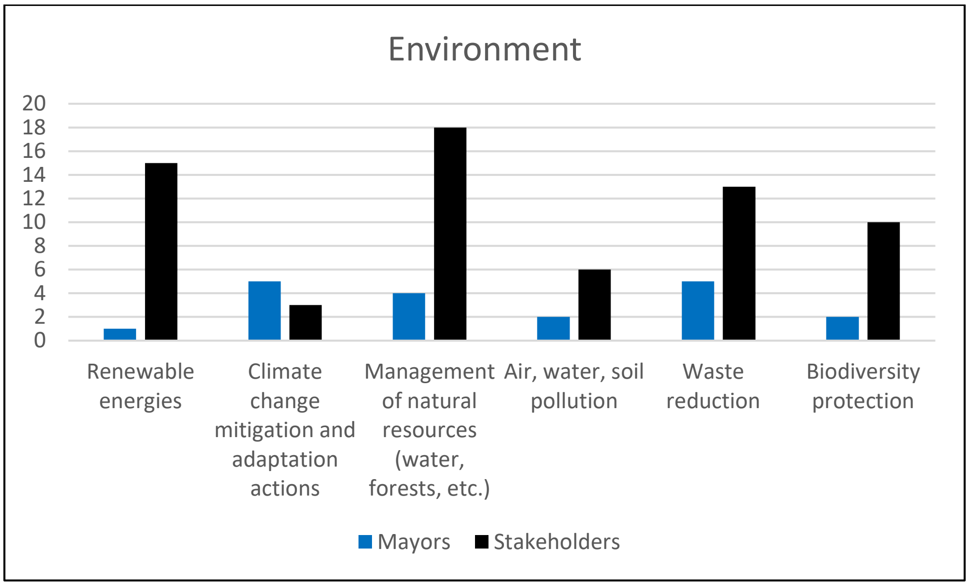


Fig 2.7.1 - Histogram of the preferences expressed in question 3 (Environment macro-theme) by the mayors and stakeholders interviewed

With reference to the questions on the environment, the option of 'management of natural resources' was among those that received the most preferences. In particular, the interviewees highlighted the presence of valuable natural areas, which in many cases are not valued as they should be *("we have a lake left to itself and people still go there, it should be valued and cared for*") and the presence of wild animals that ruin crops (wild boars in particular). Renewable energies are perceived by the majority of respondents as a means of environmental protection and job creation ("*acting on renewable energies to save the planet and create jobs*") although some reported a certain opposition due to the impact (especially wind turbines) they could have on the landscape. The mayors report the problem of waste, which is confirmed by the percentage of separate collection below the provincial average.

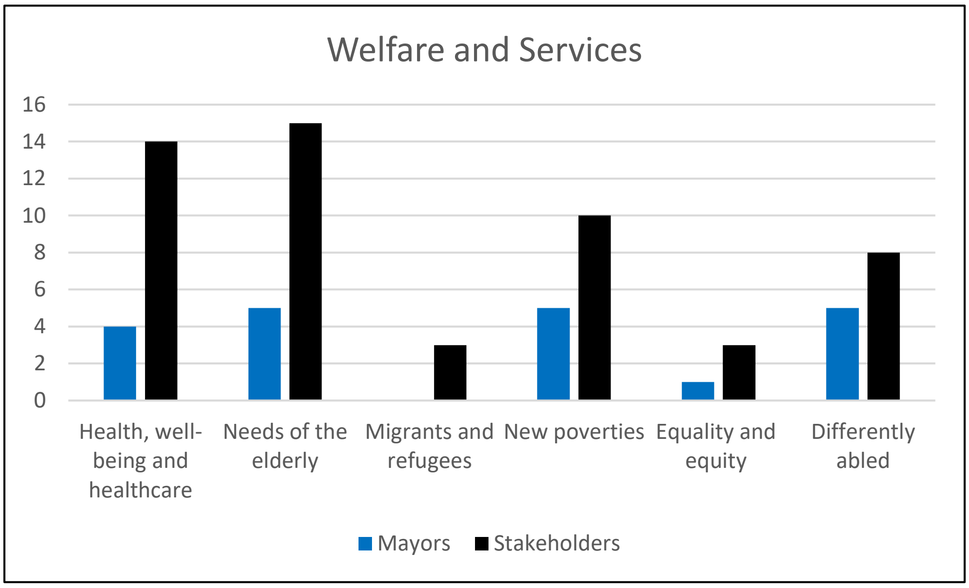


Fig 2.7.2 - Histogram of the preferences expressed in question 3 (Welfare and services macro-theme) by the mayors and stakeholders interviewed

The category on welfare highlighted a general lack of even essential services, especially in the most upstream municipalities, such as the relative ease of access to medicines ("*some medicines are only available in Morciano*") and the few opportunities for the elderly to meet *("the elderly should be involved in voluntary associations, and given a place to meet, so as to keep them active and at the same time contribute to the care of the territory*"). Respondents ("*in particular mayors*") report an appreciable numbers of people experiencing financial difficultis ("*there are a lot of families who have these problems*").

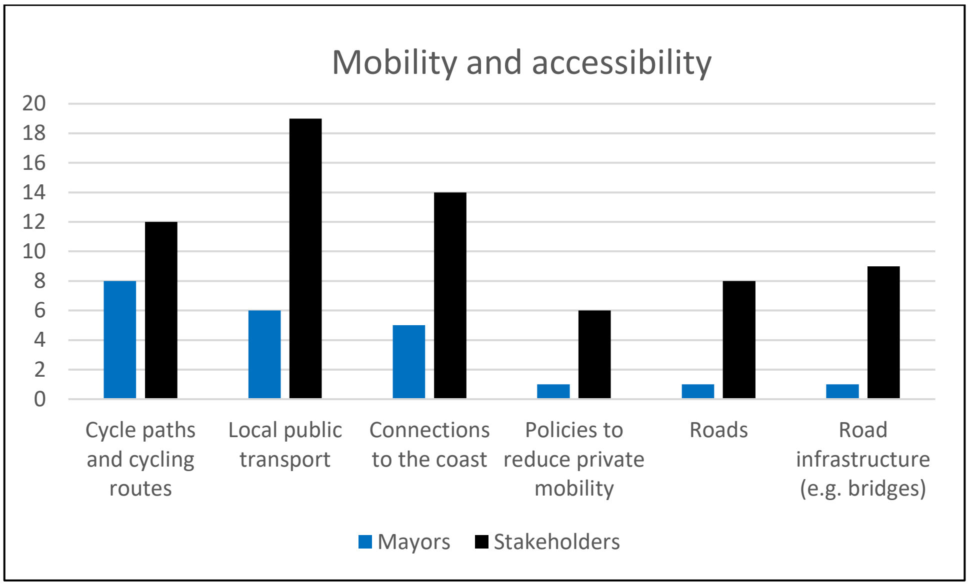


Fig 2.7.3 - Histogram of the preferences expressed in question 3 (Mobility and accessibility macro-theme) by the mayors and stakeholders interviewed

Mobility is a very important issue for the Valconca community. In particular, in some cases the poor state of the roads is highlighted, which also negatively affects tourism and commercial activities (accessibility problem). On the other hand, the mayors complain about the scarce availability of funds for the maintenance of the territory. In other cases, it is public transport with unserved areas, in some cases buses that run empty ("*they run big buses when they are not needed*") and very long waiting times. One solution that is being tried out with apparent success is the demand-responsive bus, the so-called Conca-Bus ("*The Conca-Bus... if it is made efficient it can solve this problem*").

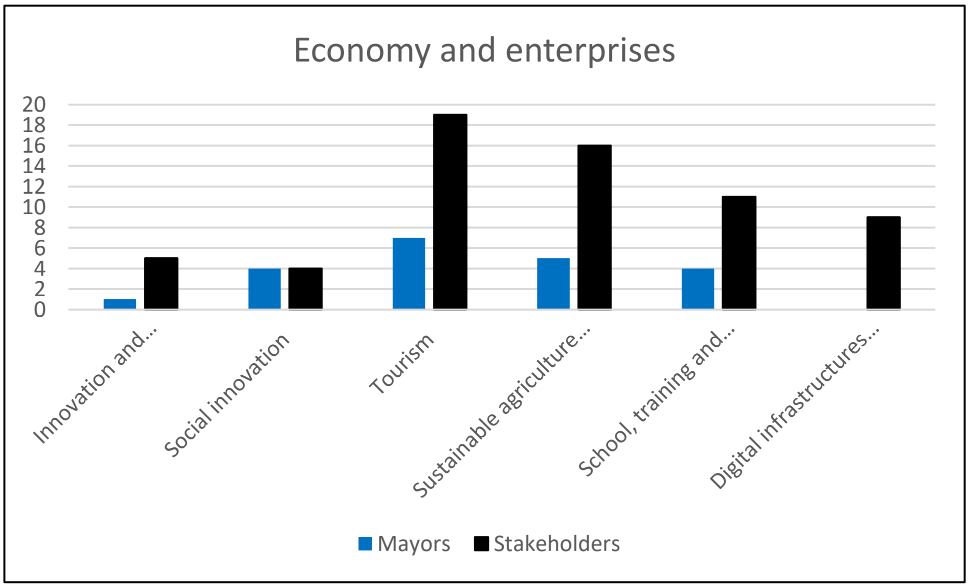


Fig 2.7.4 - Histogram of the preferences expressed in question 3 (Economy and enterprises macro-theme) by the mayors and stakeholders interviewed

The main critical points noted were the poor visibility of many small and medium-sized businesses (especially agricultural ones) and the lack (in some cases) of innovation. While large farms do not have the same care for the territory ("*large farms do not clean up around the borders of their land*"; "*large farms do not care about the territory*"). As far as businesses and economic activities are concerned, the preferences indicate that the response to the current impoverishment of the territory is to focus on tourism (1 position), possibly differentiated from that of the coast and aiming at a tourism that enhances the natural beauty of the place, together with typical products and historic villages. The second most popular answer is sustainable agriculture, with many respondents reporting the need to move in the direction of more eco-friendly agriculture (“"*we must focus on quality and environmentally sustainable agriculture*”), although in some cases bureaucracy regarding certification can be a barrier. Many respondents already practice organic farming.

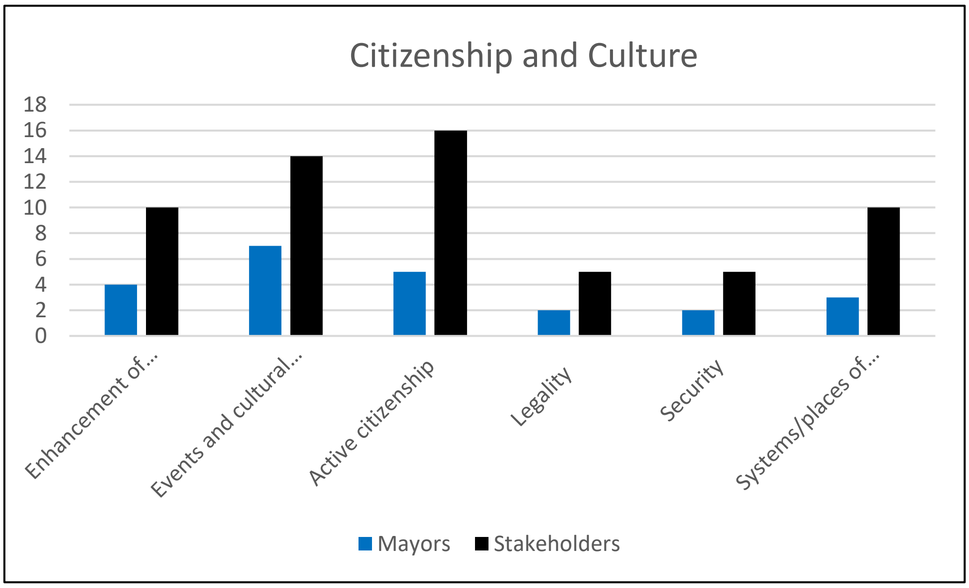


Fig 2.7.5 - Histogram of the preferences expressed in question 3 (Cizitenship and culture macro-theme) by the mayors and stakeholders interviewed

With regard to the category culture and education, one of the most popular options for stakeholders is active citizenship, which denotes a strong desire to contribute to the development and well-being of their communities ("*everyone in his or her own small way has an impact, we have to be involved*".). This desire is also expressed by the presence of many volunteers and volunteer associations in the area. Furthermore, both mayors and stakeholders think it is essential to enrich the cultural offer (“*If you organise interesting events and initiatives people react and appreciate”*) both for the well-being of the resident community and to improve territorial attractiveness.

Other

In addition to the preset issues, some respondents (including mayors themselves) reported a lack of cohesion or common direction/collaboration at the union level (“*there is no unity of purpose”; “there is a lack of dialogue and a strong parochialism”;* “*young people must look at the synergy between municipalities with the same problems, they must be solved as a system*.”). On this issue, many propose undertaking common and shared territorial projects linked to agricultural activities and tourism ("*we should create a project for the development of quality agriculture, maybe community agriculture, the current one is poor*"; “*We should focus on an integrated tourist product that combines the specific features of the area*”).

Limitations of this analysis

The major limitations of the above analysis can be found in:

i) the relatively small number of stakeholders interviewed. In fact, 25 stakeholders cannot be a statistically significant sample. However, they can provide important indications regarding territorial dynamics. This aspect is all the more motivated by the fact that, in the interviews analysed here, many themes were at one point redundant, almost as if the possible main problems and strengths of the area had in a certain sense already been highlighted and no further knowledge could be added. In addition, the point of view of primary stakeholders (such as mayors) was analysed, who, by virtue of their role as representatives of the community, are assumed to have a broader point of view on the area's problems and potential.

ii) Despite the fact that the questionnaire-style answers provide a measurable indication of the main themes that emerged, the analysis that followed, although we tried to report it with objective and verifiable criteria in the interviews, still presents a certain degree of subjectivity that is intrinsically not excluded by this type of analysis method adopted (Gianturco G. (Eds), 2004).

2.2 Land Use Analysis

Spatial analysis software

Part of the analysis of the case study was conducted using *Geographic Information System* (GIS) support and, in particular, with the open source desktop software *QGIS 3.10.8 - A Coruña*, downloaded freely from the official website (https://qgis.org/it/site/).

This software, created in 2002 and developed by a group of volunteers, allows to view, analyze and edit spatial data. Qgis supports both *raster* and *vector* data and allows to set up a territorial analysis using different sources.

A *Raster* is determined by a set of square (or rectangular) cells, of the same size, which represent a portion of the territory. Each cell contains a numerical value that quantifies an average characteristic of that area (brightness, altitude, frequency / density of a given element, etc). *Vector* data consist of a set of geometric elements (points, lines or polygons) also of different shapes, which represent a portion of the territory, a position or a set of positions. Each element can be associated with a row of a table with one or more data (numbers or text).

Qgis offers several functions that can be used for cartographic analysis, as well as many *plugins* that allow additional analysis.

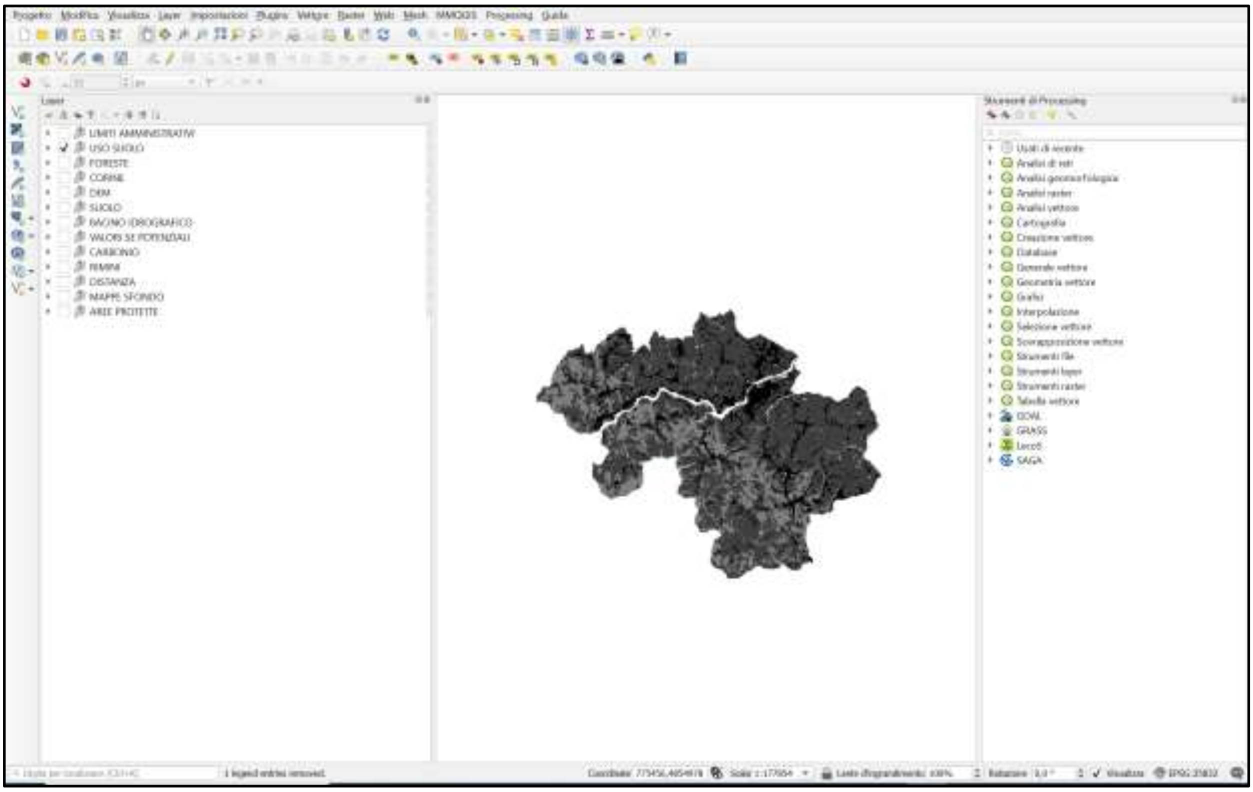


***Figure 2.7** - Snapshot of the working environment in Qgis 3.10.8 (own elaboration).*

Land use map

One of the most used cartographic data in this study (elaborated in GIS environment, through Qgis software) was the detailed land use map of the Emilia Romagna region, freely downloadable from the regional Geoportal website (https://geoportale.regione.emilia - romagna.it/).

This land use map is in vector format, at a reference scale 1: 10.000, published in 2020 and created on the basis of video interpretation of the 2017 TeA orthophotos. TeA orthophotos are high definition aerial photographs, with pixels of 20 centimeters and a minimum detail area of 0.16 hectares (Garberi et al., 2020).

The various land uses are classified according to hierarchical levels derived from the specifications of the European project Corine Land Cover (CLC) (https://land.copernicus.eu/pan-european/corine-land-cover) and integrated by the regional Land Use Working Group (CPSG-CISIS), in particular class 2.2.4. at the third level and all the present fourth levels.

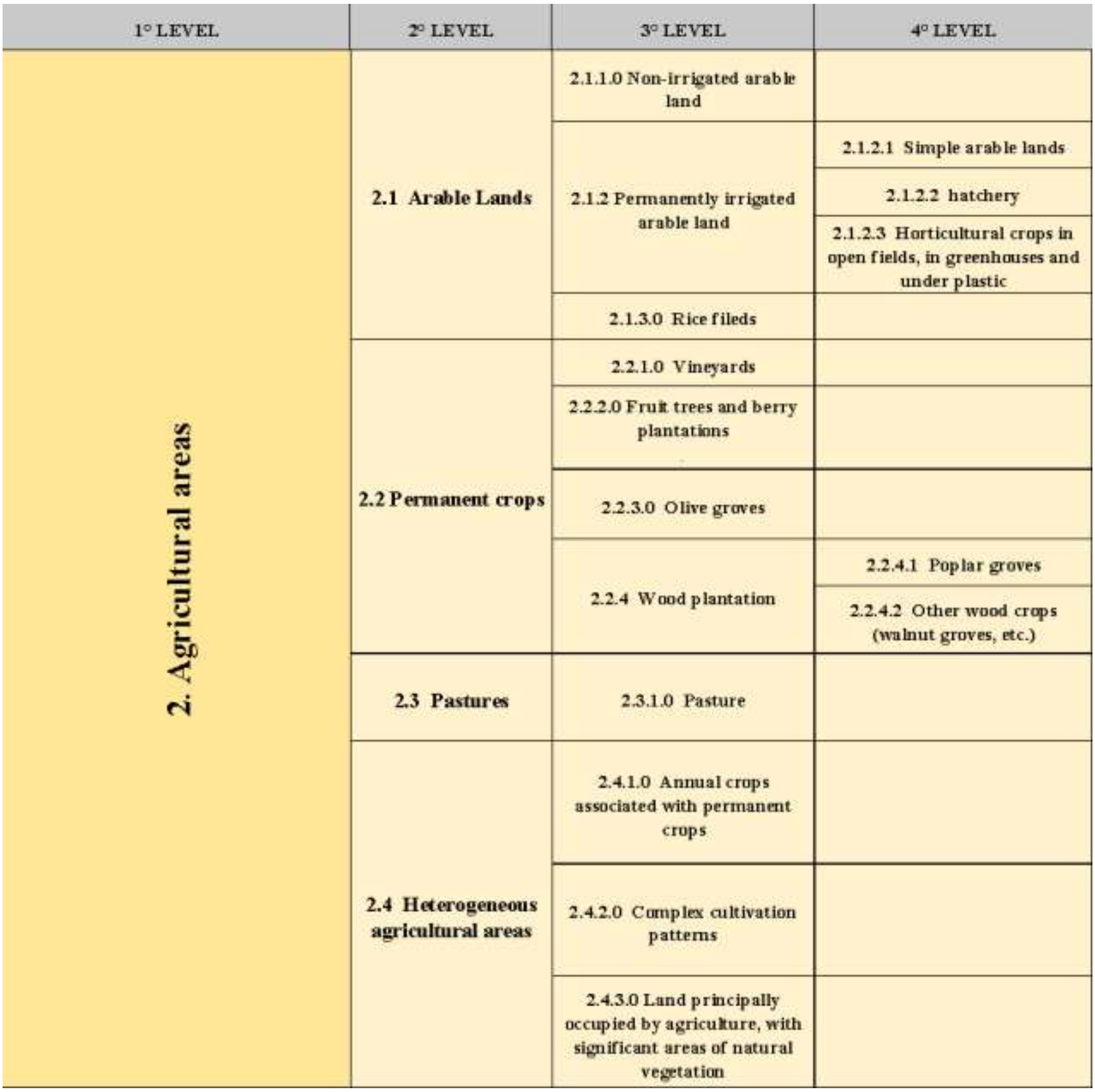
The result is a series of polygons representing the various land use of the Emilia-Romagna region, for a total of 90 different categories. Each category is defined by a specific four-digit code (identifiable under the heading "COD TOT") with each digit representing an increasing level of detail.

At the first level of classification five main land use classes are identified:

1. Artificial Surfaces
2. Agricultural areas
3. Forest and semi natural areas
4. Wetlands
5. Water bodies

An example of the four levels classification is provided below.

***Table 2.1**: Example of classification of agricultural areas used in the land use map of the Emilia Romagna region (modified from Garberi et al. 2020).*



1° LEVEL	2° LEVEL	3° LEVEL	4° LEVEL
2. Agricultural areas	**2.1 Arable Lands**	2.1.1.0 Non-irrigated arable land	
		2.1.2 Permanently irrigated arable land	2.1.2.1 Simple arable lands
			2.1.2.2 hatchery
			2.1.2.3 Horticultural crops in open fields, in greenhouses and under plastic
		2.1.3.0 Rice fileds	
	2.2 Permanent crops	2.2.1.0 Vineyards	
		2.2.2.0 Fruit trees and berry plantations	
		2.2.3.0 Olive groves	
		2.2.4 Wood plantation	2.2.4.1 Poplar groves
			2.2.4.2 Other wood crops (walnut groves, etc.)
	2.3 Pastures	2.3.1.0 Pasture	
	2.4 Heterogeneous agricultural areas	2.4.1.0 Annual crops associated with permanent crops	
		2.4.2.0 Complex cultivation patterns	
		2.4.3.0 Land principally occupied by agriculture, with significant areas of natural vegetation	

Land use study in the considered area

For land use analysis of the study area, the regional land use *shapefile* was uploaded to the Qgis software and was cut out with the “cut” function on Qgis, through the shapefile related to the administrative limits of the eight municipalities considered, available on the regional geo-portal site.

The result is a new shapefile related to the land use of the municipalities considered, where each polygon is associated with a different type of land use and related attributes.

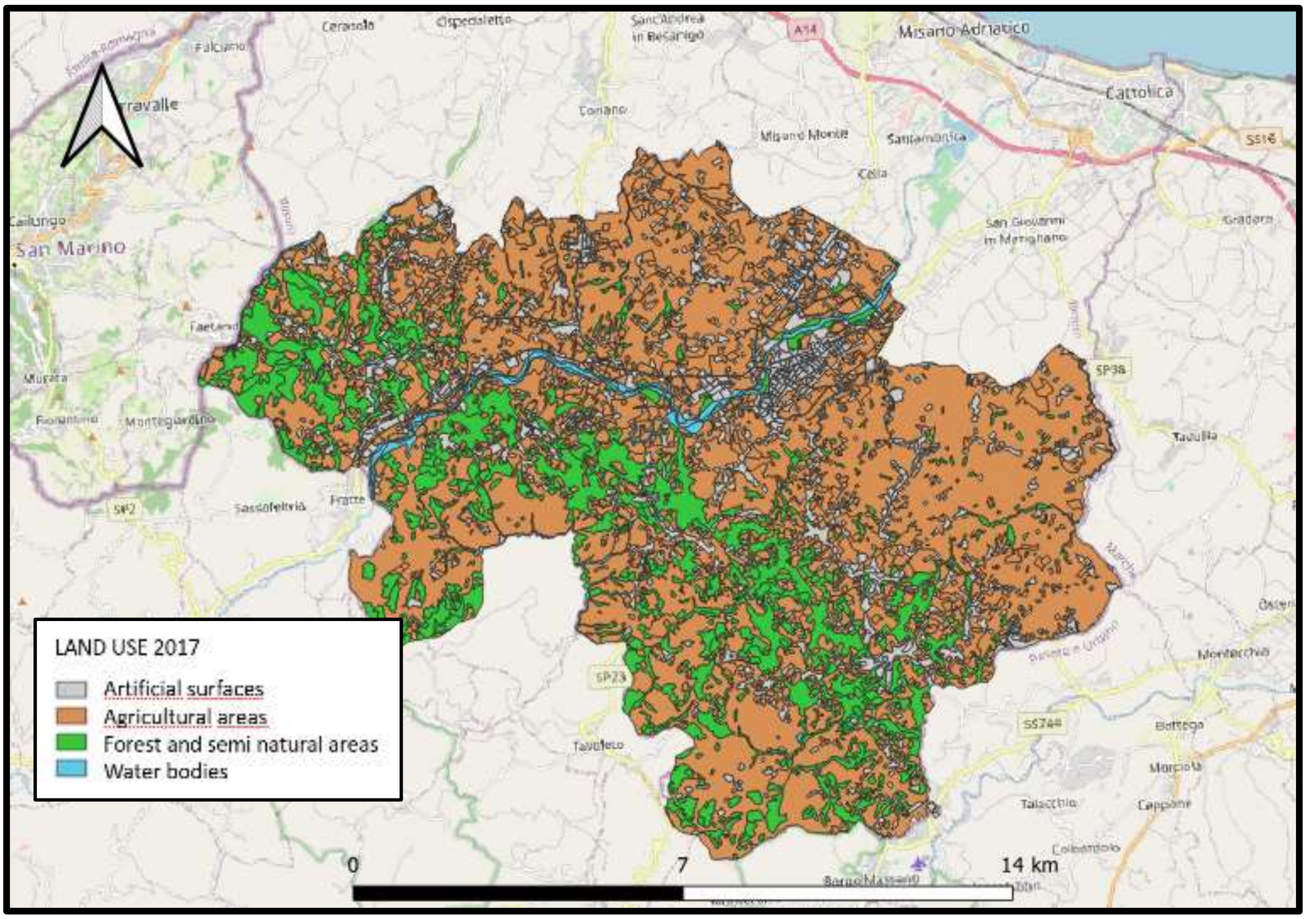


Figure 2.8: *Land use of the Valconca municipalities (2017) at the I level of CLC classification (own elaboration on regional data)*

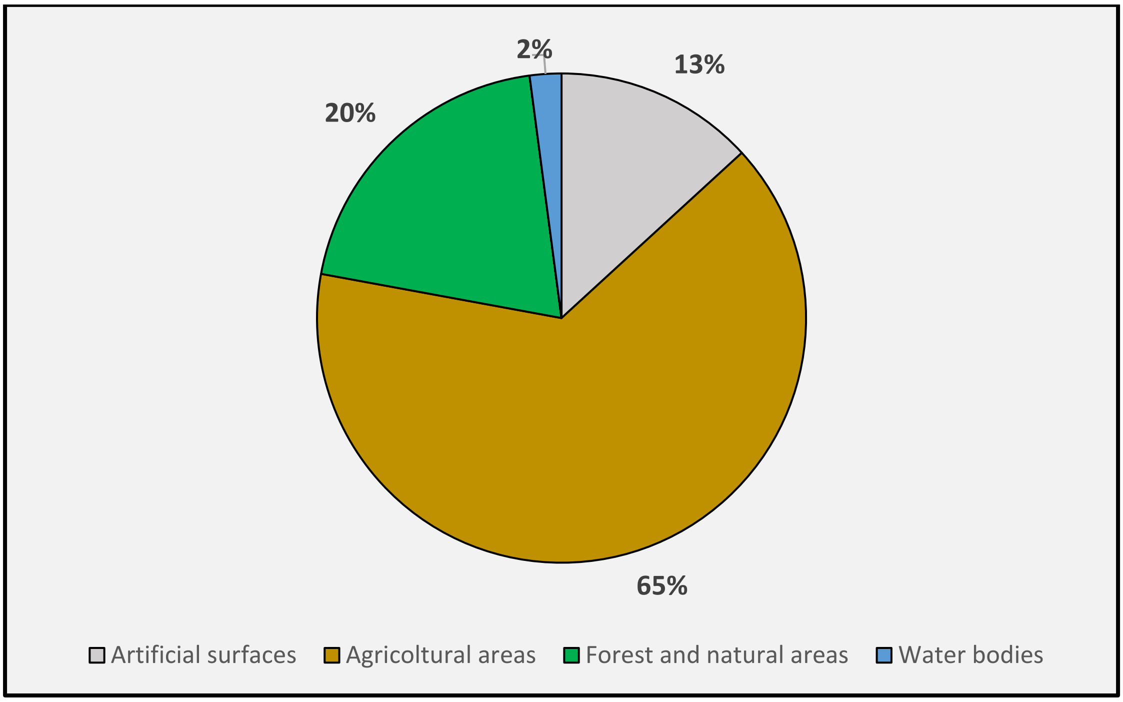


Figura 2.8*: Land use distribution (%) in the Union of Valconca municipalities*

From the figure 2.8, the agricultural vocation of the Valconca territory (65% total coverage) can be clearly seen, while the other land use macro-categories amount to 20% (about 3.220 ha) for forest and natural areas, 13% (about 2108 ha) for artificial surfaces and 2% (about 343 ha) for water bodies.

Furthermore, through the land use maps provided by the region, the trend in land use changes from 1994 to 2017 was analysed (see figure below).

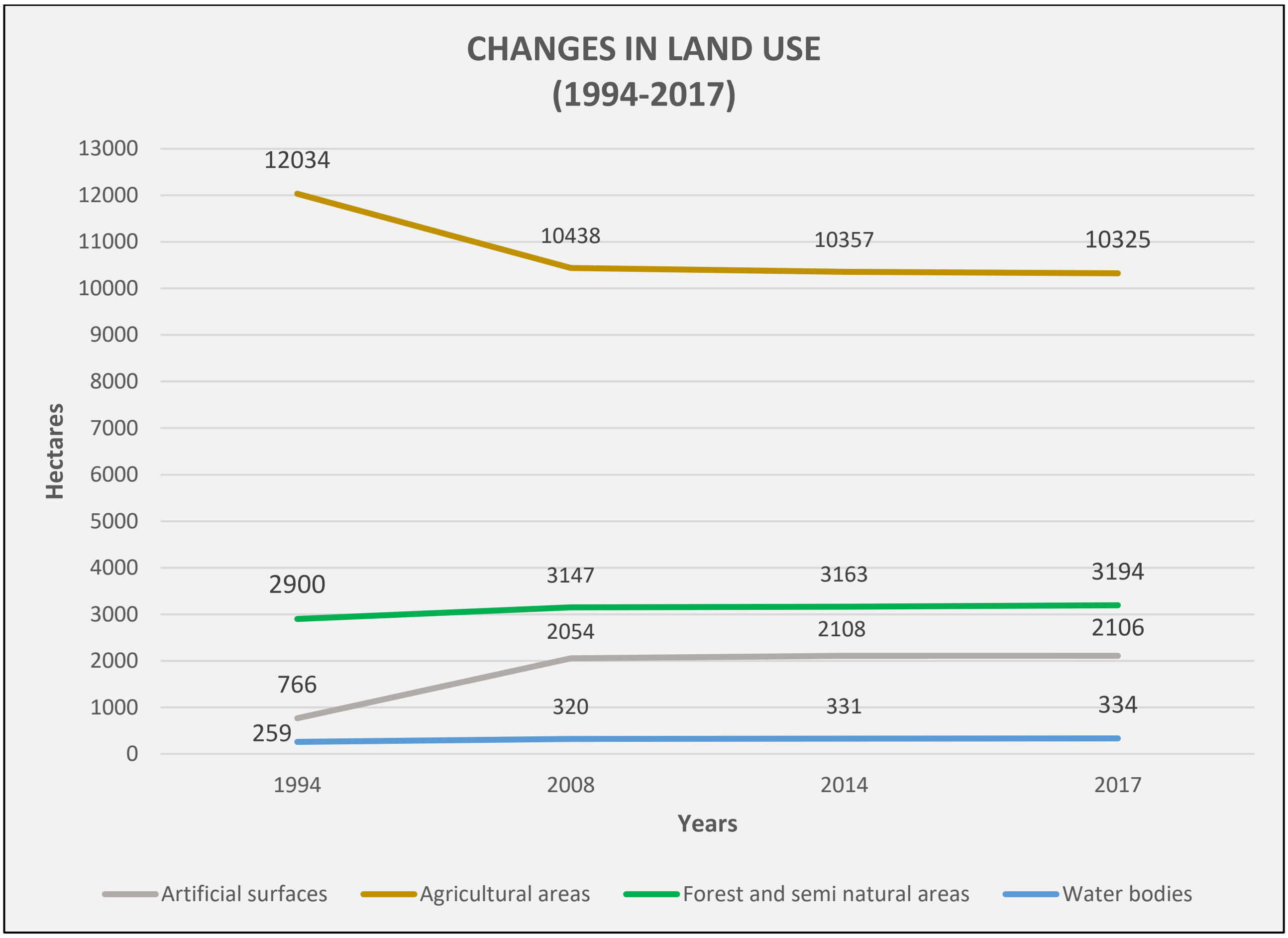


Figure 2.9*: Changes in land use from 1994 to 2017 in the UV*

It can be clearly seen that over time, agricultural areas have decreased (-1,709 ha) in favour of artificial areas (+1,340 ha), natural/semi-natural areas (+294 ha) and water bodies and basins (+75 ha).

2.3 Qualitative assessment of ecosystem services potential, demand and budget

The method

For a first screeening of the supply and demand of ecosystem services in the study area considered an "expert based" approach was used, the so called "matrix approach proposed by Burkhard et al. (2009, 2012, 2014).

This approach has been used in numerous studies both internationally (Kandziora et al., 2013; Kaiser et al., 2013; Kroll et al. 2012; Nedkov & Burkhard, 2012; Vihervaara et al., 2012) and nationally (Life MGN, 2016; Santolini et al., 2015; Scolozzi et al., 2012).

In this approach, Burkhard et al. attribute to each class of land use (at the third level of detail of Corine Land Cover) an increasing value between 0 and 5, relative to supply (2009, 2012), potential and flow (2014) and demand (2012, 2014) of ecosystem services, where:

- POTENTIAL: the maximum supply capacity of the ESs, without including human inputs;
- SUPPLY: the supply of a specific service, regardless of its current use, including some human inputs necessary to generate the service;
- FLOW: ESs (or set of ecosystem services) actually used in a particular area and at a given time
- DEMAND: the need for specific ES by society, particular stakeholder groups or individuals.

The assigned values are attributed by the authors (on the basis of previous case studies) for a hypothetical normal European landscape.
The result are matrices that present on the X axis the list of ES taken into consideration, while on the Y axis the list of land cover / use types at the third level of Corine Land Cover classification. The values assigned to ES supply, potential, flow and demand are shown in the intersection between the X and Y axis.

Reasons for selection and limitations of the method

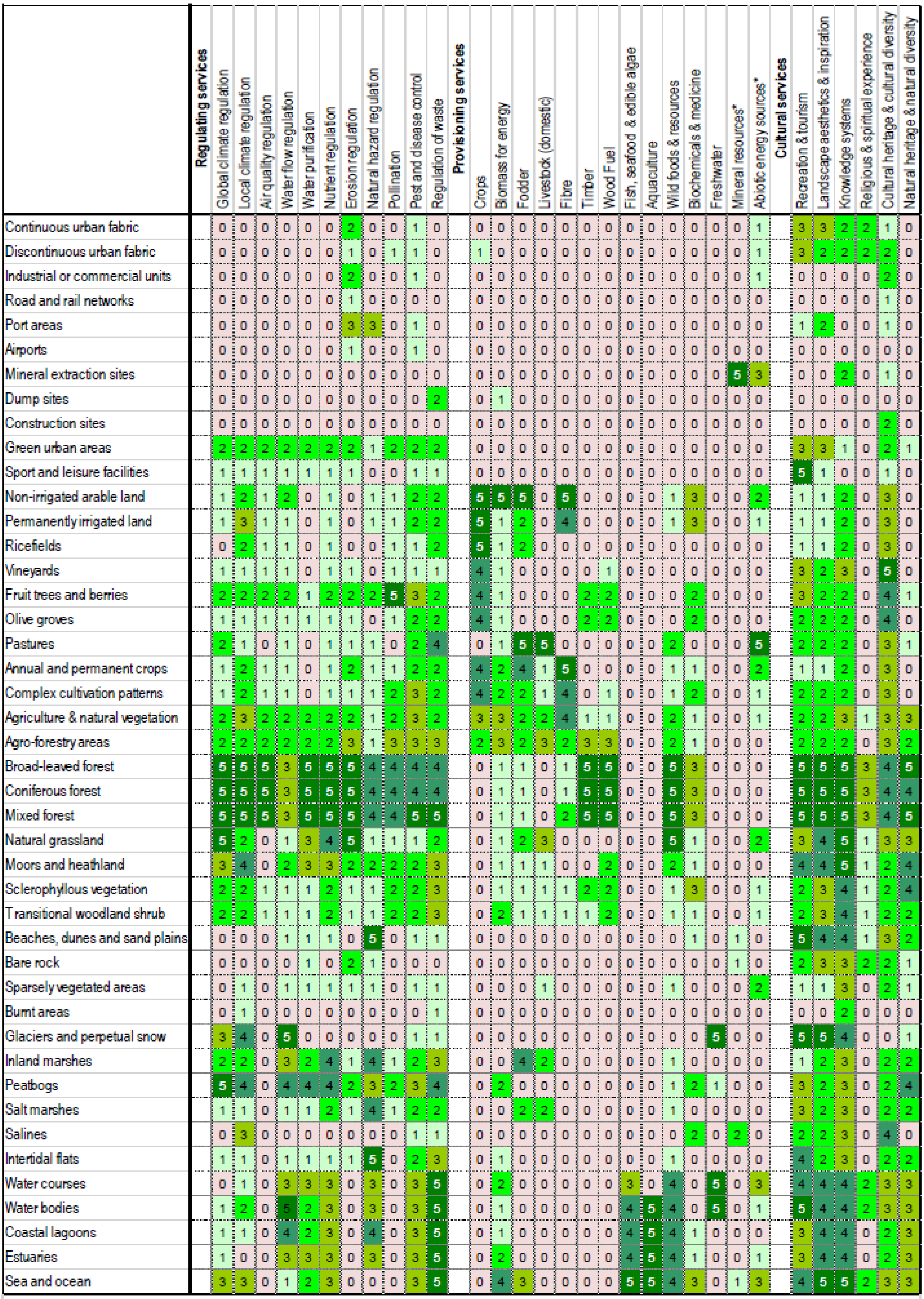
We chose to use this approach because it allows to obtain a quick and relatively simple feedback on the actual supply of ecosystem services (and related demand), compared to much more resource and time intensive procedures. Furthermore, this approach allows in a fairly easy way to hypothesize scenarios of land use change and to verify how the relative demand and supply of ES could change accordingly. This fits well with the aim of this work.

It should be remembered that in the optimal case, the application of Burkhard matrices to the specific territory should be adapted to specific factors relating to the environmental and socio-economic context. In this regard, Scolozzi et al. (2012) in a work on the Italian territory modified Burkhard's original supply matrix of ecosystem services, based on the distance from inhabited centers and altitude, while in the LIFE MGN project (2016) the values of Burkhard (2012) are been reconsidered (on a 0-3 scale) for the Italian territory, and in particular for the Natura 2000 areas.

In this work it was decided to use the ES potential and demand matrices, as proposed by Burkhard et al. (2014). In particular, we have chosen to use the ES potential matrix since, in our idea, it is more generalizable than that of supply (Burkhard, 2012) (which also includes some human inputs) and flow (which is associated with limited time periods). Burkhard and Maes themselves (Eds, 2017), underline how the ES potential matrix is suitable for strategic planning, management and creation of alternative territorial scenarios.

The original Burkhard matrix (2014) is reported below.   .

***Table 2.2**: Ecosystem service potential matrix (Burkhard et al 2014).*
Scale from 0 = no relevant potential; 1 = low relevant potential; 2 = relevant potential; 3 =medium relevant potential; 4 = high relevant potential; and 5 = very high (maximum) relevant potential.



	Regulating services	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and disease control	Regulation of waste	Provisioning services	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, seafood & edible algae	Aquaculture	Wild foods & resources	Biochemicals & medicine	Freshwater	Mineral resources*	Abiotic energy sources*	Cultural services	Recreation & tourism	Landscape aesthetics & inspiration	Knowledge systems	Religious & spiritual experience	Cultural heritage & cultural diversity	Natural heritage & natural diversity
Continuous urban fabric		0	0	0	0	0	0	2	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1		3	3	2	2	1	0
Discontinuous urban fabric		0	0	0	0	0	0	1	0	1	1	0		1	0	0	0	0	0	0	0	0	0	0	0	0	1		3	2	2	2	2	0
Industrial or commercial units		0	0	0	0	0	0	2	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	1		0	0	0	0	2	0
Road and rail networks		0	0	0	0	0	0	1	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	1	0
Port areas		0	0	0	0	0	0	3	3	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	2	0	0	1	0
Airports		0	0	0	0	0	0	1	0	0	1	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Mineral extraction sites		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	5	3		0	0	2	0	1	0
Dump sites		0	0	0	0	0	0	0	0	0	0	2		0	1	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Construction sites		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	2	0
Green urban areas		2	2	2	2	2	2	2	1	2	2	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0		3	3	1	0	2	1
Sport and leisure facilities		1	1	1	1	1	1	1	0	0	1	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0		5	1	0	0	1	0
Non-irrigated arable land		1	2	1	2	0	1	0	1	1	2	2		5	5	5	0	5	0	0	0	0	1	3	0	0	2		1	1	2	0	3	0
Permanently irrigated land		1	3	1	1	0	1	0	1	1	2	2		5	1	2	0	4	0	0	0	0	1	3	0	0	1		1	1	2	0	3	0
Ricefields		0	2	1	1	0	1	0	0	1	1	2		5	1	2	0	0	0	0	0	0	0	0	0	0	0		1	1	2	0	3	0
Vineyards		1	1	1	1	0	1	1	0	1	1	1		4	1	0	0	0	0	1	0	0	0	0	0	0	0		3	2	3	0	5	0
Fruit trees and berries		2	2	2	2	1	2	2	2	5	3	2		4	1	0	0	0	2	2	0	0	0	2	0	0	0		3	2	2	0	4	1
Olive groves		1	1	1	1	1	1	1	0	1	2	2		4	1	0	0	0	2	2	0	0	0	2	0	0	0		2	2	2	0	4	0
Pastures		2	1	0	1	0	1	1	1	0	2	4		0	1	5	5	0	0	0	0	0	2	0	0	0	5		2	2	2	0	3	1
Annual and permanent crops		1	2	1	1	0	1	2	1	1	2	2		4	2	4	1	5	0	0	0	0	1	1	0	0	2		1	1	2	0	3	0
Complex cultivation patterns		1	2	1	1	0	1	1	1	2	3	2		4	2	2	1	4	0	1	0	0	1	2	0	0	1		2	2	2	0	3	0
Agriculture & natural vegetation		2	3	2	2	2	2	2	1	2	3	2		3	3	2	2	4	1	1	0	0	2	1	0	0	1		2	2	3	1	3	3
Agro-forestry areas		2	2	2	2	2	2	3	1	3	3	3		2	3	2	3	2	3	3	0	0	2	1	0	0	0		2	2	2	0	3	2
Broad-leaved forest		5	5	5	3	5	5	5	4	4	4	4		0	1	1	0	1	5	5	0	0	5	3	0	0	0		5	5	5	3	4	5
Coniferous forest		5	5	5	3	5	5	5	4	4	4	4		0	1	1	0	1	5	5	0	0	5	3	0	0	0		5	5	5	3	4	4
Mixed forest		5	5	5	3	5	5	5	4	4	5	5		0	1	1	0	2	5	5	0	0	5	3	0	0	0		5	5	5	3	4	5
Natural grassland		5	2	0	1	3	4	5	1	1	1	2		0	1	2	3	0	0	0	0	0	5	1	0	0	2		3	4	5	1	3	3
Moors and heathland		3	4	0	2	3	3	2	2	2	2	3		0	1	1	1	0	0	2	0	0	2	1	0	0	0		4	4	5	1	2	4
Sclerophyllous vegetation		2	2	1	1	1	2	1	1	2	2	3		0	1	1	1	1	2	2	0	0	1	3	0	0	1		2	3	4	1	2	4
Transitional woodland shrub		2	2	1	1	1	2	1	1	2	2	3		0	2	1	1	1	1	2	0	0	1	1	0	0	1		2	3	4	1	2	2
Beaches, dunes and sand plains		0	0	0	1	1	1	0	5	0	1	1		0	0	0	0	0	0	0	0	0	0	1	0	1	0		5	4	4	1	3	2
Bare rock		0	0	0	0	1	0	2	1	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	1	0		2	3	3	2	2	1
Sparsely vegetated areas		0	1	0	1	1	1	1	1	0	1	1		0	0	0	1	0	0	0	0	0	1	0	0	0	2		1	1	3	0	2	1
Burnt areas		0	1	0	0	0	0	0	0	0	0	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	2	0	0	0
Glaciers and perpetual snow		3	4	0	5	0	0	0	0	0	1	1		0	0	0	0	0	0	0	0	0	0	0	5	0	0		5	5	4	0	0	1
Inland marshes		2	2	0	3	2	4	1	4	1	2	3		0	0	4	2	0	0	0	0	0	1	0	0	0	0		1	2	3	0	2	2
Peatbogs		5	4	0	4	4	4	2	3	2	3	4		0	2	0	0	0	0	0	0	0	1	2	1	0	0		3	2	3	0	2	4
Salt marshes		1	1	0	1	1	2	1	4	1	2	2		0	0	2	2	0	0	0	0	0	1	0	0	0	0		3	2	3	0	2	2
Salines		0	3	0	0	0	0	0	0	0	1	1		0	0	0	0	0	0	0	0	0	0	2	0	2	0		2	2	3	0	4	0
Intertidal flats		1	1	0	1	1	1	1	5	0	2	3		0	1	0	0	0	0	0	0	0	1	0	0	0	0		4	2	3	0	2	2
Water courses		0	1	0	3	3	3	0	3	0	3	5		0	2	0	0	0	0	0	3	0	4	0	5	0	3		4	4	4	2	3	3
Water bodies		1	2	0	5	2	3	0	3	0	3	5		0	1	0	0	0	0	0	4	5	4	0	5	0	1		5	4	4	2	3	3
Coastal lagoons		1	1	0	4	2	3	0	4	0	3	5		0	1	0	0	0	0	0	4	5	4	1	0	0	0		3	4	4	0	2	3
Estuaries		1	0	0	3	3	3	0	3	0	3	5		0	2	0	0	0	0	0	4	5	4	1	0	0	1		3	4	4	0	2	3
Sea and ocean		3	3	0	1	2	3	0	0	0	3	5		0	4	3	0	0	0	0	5	5	4	3	0	1	3		4	5	5	2	3	3

Application of Burkhard matrices to the study area

Es potential matrix

In the original matrix, all the land use classes associated with the corine land cover (CLC) classification are considered. In the study area, obviously, not all the possible land uses classes associated with CLC are present, so first of all the land use classes of the study area, have been associated with the corresponding land use classes of the original matrix and the respective values for the potential supply of ecosystem services.
Two classes of land use present in the study area (2.2.4.1. poplar groves and 2.2.4.2 wood plantations) are not present in the original evaluation matrix and therefore were not included in the analysis.

Table 2.3*: adapted ES potential matrix for the study area (own elaboration on Burkhard et al., 2014)*

CLC CODE	CLC DESCRIPTION	Global dimake regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purifcation	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and desease control	Regulation of waste	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, Seafood and edible algae	Aquaculture	Wild food & resources	Biochemicals & medicine	Fresh Water	Mineral resources*	Abiotic energy sources*	Recreation & Tourism	Landscape aesthetichs & inspiration	Knowledge system	Religious & Spiritual experience	Cultural heritage & cultural diversity	Natural heritage & natural diversity
111	Continuous Urban Fabric	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	3	2	2	1	0
112	Discontinuous Urban Fabric	0	0	0	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	3	2	2	2	2	0
121	Industrial or commercial units	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0
122	Road and rail networks	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
124	Airports	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
132	Dump sites	0	0	0	0	0	0	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
133	Construction sites	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
141	Green urbam areas	2	2	2	2	2	2	2	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	0	2	1
142	Sport and leisure facilities	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	1	0	0	1	0
211	Non-irrigated arable land	1	2	1	2	0	1	0	1	1	2	2	5	5	5	0	5	0	0	0	0	1	3	0	0	2	1	1	2	0	3	0
212	Permanently arable land	1	3	1	1	0	1	0	1	1	2	2	5	1	2	0	4	0	0	0	0	1	3	0	0	1	1	1	2	0	3	0
221	Vineyards	1	1	1	1	0	1	1	0	1	1	1	4	1	0	0	0	0	1	0	0	0	0	0	0	0	3	2	3	0	5	0
222	Fruit trees and berries	2	2	2	2	1	2	2	2	5	3	2	4	1	0	0	0	2	2	0	0	0	2	0	0	0	3	2	2	0	4	1
223	Olive groves	1	1	1	1	1	1	1	0	1	2	2	4	1	0	0	0	2	2	0	0	0	2	0	0	0	2	2	2	0	4	1
231	Pastures	2	1	0	1	0	1	1	1	0	2	4	0	1	5	5	0	0	0	0	0	2	0	0	0	5	2	2	2	0	3	1
241	Annual and permanent crops	1	2	1	1	0	1	2	1	1	2	2	4	2	4	1	5	0	0	0	0	1	1	0	0	2	1	1	2	0	3	0
242	Complex cultivation patterns	1	2	1	1	0	1	1	1	2	3	2	4	2	2	1	4	0	1	0	0	1	2	0	0	1	2	2	2	0	3	0
243	Agriculture&natural vegetation	2	3	2	2	2	2	2	1	2	3	2	3	3	2	2	4	1	1	0	0	2	1	0	0	1	2	2	3	1	3	3
311	Broad-leaved forest	5	5	5	3	5	5	5	4	4	4	4	0	1	1	0	1	5	5	0	0	5	3	0	0	0	5	5	5	3	4	5
312	Coniferous forest	5	5	5	3	5	5	5	4	4	4	4	0	1	1	0	1	5	5	0	0	5	3	0	0	0	5	5	5	3	4	4
313	Mixed forest	5	5	5	3	5	5	5	4	4	5	5	0	1	1	0	2	5	5	0	0	5	3	0	0	0	5	5	5	3	4	5
323	Sclerophyllous vegetation	2	2	1	1	1	2	1	1	2	2	3	0	1	1	1	1	2	2	0	0	1	3	0	0	1	2	3	4	1	2	4
333	Sparsely vegetated areas	0	1	0	1	1	1	1	1	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	2	1	1	3	0	2	1
511	Water courses	0	1	0	3	3	3	0	3	0	3	5	0	2	0	0	0	0	0	3	0	4	0	5	0	3	4	4	4	2	3	3
512	Water bodies	1	2	0	5	2	3	0	3	0	3	5	0	1	0	0	0	0	0	4	5	4	0	5	0	1	5	4	4	2	3	3

We proceeded to calculate the weighted average of the qualitative values (0-5) of the ecosystem services present in the study area: for each ecosystem service i (X axis), the value of the service was multiplied for associated area *i* of land use class (Y axis) that generated (or not) the ES *i*. The products were added up and divided by the total area of the study area (the sum of all the land use area).

For example, for crops provision, the preset potential value of the ES was multiplied by the area in hectares of each different land use class present in the study area. These products were then added together and the result was divided by the total area of the territory.

With the described procedures we obtain a numerical value, between 0-5, which can indicate the relative degree of potential of each ecosystem service in the study area.

ES demand

It is possible to define ecosystem services because there is a demand associated with them by the human population (Fisher et al 2009).

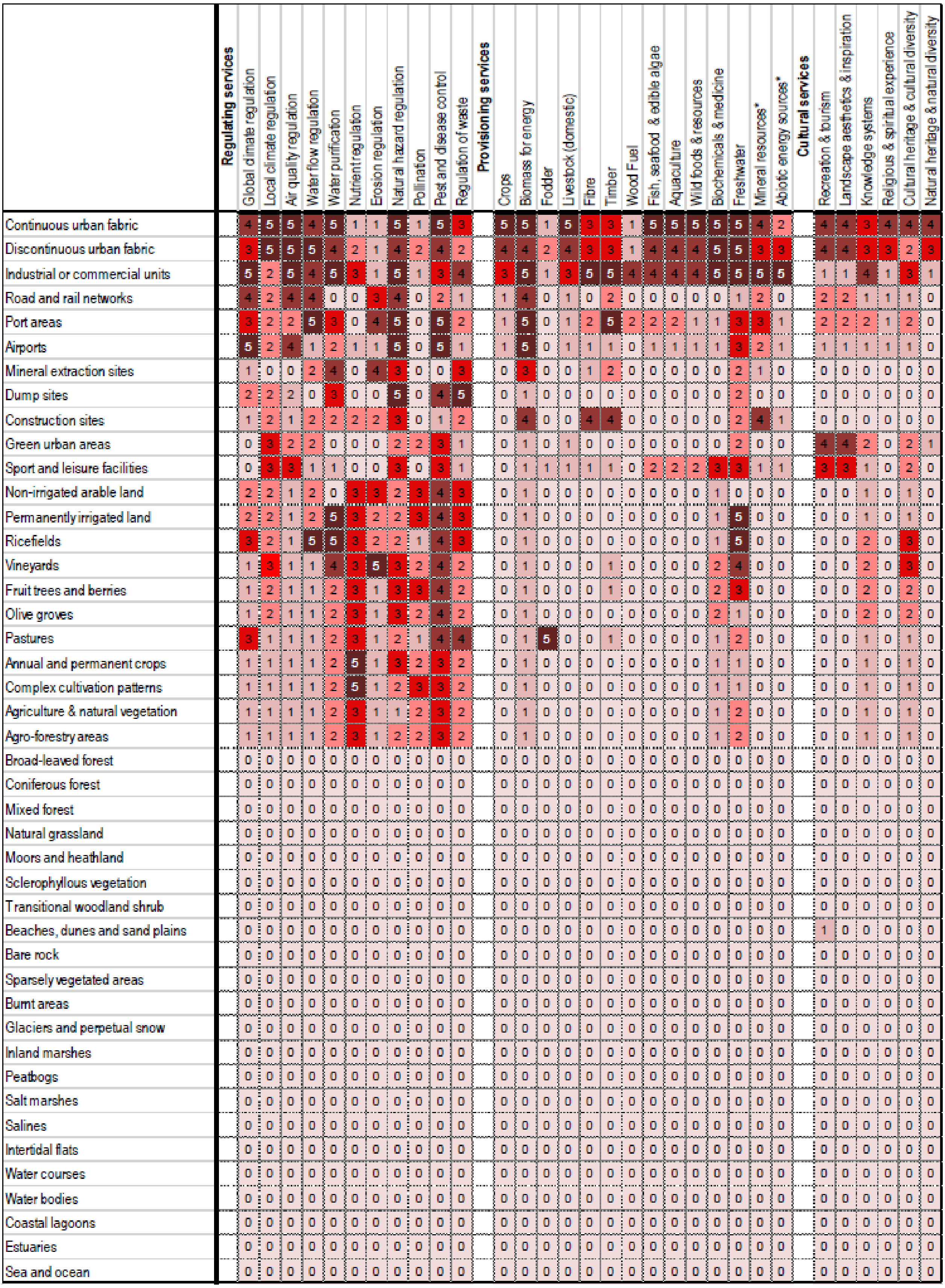
In the work of Burkhard et al. (2014), is presented a matrix, similar in form to that on the potential, but with the values that represent the demand for ES associated with the various CLC classes.

These values have been assigned on the basis of the number of inhabitants, the type of average consumption and the land use activity (Burkhard et al., 2012; Kroll et al., 2012) referable to the particular type of land cover.

In the ES demand matrix can be clearly seen that the most anthropized types of land cover (urban, industrial, commercial areas) have a higher demand for ES. Conversely, more natural land cover types show much less pronounced ES demand. Agricultural surfaces, on the other hand, show a high demand for regulating ecosystem services (eg pollination, nutrient regulation, water purification, etc.). In this case, if the demand for regulation services cannot be satisfied "naturally" by the supply of ecosystem services, additional external (anthropogenic) inputs are required such as fertilizers, irrigation systems, etc. (Burkhard et al, 2014).

The demand values indicate: 0 = no demand; 1 = little relevance demand; 2 = relevant demand 3 = medium relevant demand; 4 = high demand; and 5 = very high demand

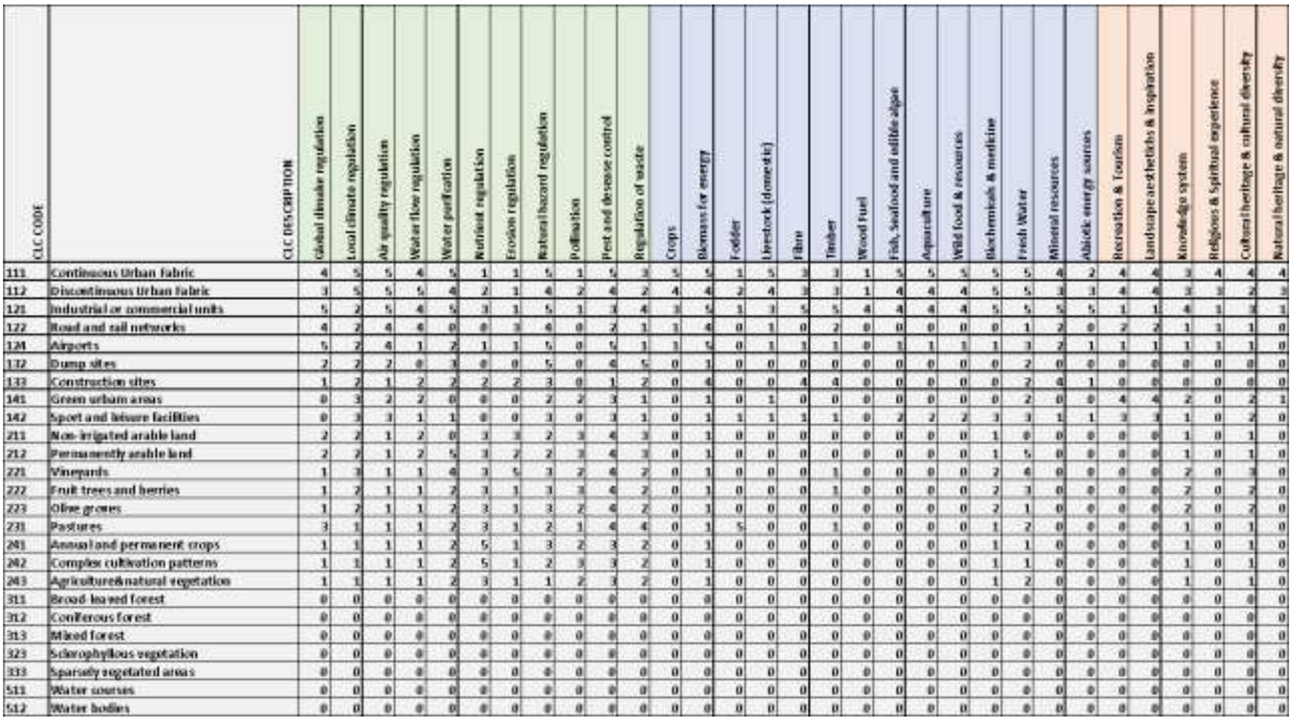
Table 2.4 - *Ecosystem service demand matrix (Burkhard et al 2014). Scale from: 0 = no relevant demand; 1 = low relevant demand; 2 = relevant demand; 3 = medium relevant demand; 4 = high relevant demand; and 5 = very high relevant demand*



	Regulating services	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and disease control	Regulation of waste	**Provisioning services**	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, seafood & edible algae	Aquaculture	Wild foods & resources	Biochemicals & medicine	Freshwater	Mineral resources*	Abiotic energy sources*	**Cultural services**	Recreation & tourism	Landscape aesthetics & inspiration	Knowledge systems	Religious & spiritual experience	Cultural heritage & cultural diversity	Natural heritage & natural diversity
Continuous urban fabric		4	5	5	4	5	1	1	5	1	5	3		5	5	1	5	3	3	1	5	5	5	5	5	4	2		4	4	3	4	4	4
Discontinuous urban fabric		3	5	5	5	4	2	1	4	2	4	2		4	4	2	4	3	3	1	4	4	4	5	5	3	3		4	4	3	3	2	3
Industrial or commercial units		5	2	5	4	5	3	1	5	1	3	4		3	5	1	3	5	5	4	4	4	4	5	5	5	5		1	1	4	1	3	1
Road and rail networks		4	2	4	4	0	0	3	4	0	2	1		1	4	0	1	0	2	0	0	0	0	0	1	2	0		2	2	1	1	1	0
Port areas		3	2	2	5	3	0	4	5	0	5	2		1	5	0	1	2	5	2	2	2	1	1	3	3	1		2	2	2	1	2	0
Airports		5	2	4	1	2	1	1	5	0	5	1		1	5	0	1	1	1	0	1	1	1	1	3	2	1		1	1	1	1	1	0
Mineral extraction sites		1	0	0	2	4	0	4	3	0	0	3		0	3	0	0	1	2	0	0	0	0	0	2	1	0		0	0	0	0	0	0
Dump sites		2	2	2	0	3	0	0	5	0	4	5		0	1	0	0	0	0	0	0	0	0	0	2	0	0		0	0	0	0	0	0
Construction sites		1	2	1	2	2	2	2	3	0	1	2		0	4	0	0	4	4	0	0	0	0	0	2	4	1		0	0	0	0	0	0
Green urban areas		0	3	2	2	0	0	0	2	2	3	1		0	1	0	1	0	0	0	0	0	0	0	2	0	0		4	4	2	0	2	1
Sport and leisure facilities		0	3	3	1	1	0	0	3	0	3	1		0	1	1	1	1	1	0	2	2	2	3	3	1	1		3	3	1	0	2	0
Non-irrigated arable land		2	2	1	2	0	3	3	2	3	4	3		0	1	0	0	0	0	0	0	0	0	1	0	0	0		0	0	1	0	1	0
Permanently irrigated land		2	2	1	2	5	3	2	2	3	4	3		0	1	0	0	0	0	0	0	0	0	1	5	0	0		0	0	1	0	1	0
Ricefields		3	2	1	5	5	3	2	2	1	4	3		0	1	0	0	0	0	0	0	0	0	1	5	0	0		0	0	2	0	3	0
Vineyards		1	3	1	1	4	3	5	3	2	4	2		0	1	0	0	0	1	0	0	0	0	2	4	0	0		0	0	2	0	3	0
Fruit trees and berries		1	2	1	1	2	3	1	3	3	4	2		0	1	0	0	0	1	0	0	0	0	2	3	0	0		0	0	2	0	2	0
Olive groves		1	2	1	1	2	3	1	3	2	4	2		0	1	0	0	0	0	0	0	0	0	2	1	0	0		0	0	2	0	2	0
Pastures		3	1	1	1	2	3	1	2	1	4	4		0	1	5	0	0	1	0	0	0	0	1	2	0	0		0	0	1	0	1	0
Annual and permanent crops		1	1	1	1	2	5	1	3	2	3	2		0	1	0	0	0	0	0	0	0	0	1	1	0	0		0	0	1	0	1	0
Complex cultivation patterns		1	1	1	1	2	5	1	2	3	3	2		0	1	0	0	0	0	0	0	0	0	1	1	0	0		0	0	1	0	1	0
Agriculture & natural vegetation		1	1	1	1	2	3	1	1	2	3	2		0	1	0	0	0	0	0	0	0	0	1	2	0	0		0	0	1	0	1	0
Agro-forestry areas		1	1	1	1	2	3	1	2	2	3	2		0	1	0	0	0	0	0	0	0	0	1	2	0	0		0	0	1	0	1	0
Broad-leaved forest		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Coniferous forest		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Mixed forest		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Natural grassland		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Moors and heathland		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Sclerophyllous vegetation		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Transitional woodland shrub		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Beaches, dunes and sand plains		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		1	0	0	0	0	0
Bare rock		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Sparsely vegetated areas		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Burnt areas		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Glaciers and perpetual snow		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Inland marshes		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Peatbogs		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Salt marshes		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Salines		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Intertidal flats		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Water courses		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Water bodies		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Coastal lagoons		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Estuaries		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0
Sea and ocean		0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0		0	0	0	0	0	0

The procedure for obtaining the ES demand values are exactly the same as those adopted for the evaluation of the potential supply. Only the preset values in the table change and therefore the relative results.

Table 2.5*: adapted ES demand matrix for the study area (own elaboration on Burkhard et al., 2014)*



CLC CODE	CLC DESCRIPTION	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and desease control	Regulation of waste	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, Seafood and edible algae	Aquaculture	Wild food & resources	Biochemicals & medicine	Fresh Water	Mineral resources	Abiotic energy sources	Recreation & Tourism	Landscape aesthetichs & inspiration	Knowledge system	Religious & Spiritual experience	Cultural heritage & cultural diversity	Natural heritage & natural diversity
111	Continuous Urban Fabric	4	5	5	4	5	1	1	5	1	5	3	5	5	1	5	3	3	1	5	5	5	5	5	4	2	4	4	3	4	4	4
112	Discontinuous Urban Fabric	3	5	5	5	4	2	1	4	2	4	2	4	4	2	4	3	3	1	4	4	4	5	5	3	3	4	4	3	3	2	3
121	Industrial or commercial units	5	2	5	4	5	3	1	5	1	3	4	3	5	1	3	5	5	4	4	4	4	5	5	5	5	1	1	4	1	3	1
122	Road and rail networks	4	2	4	4	0	0	3	4	0	2	1	1	4	0	1	0	2	0	0	0	0	0	1	2	0	2	2	1	1	1	0
124	Airports	5	2	4	1	2	1	1	5	0	5	1	1	5	0	1	1	1	0	1	1	1	1	3	2	1	1	1	1	1	1	0
132	Dump sites	2	2	2	0	3	0	0	5	0	4	5	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
133	Construction sites	1	2	1	2	2	2	2	3	0	1	2	0	4	0	0	4	4	0	0	0	0	0	2	4	1	0	0	0	0	0	0
141	Green urbam areas	0	3	2	2	0	0	0	2	2	3	1	0	1	0	1	0	0	0	0	0	0	0	2	0	0	4	4	2	0	2	1
142	Sport and leisure facilities	0	3	3	1	1	0	0	3	0	3	1	0	1	1	1	1	1	0	2	2	2	3	3	1	1	3	3	1	0	2	0
211	Non-irrigated arable land	2	2	1	2	0	3	3	2	3	4	3	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0
212	Permanently arable land	2	2	1	2	5	3	2	2	3	4	3	0	1	0	0	0	0	0	0	0	0	1	5	0	0	0	0	1	0	1	0
221	Vineyards	1	3	1	1	4	3	5	3	2	4	2	0	1	0	0	0	1	0	0	0	0	2	4	0	0	0	0	2	0	3	0
222	Fruit trees and berries	1	2	1	1	2	3	1	3	3	4	2	0	1	0	0	0	1	0	0	0	0	2	3	0	0	0	0	2	0	2	0
223	Olive groves	1	2	1	1	2	3	1	3	2	4	2	0	1	0	0	0	0	0	0	0	0	2	1	0	0	0	0	2	0	2	0
231	Pastures	3	1	1	1	2	3	1	2	1	4	4	0	1	5	0	0	1	0	0	0	0	1	2	0	0	0	0	1	0	1	0
241	Annual and permanent crops	1	1	1	1	2	5	1	3	2	3	2	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0
242	Complex cultivation patterns	1	1	1	1	2	5	1	2	3	3	2	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1	0	1	0
243	Agriculture&natural vegetation	1	1	1	1	2	3	1	1	2	3	2	0	1	0	0	0	0	0	0	0	0	1	2	0	0	0	0	1	0	1	0
311	Broad-leaved forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
312	Coniferous forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
313	Mixed forest	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
323	Sclerophyllous vegetation	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
333	Sparsely vegetated areas	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
511	Water courses	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
512	Water bodies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Es Budget

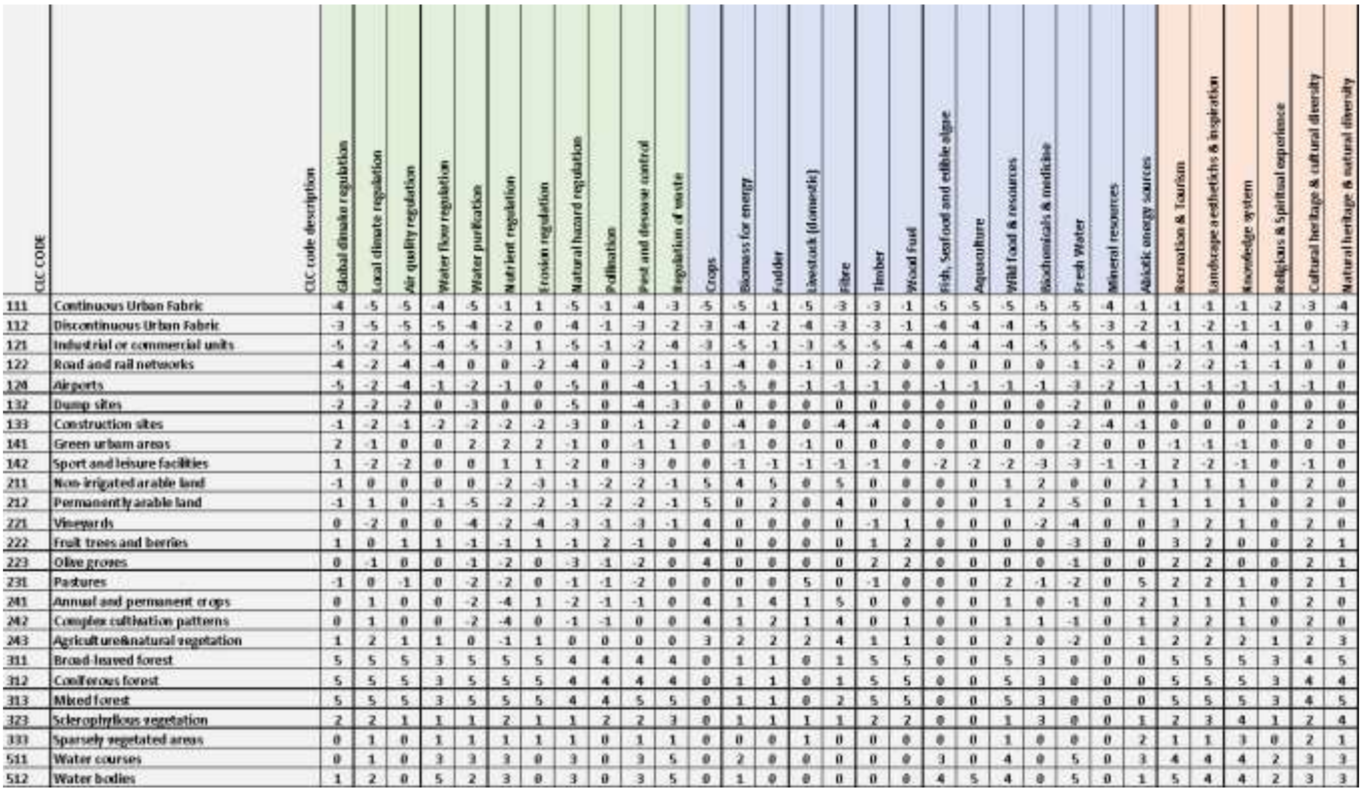
Analyzing the supply and demand of ecosystem services and identifying their budget is the heart of the contemporary debate on sustainability and one of the keys to understanding the link between people and nature (Burkhard & Maes (eds) 2017). Defining a ESs budget of makes it possible to identify territorial imbalances in the socio-ecological system analyzed, highlighting the impact of the socio-economic system on ecosystems (Syrbe et al., 2017). This analysis can help policy makers to manage the territory according to a sustainable use of resources (Kroll et al., 2012) and to define strategies for sustainable development (Marino et al, 2021). The budget of ES can also have a strong communicative power.

In recent years there have been many studies to evaluate this balance: Burkhard et al. (2012, 2014) have developed matrices for the assessment of this budget, Chen et al. (2019) to evaluate the balance sheet of ES in the Shanghai municipality developed a supply-demand ratio (ESDR), Li et al. (2016) appear the supply-demand of some ES in the Taihu River Basin.

To proceed with the evaluation of the ESs budget, the matrices of ES potential and demand were used. In particular, a new matrix has been constructed where each intersection of the X, Y axes corresponds to the potential supply value of the specific ES (for the related land use class), minus the ES demand value.

A table was thus obtained (Table X) which represents, in this case, the budget of the potential of the service and the relative demand, in the territory considered.

Table 2.6*: ES (potential- demand) budget matrix for the study area. Negative values indicate a demand for the service that exceeds the relative ES potential (own elaboration on Burkhard et al., 2014).*



CLC CODE	CLC code description	Global climate regulation	Local climate regulation	Air quality regulation	Water flow regulation	Water purification	Nutrient regulation	Erosion regulation	Natural hazard regulation	Pollination	Pest and desease control	Regulation of waste	Crops	Biomass for energy	Fodder	Livestock (domestic)	Fibre	Timber	Wood Fuel	Fish, Seafood and edible algae	Aquaculture	Wild food & resources	Biochemicals & medicine	Fresh Water	Mineral resources	Abiotic energy sources	Recreation & Tourism	Landscape aesthetics & inspiration	Knowledge system	Religious & Spiritual experience	Cultural heritage & cultural diversity	Natural heritage & natural diversity
111	Continuous Urban Fabric	-4	-5	-5	-4	-5	-1	1	-5	-1	-4	-3	-5	-5	-1	-5	-3	-3	-1	-5	-5	-5	-5	-5	-4	-1	-1	-1	-1	-2	-3	-4
112	Discontinuous Urban Fabric	-3	-5	-5	-5	-4	-2	0	-4	-1	-3	-2	-3	-4	-2	-4	-3	-3	-1	-4	-4	-4	-5	-5	-3	-2	-1	-2	-1	-1	0	-3
121	Industrial or commercial units	-5	-2	-5	-4	-5	-3	1	-5	-1	-2	-4	-3	-5	-1	-3	-5	-5	-4	-4	-4	-4	-5	-5	-5	-4	-1	-1	-4	-1	-1	-1
122	Road and rail networks	-4	-2	-4	-4	0	0	-2	-4	0	-2	-1	-1	-4	0	-1	0	-2	0	0	0	0	0	-1	-2	0	-2	-2	-1	-1	0	0
124	Airports	-5	-2	-4	-1	-2	-1	0	-5	0	-4	-1	-1	-5	0	-1	-1	-1	0	-1	-1	-1	-1	-3	-2	-1	-1	-1	-1	-1	-1	0
132	Dump sites	-2	-2	-2	0	-3	0	0	-5	0	-4	-3	0	0	0	0	0	0	0	0	0	0	0	-2	0	0	0	0	0	0	0	0
133	Construction sites	-1	-2	-1	-2	-2	-2	-2	-3	0	-1	-2	0	-4	0	0	-4	-4	0	0	0	0	0	-2	-4	-1	0	0	0	0	2	0
141	Green urbam areas	2	-1	0	0	2	2	2	-1	0	-1	1	0	-1	0	-1	0	0	0	0	0	0	0	-2	0	0	-1	-1	-1	0	0	0
142	Sport and leisure facilities	1	-2	-2	0	0	1	1	-2	0	-3	0	0	-1	-1	-1	-1	-1	0	-2	-2	-2	-3	-3	-1	-1	2	-2	-1	0	-1	0
211	Non-irrigated arable land	-1	0	0	0	0	-2	-3	-1	-2	-2	-1	5	4	5	0	5	0	0	0	0	1	2	0	0	2	1	1	1	0	2	0
212	Permanently arable land	-1	1	0	-1	-5	-2	-2	-1	-2	-2	-1	5	0	2	0	4	0	0	0	0	1	2	-5	0	1	1	1	1	0	2	0
221	Vineyards	0	-2	0	0	-4	-2	-4	-3	-1	-3	-1	4	0	0	0	0	-1	1	0	0	0	-2	-4	0	0	3	2	1	0	2	0
222	Fruit trees and berries	1	0	1	1	-1	-1	1	-1	2	-1	0	4	0	0	0	0	1	2	0	0	0	0	-3	0	0	3	2	0	0	2	1
223	Olive groves	0	-1	0	0	-1	-2	0	-3	-1	-2	0	4	0	0	0	0	2	2	0	0	0	0	-1	0	0	2	2	0	0	2	1
231	Pastures	-1	0	-1	0	-2	-2	0	-1	-1	-2	0	0	0	0	5	0	-1	0	0	0	2	-1	-2	0	5	2	2	1	0	2	1
241	Annual and permanent crops	0	1	0	0	-2	-4	1	-2	-1	-1	0	4	1	4	1	5	0	0	0	0	1	0	-1	0	2	1	1	1	0	2	0
242	Complex cultivation patterns	0	1	0	0	-2	-4	0	-1	-1	0	0	4	1	2	1	4	0	1	0	0	1	1	-1	0	1	2	2	1	0	2	0
243	Agriculture&natural vegetation	1	2	1	1	0	-1	1	0	0	0	0	3	2	2	2	4	1	1	0	0	2	0	-2	0	1	2	2	2	1	2	3
311	Broad-leaved forest	5	5	5	3	5	5	5	4	4	4	4	0	1	1	0	1	5	5	0	0	5	3	0	0	0	5	5	5	3	4	5
312	Coniferous forest	5	5	5	3	5	5	5	4	4	4	4	0	1	1	0	1	5	5	0	0	5	3	0	0	0	5	5	5	3	4	4
313	Mixed forest	5	5	5	3	5	5	5	4	4	5	5	0	1	1	0	2	5	5	0	0	5	3	0	0	0	5	5	5	3	4	5
323	Sclerophyllous vegetation	2	2	1	1	1	2	1	1	2	2	3	0	1	1	1	1	2	2	0	0	1	3	0	0	1	2	3	4	1	2	4
333	Sparsely vegetated areas	0	1	0	1	1	1	1	1	0	1	1	0	0	0	1	0	0	0	0	0	1	0	0	0	2	1	1	3	0	2	1
511	Water courses	0	1	0	3	3	3	0	3	0	3	5	0	2	0	0	0	0	0	3	0	4	0	5	0	3	4	4	4	2	3	3
512	Water bodies	1	2	0	5	2	3	0	3	0	3	5	0	1	0	0	0	0	0	4	5	4	0	5	0	1	5	4	4	2	3	3

2.3 Organic Farming in the study area

After contextualising the considered territory through by the desk researches and by the initial screening of the ecosystem services's budget with the "*matrix approach*" that has been done through the matrix approach, it has been considered reasonable to hypothesize that one of the integrated sustainable development's drivers for the considered area could have been both the adoption of organic farming practices and the social and economic implications generated by the adoption of these practices. With particular reference to the social and economic aspects, it has been considered possible to reconfigure the territory considered in the form of a *bio- district*.

In order to investigate how the organic farming practices are already settled in the considered territory and how much the adoption of these practices can affect the current supply of ecosystem services, it has been proceeded as follow:

1) identify the area that is already organically cultivated in the territory;

2) Compare the potential supply of ES generated by organically managed agro-ecosystems with that generated by conventionally managed agro-ecosystems;

3) build some future scenarios to investigate the foreseeable ES supply in the next years to come, according to:

a) the current trend of adoption of organic practices (BAU)

b) some alternative scenarios on the adoption of these practices

The Information related to the organic cultivated area on a municipal level can be found in a different way. ISTAT (2010), for example, provides the results of the agricultural census for the year 2010, that usually takes place every ten years (the 7th census is expected in 2021). The Regional Agency for Disbursements in Agriculture (AGREA) brings the data related to the areas cultivated organically from 2014 to 2020, calculated on the basis of the requests for the public funding related to the Common Agricultural Policy (CAP). The rate of these requests for subsidies is around 90% of the total farmers (AGREA, personal communication).

Lastly, the regional Sustainable Agriculture Service (SAS) provides, only upon specific request, the real municipal area (and not only that derived from the CAP requests) cultivated with the organic method from 2015 to 2020. By virtue of the greater completeness, it has been chosen to refer to the data provided by the regional Sustainable Agriculture Service. In particular , it has been referred to the utilized agricultural area (UAA), which differs from the total agricultural area (TAA) due to the exclusion of natural woodland areas , wood arboriculture and various tares (buildings, etc.) (INEA, nd.).

Table 2.7 - *Organic Utilized Agricultural area (UAA_{org}) cultivated in the municipalities of the Valconca Union (own elaborarion on SAS data) from 2015 to 2020 and relative annual increase (own elaborarion on SAS data).*

Year	**UAA_{org} (hectares)**	**variation (%) over the previous year**
2015	**901**	**-**
2016	**1043**	**16%**
2017	**1129**	**3%**
2018	**1225**	**9%**
2019	**1302**	**6%**
2020	**1371**	**5%**

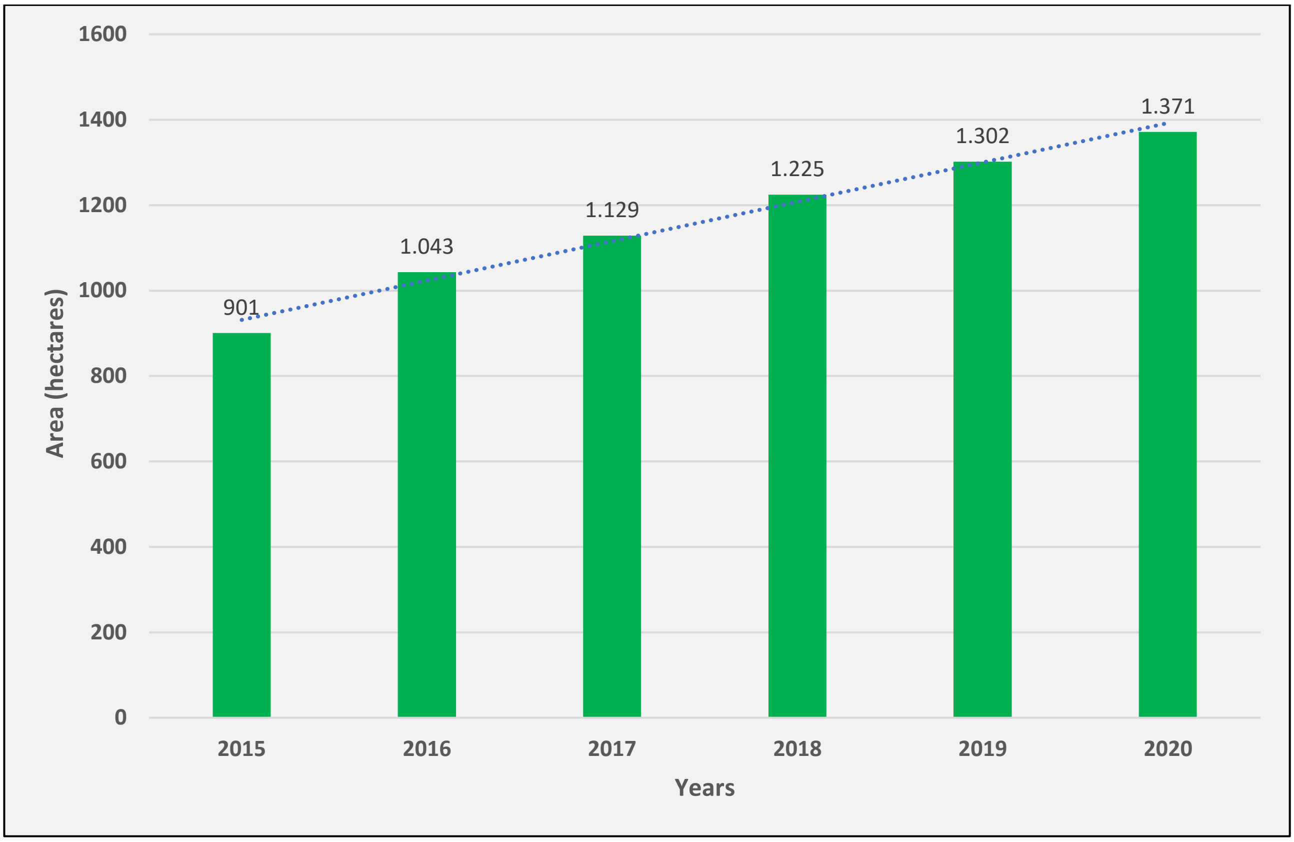


Figure 2.10- *Organic Utilized Agricultural area (UAA$_{org}$) cultivated in the municipalities of the Valconca Union from 2015 to 2020. (own elaborarion on SAS data)*

From the above reported data, it is clearly shown how the UAA$_{org}$ is definitely growing in the last years analyzed. The average annual rate (calculated as the average of the annual increases) with which the UAA grew from 2015 to 2020 is in fact 9%.

The data provided by the SAS also makes it possible to differentiate the UAA from organic, based on the following crop categories:

- arable land (including forage crops in rotation)
- vineyards
- olive groves
- orchards
- other permanent crops
- Permanent meadows and pastures

The organic UAA of these categories (for the years considered) are reported below.

***Table 2.8**: UAA$_{org}$ for the different crop categories from 2015 to 2020 and its average annual rate of change (%)*

	2015	2016	2017	2018	2019	2020	Incr. Average per year (%)
Arable Land	805	909	987	1029	1061	1082	**6%**
Vineyards	34	42	46	51	51	30*	**11%**
Olive Groves	27	28	32	36	47	64	**18%**
Orchard	2	7	8	18	23	21	**78%**
Other permanent crops	0,3	0,3	0,1	0,0	0,2	0,2	**-29%**
Permanent meadows and pastures	32	57	55	89	119	174	**40%**

**This data has not been included in the analysis of the average annual increase, because it is strangely dissonant. It has been controlled the same data supplied from AGREA and it is equal to 44 ha . Therefore, tt has been decided to exclude it both from the calculation of the average increase (which was calculated only with respect to the years from 2015 to 2019) and in the calculation of the total organic UAA, where the 2019 data was used.*

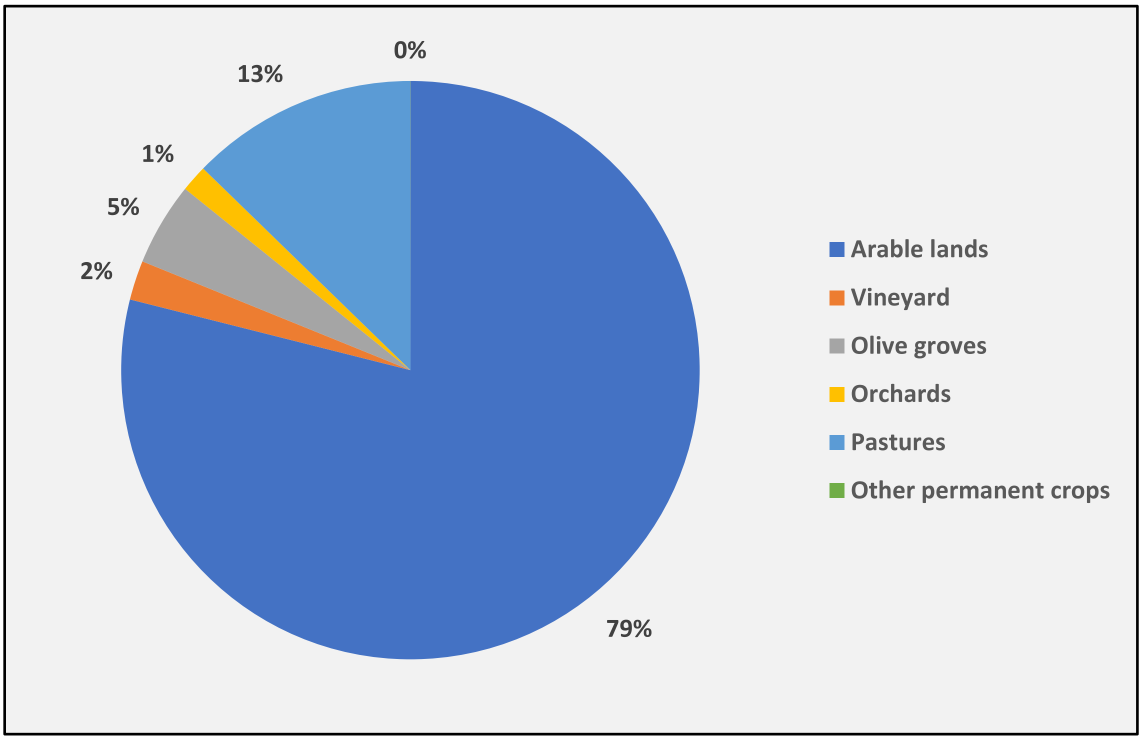


Figure 2.11: *UAA$_{org}$ distribution (%) for the different crop categories, for the year 2020. (own elaboration on SAS data)*

Total utilised agricultural area (TUAA)

The data of the total UAA (organic UAA + conventional UAA) are not available with municipal detail. The only data available with this detail are those referring to the 2010 ISTAT census and those of AGREA, which are based on applications for CAP subsidies (about 90% of the total). Moreover, the data on land use (2017) does not allow to distinguish between UAA and total agricultural area (TAA). The data from the ISTAT census, besides referring to a relatively old year, do not contain the same crop classification used for the organic UAA (olive groves merged with orchards). It was therefore decided to use the AGREA data as a reference for the total UAA, bearing in mind that, in doing so, the organic UAA is slightly overestimated in the total.

Table 2.9: *Total UAA and organic UAA in the study area*

	UAA total (2020)	**UAA organic (2020)**	**UAA_{org}/UAA_{tot} (%)**
Arable lands	6507	1082	17%
Vineyard	335	51*	15%
Olive groves	464	64	14%
Orchards	64	21	32%
Other permanent crops	4	0,2	5%
Pastures	411	174	42%
tot	**7764**	**1392**	**18%**

2.4 Building Future Scenarios

In order to evaluate over time how the adoption of organic farming practices may affect the supply of some ecosystem services, several scenarios have been developed with a time horizon of 2030. In the most optimistic, but plausible, scenarios, the adoption of the conservative practice of "no-tillage" was assumed, i.e. the absence of plowing (see chapter 1.3). To simplify the modeling instead, it was assumed that the total UAA per specific crop class remains the same over time, with UAAtot therefore equal and constant to that reported by AGREA in 2020 (AGREA, 2021). Where the organic area of the crop categories, projected to 2030, exceeds the total UUA, the UAA_{org} at 2030 was assumed to be equal to the UAA_{tot} in 2020.

a) "Business as Usual" scenario - organic UAA is still growing at the same rate of the last 5 years.

For the construction of the business-as-usual scenario it is first derived the average annual rate of change μ of each crop category (calculated as the geometric mean of the moving base index numbers, minus 1) on the basis of SAS data available from 2015 to 2020.

Note that the moving base indices are given by:

$$I_k = \frac{UAA\ year_{k+1}}{UAA\ year_k}$$

and the average annual rate of change :

$$\mu = \sqrt[n-1]{\prod_{i=k}^{n-1} \quad} I_k - 1$$

Where

n = number of known time instants

I_k = moving base indices

In this way it is possible to obtain for each crop category the average annual rate of change calculated for the years 2015 to 2020 (reported as such also in the previous paragraph).

Table 2.10*: UAA$_{org}$ average annual rate of change (%) for the different crops categories.*

Culture category	**Average annual rate of change (%)** **UAA$_{org\ (2015\text{-}2020)}$**
Arable lands	6%
Vineyard	11%
Olive groves	18%
Orchards	57%
Other permanent crops	-29%
Pastures	40%

Once the average annual rate of change is been obtained, the projection of the following years is set as follows:

$$UAA_{org_t} = UAA_{org_{2015}} \times \ (1+\mu)^{t-2015}$$

〖UAA〗_(〖org〗_t)=〖UAA〗_(〖org〗_2015)×〖 (1+μ)〗^(t-2015)

If we want to set the projection to 2030 as an example, this is obtained by setting t=2030, so:

$$UAA_{org_{2030}} = UAA_{org_{2015}} \times \ (1+\mu)^{2030-2015}$$

Namely:

$$UAA_{org_{2030}} = UAA_{org_{2015}} \times \ (1+\mu)^{15}$$

The UUA$_{tot}$ at time t is assumed to be always equal to the UUAtot of 2020, the UUA$_{conv}$ at time t, is obtained by subtracting from the UUA$_{tot2020}$, the UUA$_{org}$ at time t.

$$UAA_{conv_t} = UAA_{tot_{2020}} - UAA_{org_t}$$

In this way it is possible to obtain, for each crop category, the hypothetical UUA$_{org}$ that could be cultivated in 2030 (from which the residual conventional UAA), based on the average increase of the last 5 years and UAA$_{tot}$ constant over time.

***Table 2.11**: Initial and projected to 2030 organic and conventional UAA according to this scenario*

	UAA$_{org}$ 2020 (ha)	**UAA$_{conv}$ 2020 (ha)**	**μ (%)UAA$_{org}$ (2015-2020)**	**UAA$_{org}$ 2030 (ha)**	**UAA$_{conv}$ 2030 (ha)**
Arable lands	1082	5424	6%	1954	4553
Vineyard	51*	263	11%	163	151
Olive groves	64	400	18%	347	117
Orchards	21	44	57%	64	0
Other permanent crops	0,2	4	-29%	0	4
Pastures	174	237	40%	411	0

This scenario can be classified as “*probable futures*” (Amara, 1981 in Poli, 2017), which are the kind of futures that can be studied, based on the available empirical data.

Obviously, these types of futures do not take into account the hypothesis of "*black swans*" (a very rare, unpredictable event that can substantially alter the flow of events). Just as they do not take into account the possibility of an increase in some *capabilities* (knowledge, technology, etc.) that have the possibility to change the current trend.

For the following scenarios, only the data for the Arable Lands is reported, since the following elaborations mainly concerns this category.

b) *"Pessimistic" scenario - organic stops: the area under organic cultivation in 2030 remains the same as in 2020*

In this scenario, it is assumed that the growing trend of organic agricolture stops completely at 2020. Therefore, the area under organic cultivation remains constant (and equal to those of 2020) in ther next years.

This kind of scenario can be justified by the fact that the number of farmers potentially interested in organic farming is saturated at 2020. All the farmers who wanted to convert to organic therefore did so in 2020, while the remaining part of farmers are not interested in converting their crops and therefore continue with conventional practices. An additional factor that could lead to this scenario could be the hypothetical saturation of the demand for organic products on the market: farmers who have not yet converted to organic (and who at the same time have no interest in environmental protection and/or healthiness of products) would have no interest in doing so.

In particular:

$$\mathrm{UAA}_{\mathrm{org2030}} = \mathrm{UAA}_{\mathrm{org2020}}$$

Table 2.12*: Initial and projected to 2030 organic and conventional UAA according to this scenario*

	UAA_{org} 2020 (ha)	UAA_{conv} 2020 (ha)	μ (%) UAA_{org} (2015-2020)	UAA_{org} 2030 (ha)	UAA_{conv} 2030 (ha)
Arable lands	1082	5424	0%	1082	5424

c) A "very pessimistic" scenario - the conventional practice gains again the upper hand: the organic area by 2030 is reduced to zero.

This scenario could come true if new study results report a possible danger to human health or the environment (of which we were unaware) due to organic farming.

Other factors that could lead to this scenario could be the simultaneous saturation of the market for organic products, and cessation of CAP subsidies to organic agriculture.

$$\mathrm{UAA}_{\mathrm{org2030}} = 0$$

Table 2.13: *Initial and projected to 2030 organic and conventional UAA according to this scenario*

	UAA_{org} 2020 (ha)	UAA_{conv} 2020 (ha)	μ (%)UAA_{org} (2015-2020)	UAA_{org} 2030 (ha)	UAA_{conv} 2030 (ha)
Arable lands	1082	5424	negative	0	6507

d) "Optimistic" scenario or even “plausible” (Amara 1981, in Poli 2017).

Organic growth continues at the same rate of the past 5 years till 2030. Moreover, by 2030, 30% of organic farmers have adopted the conservative practice of "no-tillage".

The "no-tillage" is a practice of conservative agriculture already adopted by some farmers around the world and in Italy, it is plausible to consider that in 2030 a 30% of farmers in the study area may adopt this practice.
In Amara's classification, this practice can be considered as "*latent*".

In particular:

$$UAA_{org_{2030}} = \left[UAA_{org_{2015}} \times \ (1+\mu)^{15}\right] x\ 0{,}7$$

And

$$UAA_{orgNT_{2030}} = \left[UAA_{org_{2015}} \times \ (1+\mu)^{15}\right] x\ 0{,}3$$

With

$$UAA_{conv_t} = \ UAA_{tot_{2020}} \ - \ UAA_{org_{2030}} - UAA \quad _{orgNT2030}$$

Where:

UAA$_{orgNT2030}$ =Utilised agricultural area under organic farming and no-tillage practice

***Table 2.14**: Initial and projected to 2030 organic and conventional UAA according to this scenario*

	UAA$_{org}$ 2020 (ha)	**UAA$_{org}$ with No-**	**UAA$_{conv}$ 2020 (ha)**	**μ(%)UAA$_{org}$ (2015-2020)**	**UAA$_{org}$ 2030 (ha)**	**UAAorg 2020**	**UAA$_{conv}$ 2030 (ha)**

		till 2020 (ha)				with No-till (ha)	
Arable lands	1082	0	5424	6%	1368	586	4553

…

e) Very optimistic scenario - Organic farming accelerates, the area cultivated in organic way increases at twice the average rate of the last 5 years, and by 2030 the 50% will be using the conservative practice of "no-tillage"

The drivers (also working in synergy) of this scenario could be:

- an even greater confidence of farmers in organic production;

- a constantly growing demand for organic products, both local and national (if not international), which is never satisfied by the supply;

- European/national/regional policies supporting organic production, with a consequent flow of incentives;

- personal motivations related to environmental protection and/or product whole someness.

In particular:

$$UAA_{org_{2030}} = \left[UAA_{org_{2015}} \times \ (1 + 2\mu)^{15}\right] x \ 0{,}5$$

And

$$UAA_{orgNT_{2030}} = \left[UAA_{org_{2015}} \times \ (1 + 2\mu)^{15}\right] x \ 0{,}5$$

Where:

$UAA_{orgNT2030}$ =Utilised agricultural area under organic farming and no-tillage practice

***Table 2.15**: Initial and projected to 2030 organic and conventional UAA according to this scenario*

	UAA_{org} 2020 (ha)	**UAA_{org} with No-till 2020 (ha)**	**UAA_{conv} 2020 (ha)**	**μ (%)UAA_{org} (2015-2020)**	**UAA_{org} 2030 (ha)**	**UAAorg 2020 with No-till (ha)**	**UAA_{conv} 2030 (ha)**
Arable lands	1082	0	5424	12%	2258	2258	1991

These elaborations gives different scenarios to 2030, based on the recent (2015- 2020) average annual rate of change in organic utilised agricultural area and modified for some possible variations.

Limitations of scenario creation

The methodological limitations in scenario creation are firstly due to the use of a time series of only 6 years (2015-2020). This is due to the absence of homogeneous data on the extent of organic farming prior to 2015. With the sole exception of ISTAT 2010, which, however, considers different crop categories than those analysed.

Furthermore, the creation of the business-as-usual scenario, based on the calculation and projection to 2030 of the average annual growth rate (calculated as the geometric mean of the moving base index numbers of the available historical series), implies the assumption that the average annual growth rate will remain constant for the following years. However, this statistical method is frequently used in cases similar to the one reported in this paper and remains one of the most appropriate methods for analyses of this type (Leti, 1983; Ross Sheldon, 2014).

The creation of alternative scenarios to business as usual allows, in part, to overcome this limitation, presenting possible futures where the rate of increase undergoes variations (doubles, becomes negative, etc.). Even the creation of these scenarios, however, is not free of uncertainties and limitations: they represent a simplification of the possible futures that could be realised in the study area. The wide margin of variation of the average annual rate of increase used in the construction of the alternative scenarios, however, makes it possible to better circumscribe the perimeter within which a large number of "intermediate futures" could be realised.

2.5 Estimating changes in soil organic carbon according to the type of agricultural management

METHOD

The impact on the carbon balance of agricultural soils as a consequence of farming management practices was simulated using a calculation tool created by FAO: *the ex-ante carbon balance too*l (EX-ACT) (http://www.fao.org/in-action/epic/ex-act-tool/suite-of-tools/ex-act/en/) . The latest available version of EX-ACT (v.9), updated to 2020, is based primarily on volume 4 of the IPCC 2019, Refinement to the "2006 Guidelines for National Greenhouse Gas Inventories" (IPCC 2006) and it was complemented by other existing reviews of default coefficients when available.
The choice to use this method was motivated by:

- the presence of clear and well-structured guidelines;
- the authoritativeness of the authors and the use of recently updated parameters based on IPCC's standards (2019);
- the possibility to compare different scenarios;
- the familiar and intuitive interface.

EX ACT allows to estimate in advance the impact attributable to potential changes in land use, agricultural and forest management practices on the emission and removals of greenhouse gases (GHG, in tCO2_eq) in the selected area. It is possible to obtain the specific result per type of GHG: methane (CH4), nitrogen dioxide (NO2) and carbon dioxide (CO2). Furthermore, the tool allows to compare the Business as Usual (BAU) scenario with new scenarios based on land use change or alternative agricultural/forestry practices.

EX-ACT consists of a set of linked Microsoft Excel sheets into which it is possible to insert data on land-use and management practices foreseen under different scenarios. EX-ACT adopts a modular approach, i.e. each module describing a specific land-use, and follows a three-step logical framework:

a. A description of the context (geographic area, climate and soil characteristics, time horizon of the scenarios);

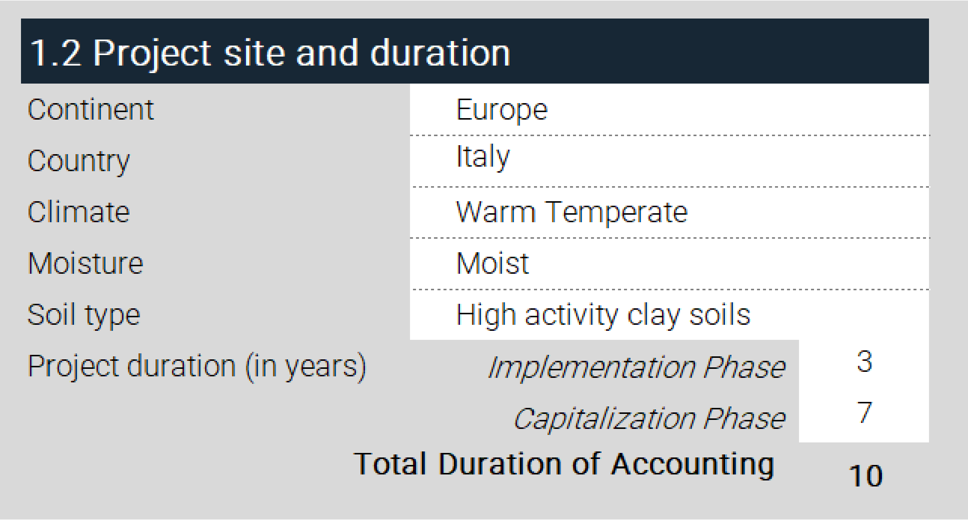
b. The identification of changes in land-use and technologies foreseen by scenarios, using specific modules, e.g. deforestation, forest degradation, afforestation/reforestation, annual/perennial crops, etc).

c. The computation of GHG balance with and without the project using IPCC default values (with the possibility of using their own parameters by using the "Tier 2" module).

METHODOLOGY

a. Input of information associated with the geographical context considered

As a first step, the geographical information for the case study was entered (fig. 2.12). In particular, for the climate and moisture information has been referred to the IPCC climate zones map (IPCC 2006, p. 338) while the prevailing soil type was identified through GIS analysis of the Emilia Romagna soil map. Finally, a time horizon of 10 years was chosen, with the first three years assumed for the conversion of agricultural practices.

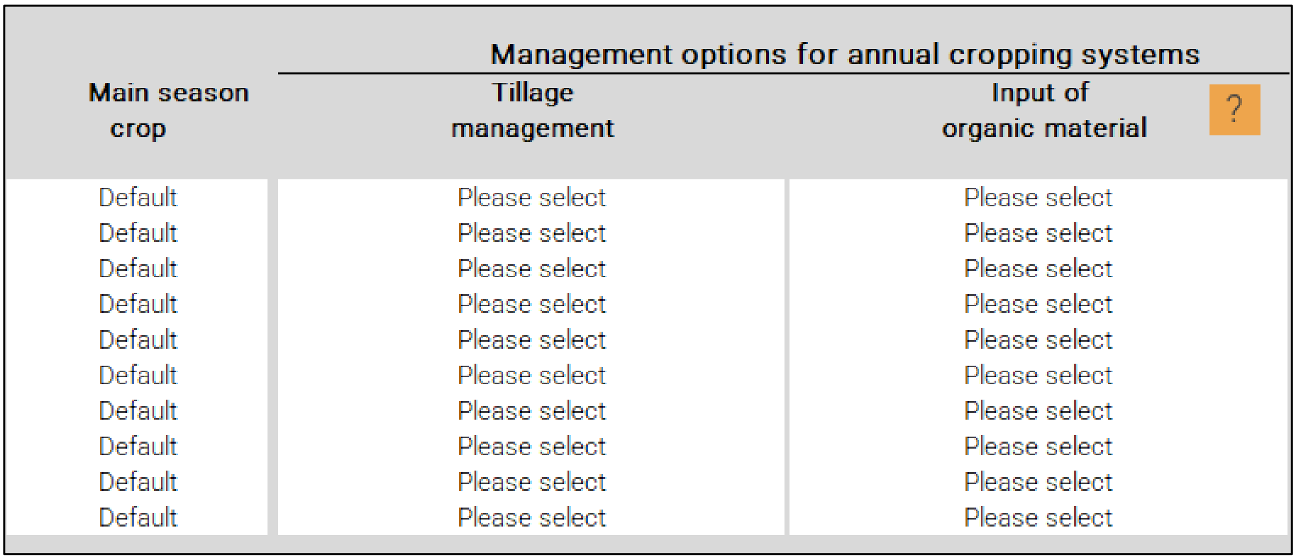


1.2 Project site and duration		
Continent	Europe	
Country	Italy	
Climate	Warm Temperate	
Moisture	Moist	
Soil type	High activity clay soils	
Project duration (in years)	*Implementation Phase*	3
	Capitalization Phase	7
	Total Duration of Accounting	10

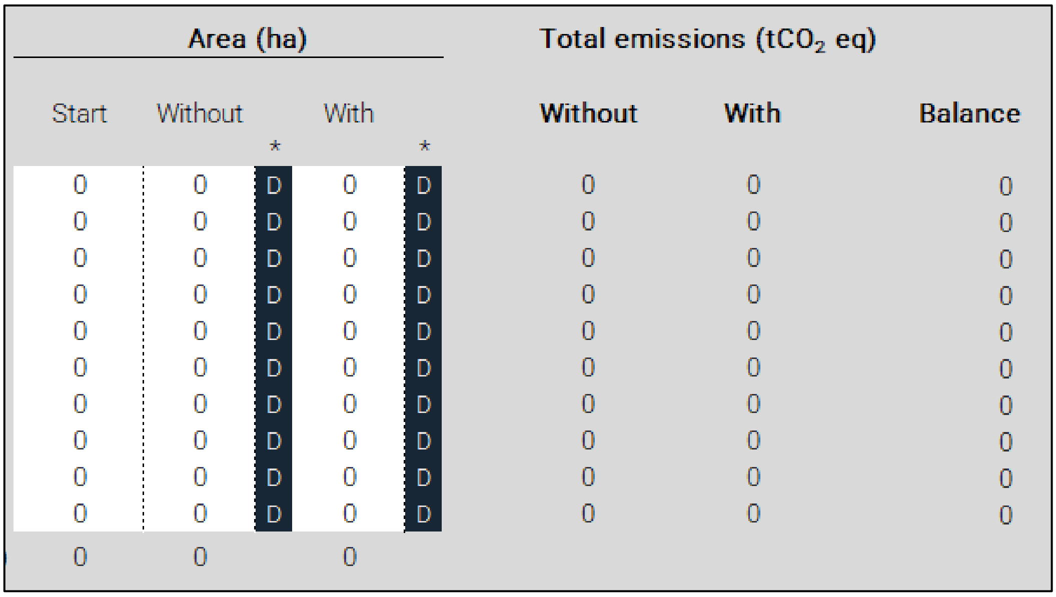
***Figure 2.12**: Screenshot of Initial settings related to the case study insert in the EX -ACT tool*

b) Entering information on the type of farming and the area involved

The next step was to complete the “cropland module” of EX-ACT with the necessary information about: the crops in question, the type of farming practices used and the area concerned, for previously created scenarios.



Main season crop	Management options for annual cropping systems	
	Tillage management	Input of organic material ?
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select
Default	Please select	Please select



Area (ha)					Total emissions (tCO_2 eq)		
Start	Without	*	With	*	Without	With	Balance
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0	D	0	D	0	0	0
0	0		0				

Figure 2.13: *Screenshot of Cropland sub-module used in this analysis.*

In particular, in the sub modules used, EX-ACT allows to define:

- The type of annual crop: cereals, legumes, potatoes, etc.
- The tillage management : choosing between full tillage, reduced tillage and no tillage.
- The type of organic input, i.e. low carbon input;

  medium carbon input;

  high carbon input, without manure;

  high carbon input with manure.

Where different agricultural practices are defined according to IPCC 2019 as (see table below):

Table 2.14: *Definitions used in EX-ACT and associated farming practices*

FULL TILLAGE	Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g., <30 percent) of the surface is covered by residues.
REDUCED TILLAGE	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30 percent coverage by residues at planting
NO-TILLAGE	Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control.*
LOW C INPUT	Low residue return occurs when there is removal of residues (via collection or burning), frequent bare-fallowing, production of crops yielding low residues (e.g., vegetables, tobacco, cotton), no mineral fertilization or N-fixing crops.
MEDIUM C INPUT	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires mineral fertilization or N-fixing crop in rotation.
HIGH C INPUT WITHOUT MANURE	Represents significantly greater crop residue inputs over medium carbon input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied.
HIGH C INPUT WITH MANURE	Represents significantly higher carbon input over medium carbon input cropping systems due to an additional practice of regular addition of animal manure.

* Herbicides are not allowed in organic practices

Initial data, referred to 2020, for the conventional and organic UUA of annual crops in the study area are taken from AGREA (2021) and SAS (2021) respectively (see section 2.3 of this chapter).

Based on the previous literature review, it was decided to attribute to conventional practices the *full tillage* and *medium C input* practices. Whereas *reduced tillage* and *high C input with manure* were associated with organic farming practices. Furthermore, in the most optimistic scenarios, it was assumed that part of the organic farmers (soil health conscious) would adopt the conservative practice of *no-tillage*.

With regard to the Area (ha), the UUA under conventional and organic cultivation (with or without the corresponding no-tillage fraction) at 2030, derived from scenario creation were used.

Table 2.14: *Assumed agricultural practices associated with type of farming.*

Type of farming	**Assumed agricoltural practices**
Conventional	Full tillage Medium C input
Organic	Reduced tillage High C input with manure
Organic with no tillage	No tillage High C input with manure

Table 2.15: *Summary description of the scenarios assumed in 2030 and used in the analysis with the EX-ACT tool.*

SCENARIOS NAME	SCENARIOS DESCRIPTION
BAU (Business As Usual)	*The UAA under organic farming, assumed in 2030, is calculated as the projected average annual rate of change (μ) of the organic UUA for the years 2015-2020.*
Pessimistic	*Organic stops: organic UAA in 2030 equals organic UUA in 2020*
Very pessimistic	*Organic is going backwards: Organic UAA in 2030 is equal to 0.*
Optimistic	*Organic area increases according to the BAU and by 2030 30% of organic farmers will adopt no-tillage practices.*
Very optimistic	*Organic accelerates: organic area increases at twice the average annual rate of change (μ) (2015-2020) and by 2030 50% of organic farmers adopt no-tillage practices.*

Note: conventional $UAA_{2030} = UAA_{tot\ 2020} - UAA_{organic\ 2030}$

Calculation of GHG emissions and removals

Annual crops are planted and harvested within one year and therefore there will be no net gain or loss of biomass in annual cropping systems. In general cropland, with the exception of perennial systems, have little or no dead wood or litter. Therefore EX-ACT does not take into account carbon stock changes of dead wood and litter for annual system, and assumes there are zero t-CO2eq emissions and removals from biomass (IPCC, 2019).

The methodology used for calculating the annual rates of SOC stock changes in (mineral) soils is based on the difference of SOC stocks in the sceanarios analyzed. Change in organic carbon stocks in soils is calculated as (equation based on Chapter 2, Volume 4, IPCC 2019, p 2.35):

$$SOC = \Sigma\ (SOC_{ref} * F_{Lu} * F_{MG} * F_{I} * A)$$

Where:

SOC = Total mineral SOC at a defined time, in tC;

SOC_{ref} = SOC in the reference condition, in tC/ha;

F_{Lu} = Stock change factor for mineral SOC land-use system or sub-systems, dimensionless;,

F_{MG} = Stock change factor for mineral SOC for management regime, dimensionless;

F_{I} = Stock change factor for mineral SOC for the inputs of organic amendments; dimensionless and

A = Land area under the different management, in ha.

Default SOC in the reference condition is 64 tC/ha. Having the map of organic carbon content (in the 0-30 cm layer) of the Emilia Romagna region (2020), this value was modified (with the *tier 2* function) by inserting the average value obtained for the land use class relative to arable land (equal to 61 tC/ha).

Default soil stock change factors for land-use, management and inputs (FLu, FMG, FI) represent the influence of management to a depth of 30 cm. Default values are taken from the updated Table 5.5, in IPCC 2019, (see Table 2.16).

***Table 2.16** - relative stock change factos for management practices on cropland*

	FLu	FMG Full tillage	FMG Reduced tillage	FMG No tillage	FI Low carbon input	FI Medium carbon input	FI High carbon input, no manure	FI High carbon input, no manure
Boreal dry	0.77	1.00	0.98	1.03	0.92	1.00	1.11	1.44
Boreal moist	0.70	1.00	1.04	1.09	0.95	1.00	1.04	1.37
Cool temperate dry	0.77	1.00	0.98	1.03	0.95	1.00	1.04	1.37
Cool temperate moist	0.70	1.00	1.04	1.09	0.92	1.00	1.11	1.44
Warm temperate dry	0.76	1.00	0.99	1.04	0.95	1.00	1.04	1.37
Warm temperate moist	0.69	1.00	1.05	1.10	0.92	1.00	1.11	1.44
Tropical dry	0.92	1.00	0.99	1.04	0.95	1.00	1.04	1.37
Tropical moist	0.83	1.00	1.04	1.10	0.92	1.00	1.11	1.44
Tropical wet	0.83	1.00	1.04	1.10	0.92	1.00	1.11	1.44
Tropical montane	**0.64**	1.00	**1.09**	**1.16**	0.94	1.00	1.08	1.41

Note: values in bold are from IPCC 2006. The green box highlights the corresponding values for the study area (EX-ACT team elaboration based on Table 5.5. IPCC, 2006 and IPCC, 2019.)

Together with changes of SOC storage, land-use management is also accompanied by mineralization of nitrogen (N), which is an additional source of N available for N2O emissions. Where soil carbon losses occur, the release of N by mineralization is estimated according with (Equation based on Chapter 11, Volume 4, IPCC 2019, p 11.) :

$$F_{SOM} = \Sigma \left(\left(\Delta C_{mineral} \times 1/R \right) \times 1000 \right)$$

Where:

F_{SOM} = the net annual amount of N mineralized in mineral soils as a result of loss of soil carbon through change in land-use or management, in kg N;

$\Delta C_{mineral}$ = average annual loss of soil carbon for each land-use type, in tonnes C;

R = C:N ratio of the soil organic matter.
(For R, a default value of 10 for cropland remaining cropland is applied. Default values are provided in Chapter 11 in IPCC 2019.)

The results obtained are included in the results chapter of this thesis.

LIMITATIONS OF THE METHODOLOGY USED

The major limitations of using the method in this work are presented below:

- The EX-ACT methodology assumes that the change in SOC stock due to different agricultural practices towards a new equilibrium occurs in a linear manner. Changes in the soil carbon stock are better described by non-linear functions, such as the S-shaped curve or logistic function. Despite this, the total amount of GHG release associated with an S-curve is similar to a linear curve (cit. ex act user manual), so using a linear dynamic, while simplifying the process, allows for a good approximation, especially in the long term.
- The use of specific data for the carbon content of the soils in the territory considered has made it possible to reduce the error from 50 to 30%. The error is still quite high, but considering the purpose of this work, which did not aim at an extremely precise calculation of the emitted/absorbed emissions, but rather at an initial exploration of the orders of magnitude involved in changing agricultural practices, it can be considered acceptable. A further refinement of the calculations, through the increased use of tier, is necessary in case one wishes to estimate emissions/absorption even more precisely in order to, for example, establish a voluntary carbon market.
- In this work, with reference to the different scenarios related to the adoption of organic farming practices, the change in C sequestration by soils was calculated.
- On the other hand, the reduction in climate-altering gas emissions due to the reduced use of pesticides and synthetic fertilisers that these practices entail has not been taken into account. The production of these additives is in fact responsible for considerable GHG emissions.
- Moreover, the analysis only refers to annual crops, which represent the largest part of the crops in the territory, but not all of them.

Both of these last two considerations may be further lines of investigation in a possible follow-up of the study project.

3. RESULTS

3.1 Qualitative assessment of ecosystem services potential, demand and budget

The results of the qualitative assessment of ecosystem services, plus some examples of spatialized values through GIS methodologies, are reported below.

3.1.1 Ecosystem services potential

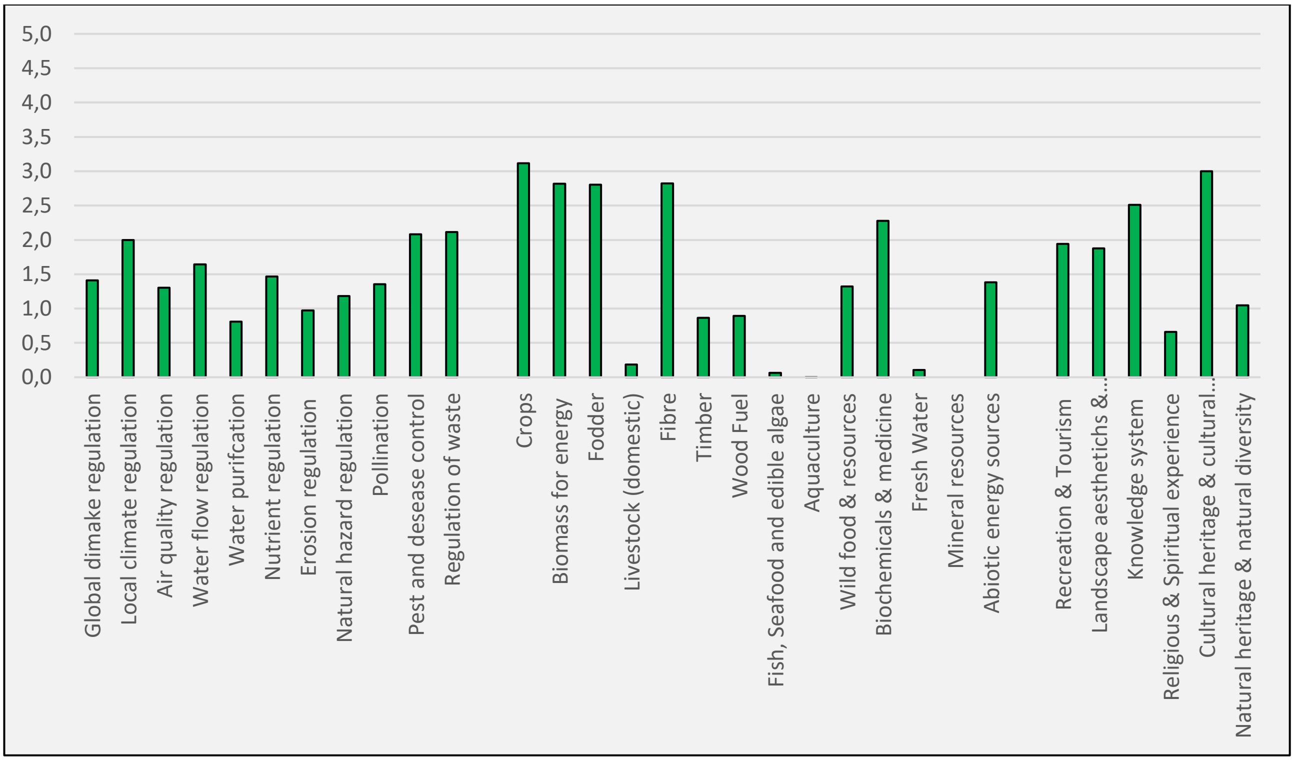


Figure 3.1*: Histogram of the ES potential in the study area*

Table 3.1*: ES potential numerical value (decreasing order)*

REGULATING SERVICES	Value	**PROVISIONING SERVICES**	Value	**CULTURAL SERVICES**	Value

Regulation of waste	2,12	Crops	3,12	Cultural heritage & cultural diversity	3,00
Pest and desease control	2,08	Fibre	2,82	Knowledge system	2,51
Local climate regulation	2,00	Biomass for energy	2,82	Recreation & Tourism	1,94
Water flow regulation	1,64	Fodder	2,80	Landscape aesthetichs & inspiration	1,88
Nutrient regulation	1,47	Biochemicals & medicine	2,28	Natural heritage & natural diversity	1,05
Global dimake regulation	1,41	Abiotic energy sources	1,38	Religious & Spiritual experience	0,66
Pollination	1,36	Wild food & resources	1,32		
Air quality regulation	1,30	Wood Fuel	0,89		
Natural hazard regulation	1,18	Timber	0,86		
Erosion regulation	0,97	Livestock (domestic)	0,18		
Water purifcation	0,81	Fresh Water	0,11		
		Fish, Seafood and edible algae	0,07		
		Aquaculture	0,01		
		Mineral resources	0,00		

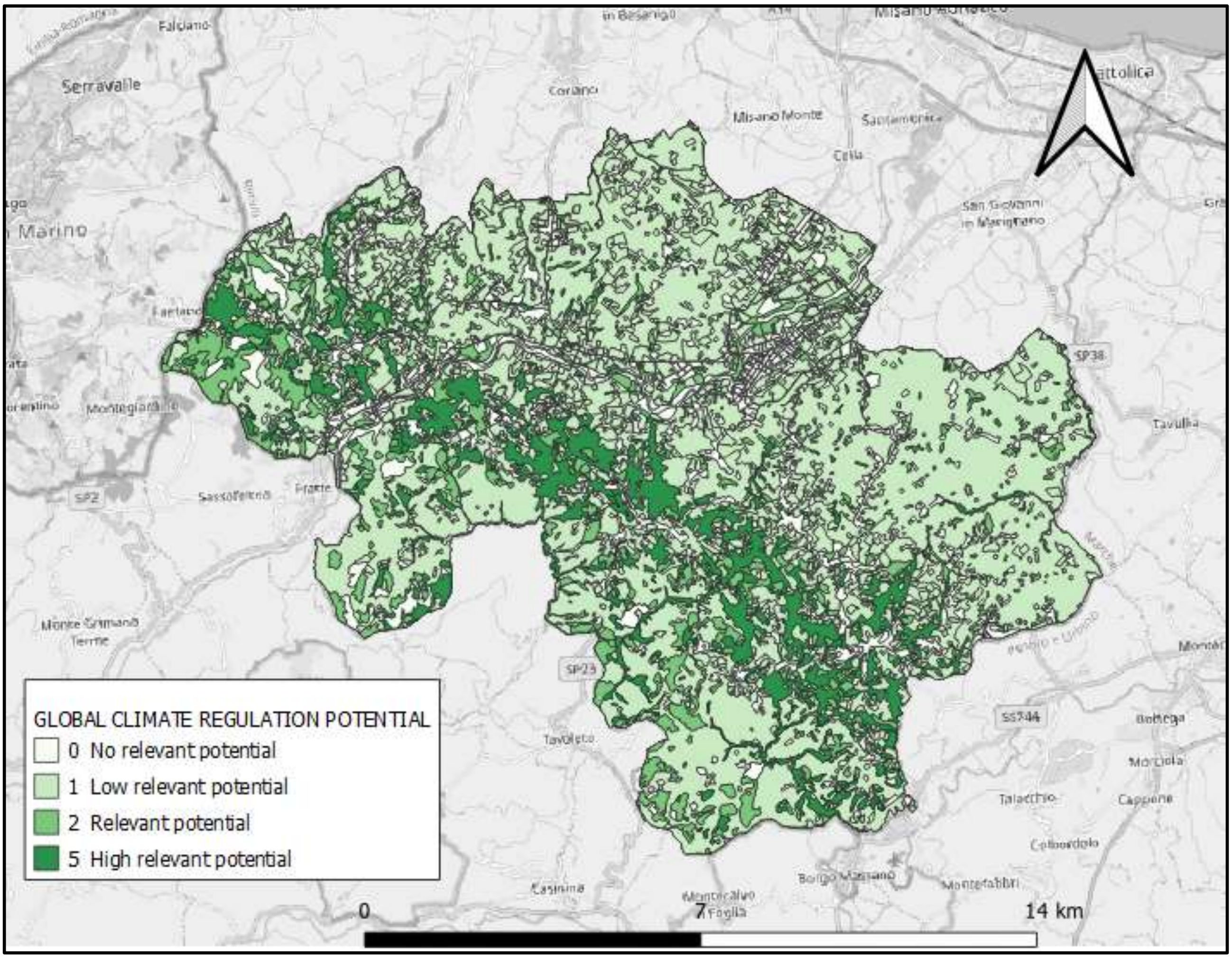


Figure 3.2: *Map of global climate regulation potential in the study area*

3.1.2 Ecosystem services demand

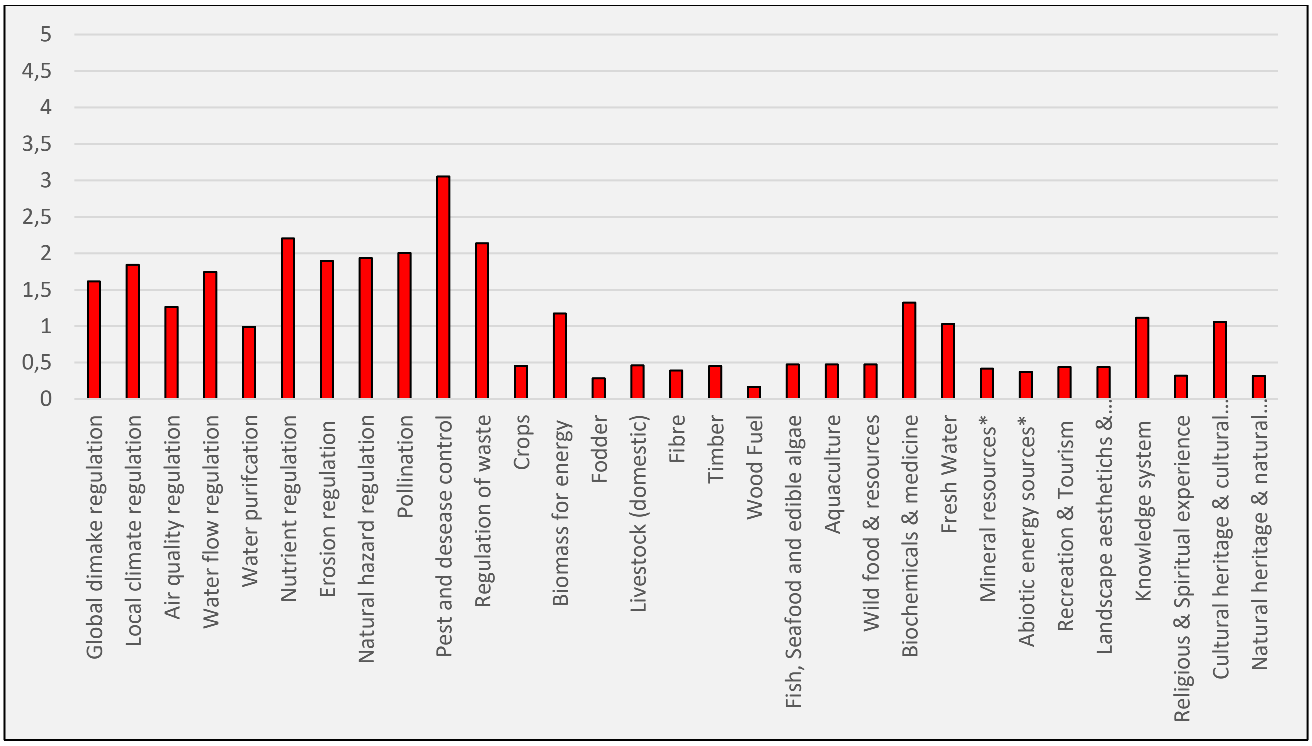


Figure 3.3: *Histogram of the ES demand values in the study area*

Tabella 3.2: *ES demand numerical value (in descending order: higher values correspond to higher demand for ES)*

REGULATING SERVICES		PROVISIONING SERVICES		CULTURAL SERVICES	
Pest and desease control	3,05	Biochemicals & medicine	1,32	Knowledge system	1,12
Nutrient regulation	2,20	Biomass for energy	1,17	Cultural heritage & cultural diversity	1,06
Regulation of waste	2,14	Fresh Water	1,03	Recreation & Tourism	0,44
Pollination	2,00	Fish, Seafood and edible algae	0,48	Landscape aesthetichs & inspiration	0,44
Natural hazard regulation	1,94	Aquaculture	0,48	Religious & Spiritual experience	0,32
Erosion regulation	1,89	Wild food & resources	0,48	Natural heritage & natural diversity	0,32
Local climate regulation	1,84	Livestock (domestic)	0,46		
Water flow regulation	1,75	Timber	0,45		
Global dimake regulation	1,61	Crops	0,45		
Air quality regulation	1,27	Mineral resources	0,42		
Water purifcation	0,99	Fibre	0,39		
		Abiotic energy sources	0,37		
		Fodder	0,28		
		Wood Fuel	0,17		

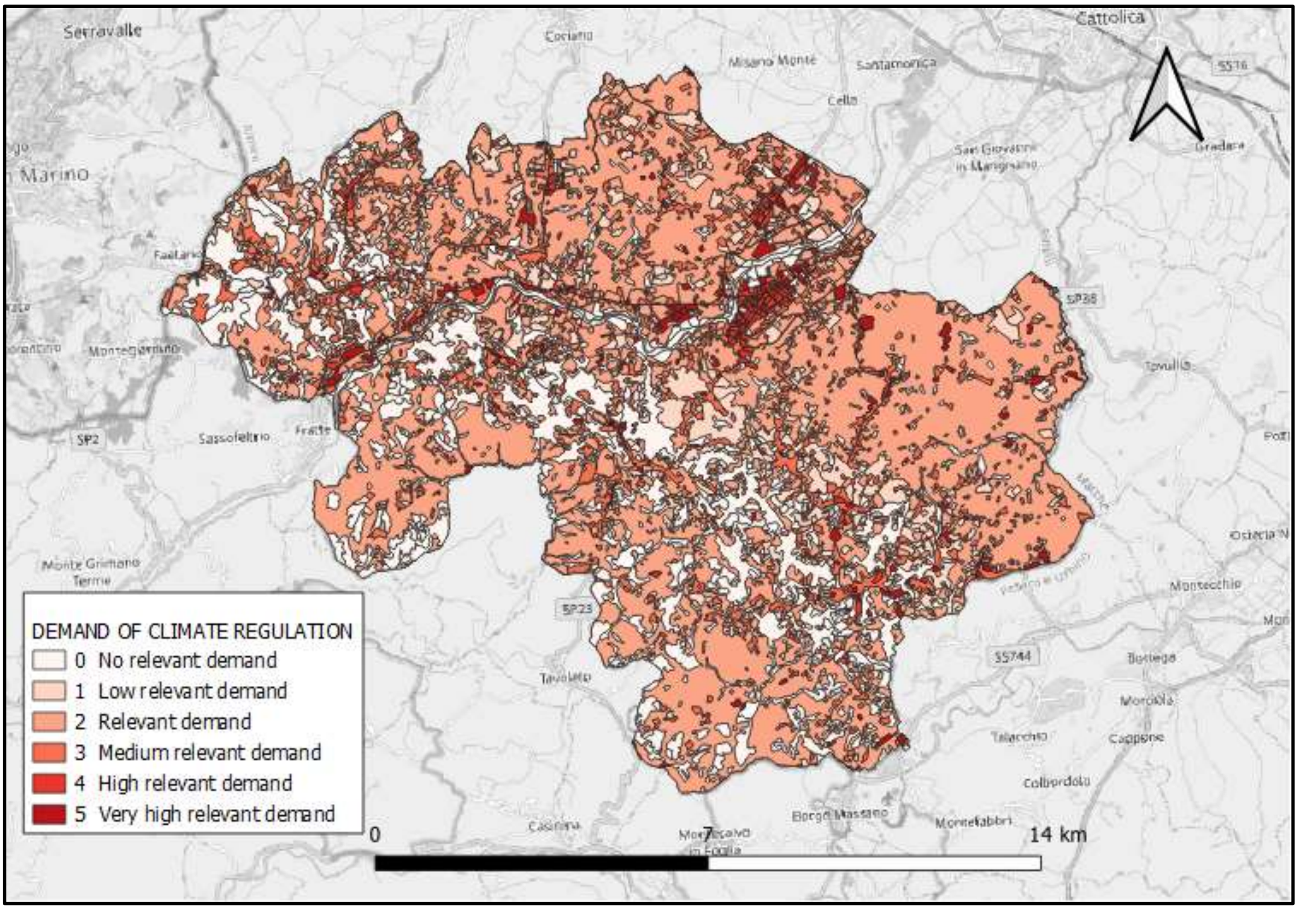


Figure 3.4 – *Map of global climate regulation demand in the study area*

3.1.3 Ecosystem services (potential-demand) budget

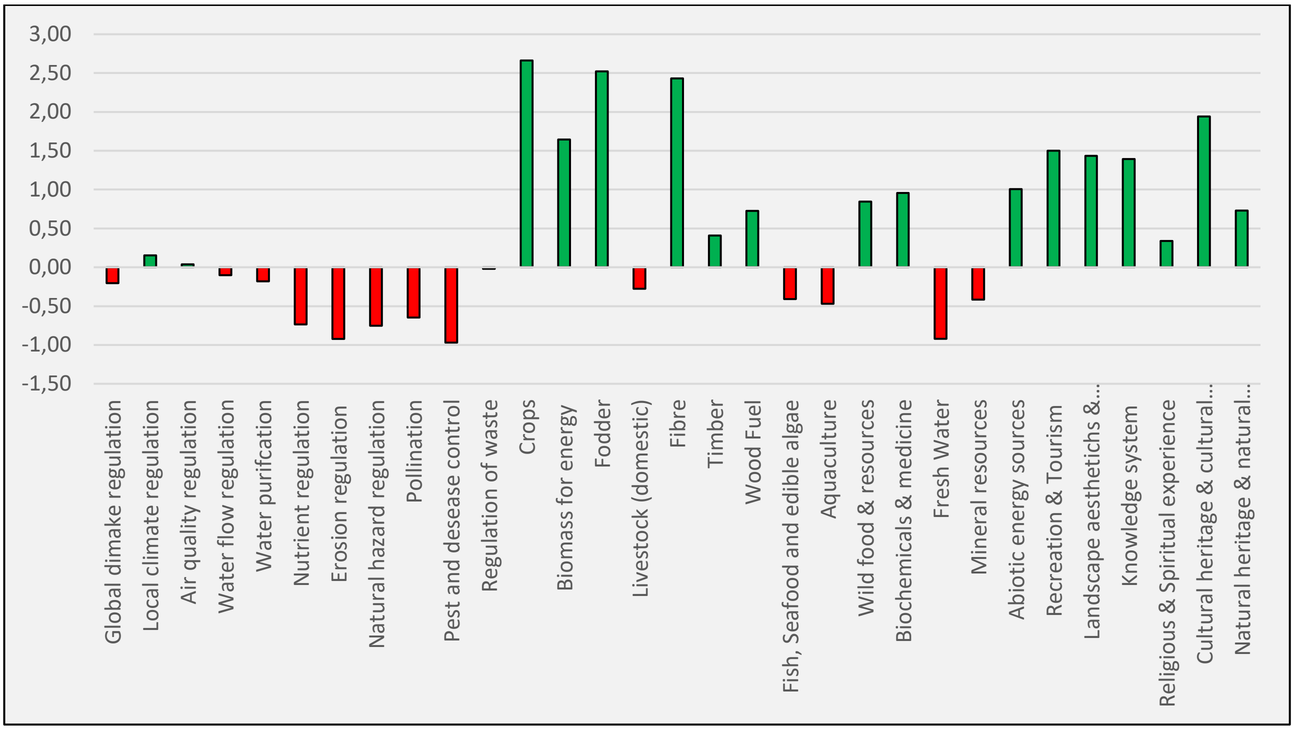


Figure 3.5*- Histogram of ES (potential-demand) budget in the study area*

Table 3.3*- ES (potential-demand) budget numerical value in the study area*

REGULATING SERVICES		**PROVISIONING SERVICES**		**CULTURAL SERVICES**	
Pest and desease control	-0,97	Fresh Water	-0,92	Religious & Spiritual experience	0,34
Erosion regulation	-0,92	Aquaculture	-0,47	Natural heritage & natural diversity	0,73
Natural hazard regulation	-0,75	Mineral resources	-0,42	Knowledge system	1,40
Nutrient regulation	-0,74	Fish, Seafood and edible algae	-0,41	Landscape aesthetichs & inspiration	1,44
Pollination	-0,65	Livestock (domestic)	-0,28	Recreation & Tourism	1,50
Global dimake regulation	-0,20	Timber	0,41	Cultural heritage & cultural diversity	1,94
Water purifcation	-0,18	Wood Fuel	0,73		
Water flow regulation	-0,10	Wild food & resources	0,84		

Regulation of waste	-0,02	Biochemicals & medicine	0,96	
Air quality regulation	0,04	Abiotic energy sources	1,01	
Local climate regulation	0,16	Biomass for energy	1,64	
		Fibre	2,43	
		Fodder	2,52	
		Crops	2,66	

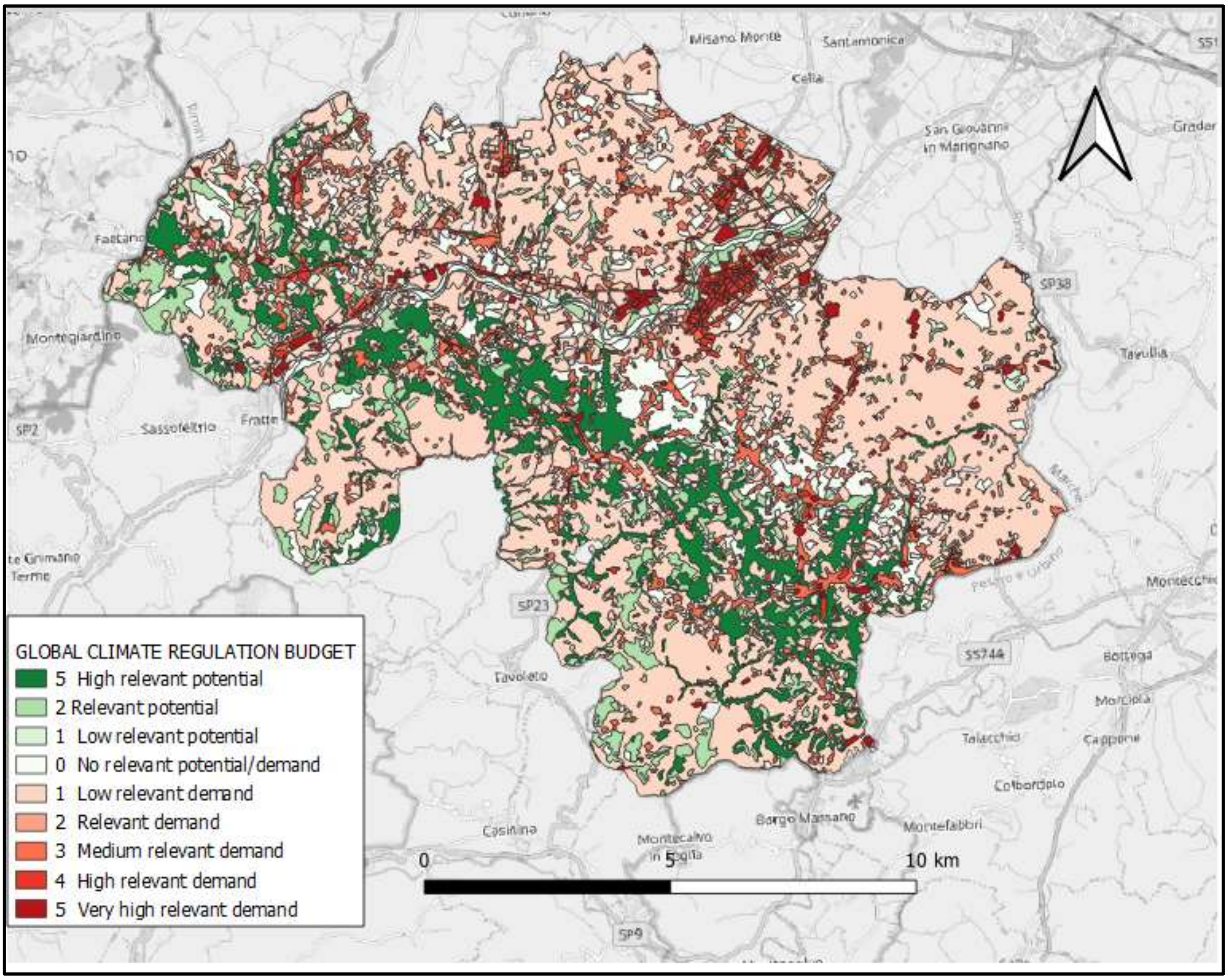


***Figure 3.5** – Map of global climate regulation (potential – demand) budget in the study area*

3.2 Effects of agricultural practices on soil organic carbon

The results obtained on GHG gas emissions and removals for arable lands in the considered territory are reported below. The results are differentiated according to the different scenarios assumed and calculated with the EX-ACT tool.

Table 3.4*: Utilised agricultural area (UAA) in 2030 for the different scenarios assumed*

	BAU	**Pessimistic**	**Very pessimistic**	**Optimistic**	**Very optimistic**
$UAA_{org2030}$	1954	1082	0	1368	2258
$UAA_{conv\ 2030}$	4553	5424	6507	4553	1991
$UAA_{orgNT2030}$	0	0	0	586	2258

Notes:

UAA_{org} = agricultural area used in organic farming practices

UAA_{conv}= Agricultural area under conventional farming practices

UUA_{orgNT}= Agricultural area utilised by organic farming and no-tillage practices

Notes:

UAA_{org} = agricultural area used in organic farming practices

UAA_{conv}= Agricultural area under conventional farming practices

UUA_{orgNT}= Agricultural area utilised by organic farming and no-tillage practices

***Table 3.5**: Total CO2 eq emissions to 2030, annual averages, per hectare and per hectare/year*

	BAU	**Pessimistic**	**Very pessimistic**	**Optimistic**	**Very optimistic**
Total tCO2-eq 2020-2030	164.940	196.013	234.588	162.174	62.920
Average* annual emission, tCO2-e/yr	16.494	19.601	23.459	16.217	6.292
Total emissions tCO2-e/ha	25,3	30,1	36,1	24,9	9,7
Total emissions, tCO2-e/ha/yr	2,5	3,0	3,6	2,5	1,0

* *assuming linear emission dynamics over the years*

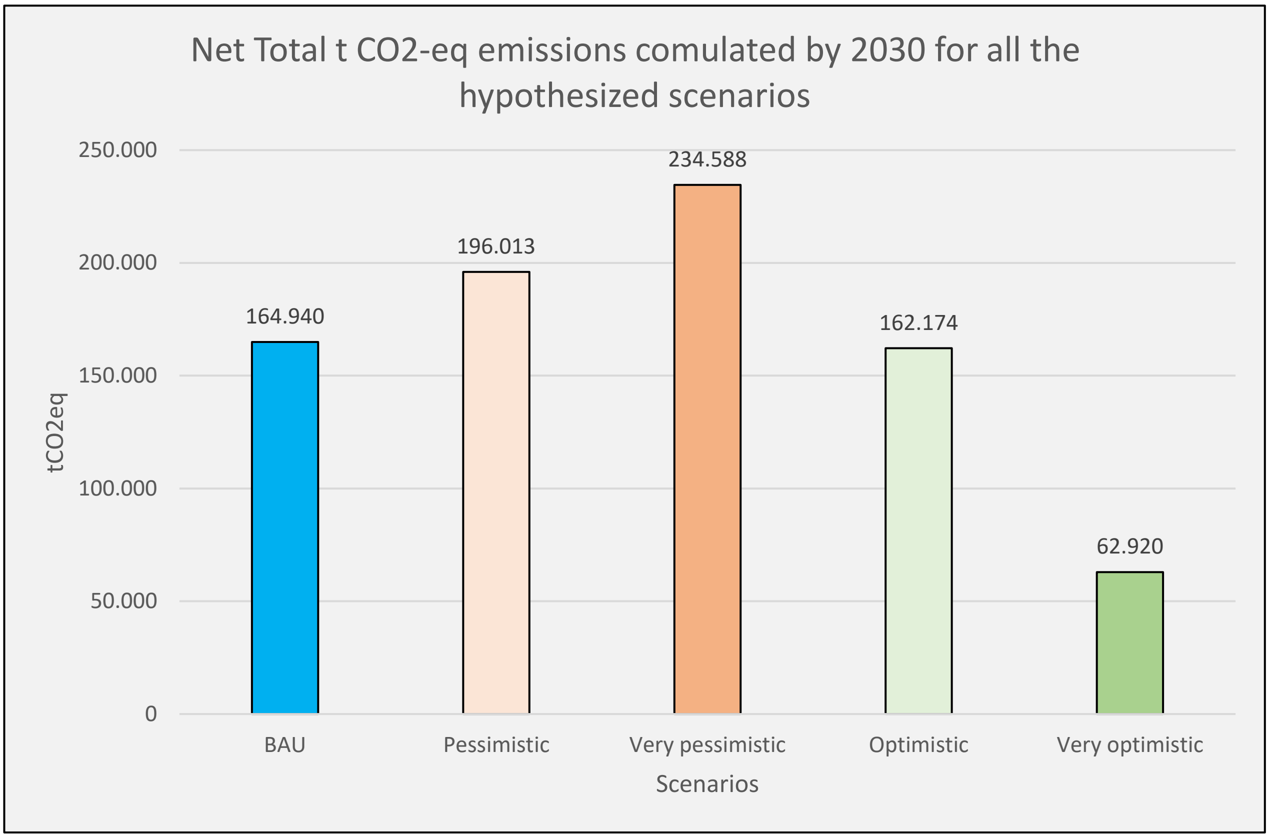


***Figure 3.6**: Net tCO2-eq emissions up to 2030 under the different scenarios assumed*

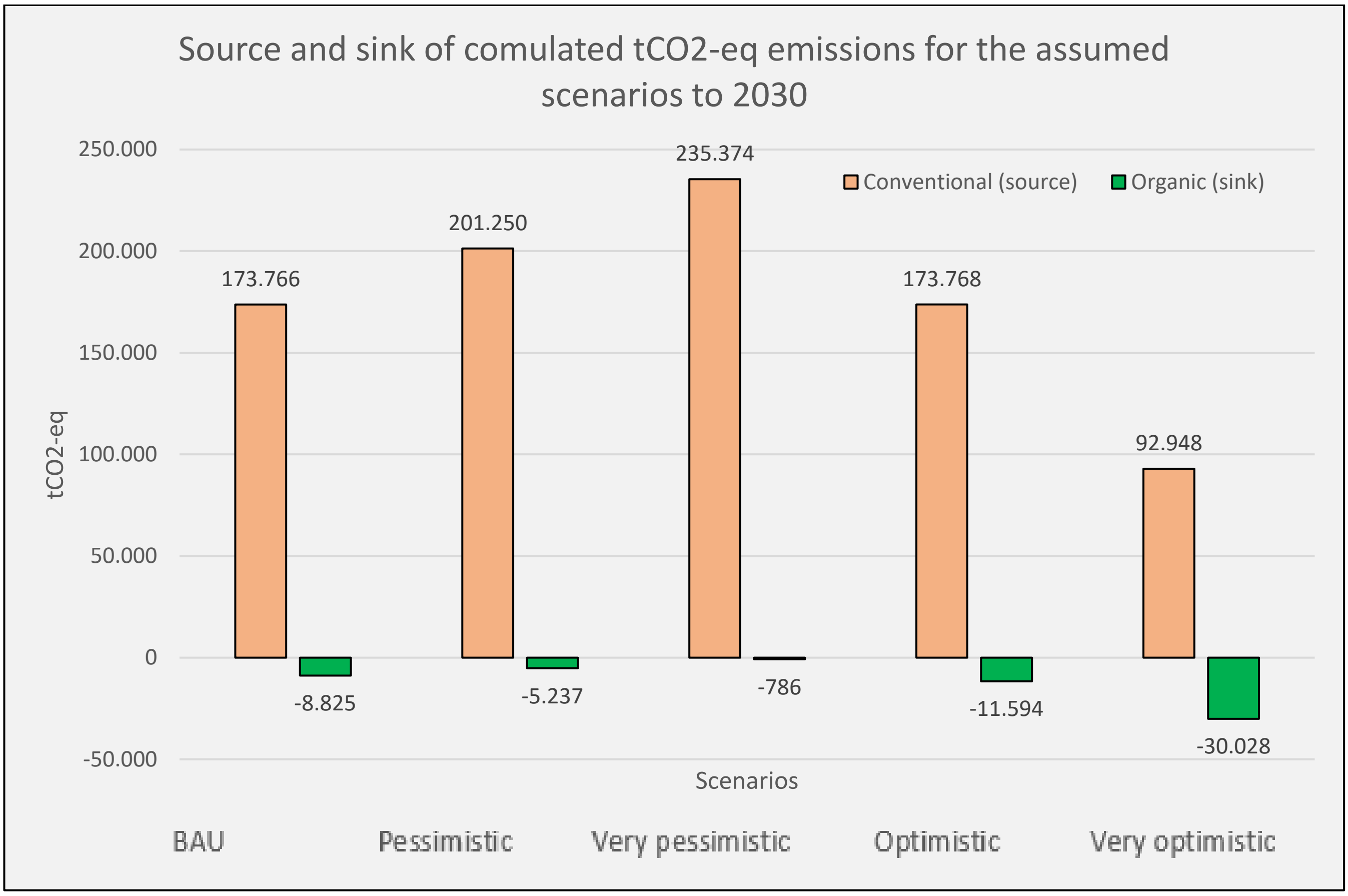


Figure 3.7: *Source and sink of comulated tCO2-eq emissions for the assumed scenarios to 2030*

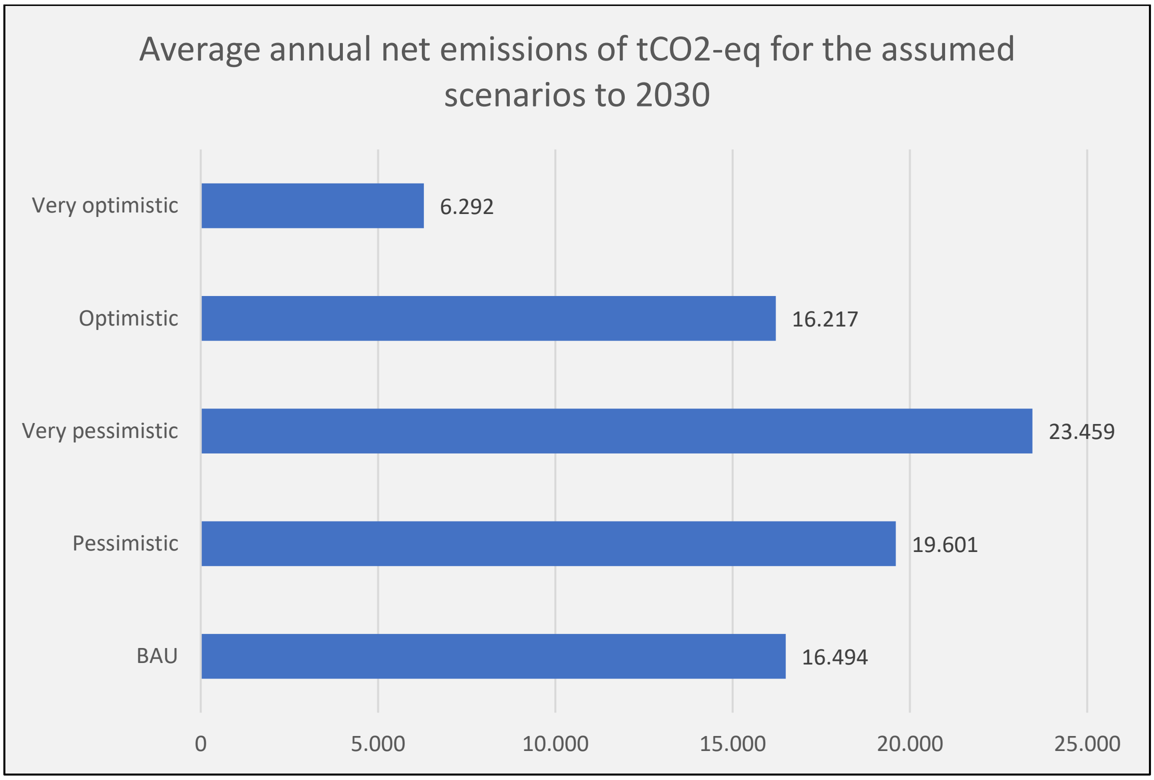


Figure 3.8: *Average annual net tCO2-eq emissions for scenarios assumed to 2030 (assuming linear emission dynamics over the years).*

4. DISCUSSION

4. 1 Potential, demand and budget of ecosystem services in the study area

This initial screening of ES potential with matrices from Burkhard et al. (2014) was useful, first of all because it allows to directly recognize and to spatialise which types of land cover/land use are associated with a certain type of ES potential. It is clear that in general the greatest potential supply of ES comes from semi-natural and natural environments. In fact, if we were to draw up a ranking, simply by adding up the values given by Burkhard et al. (2014), the first three classes or ecosystems that can offer ES are mixed forest (CLC_{code}313, 100 points), deciduous forest (CLC_{code}311, 97) and coniferous forest (CLC_{code} 312,96). In the last position, we would obviously find the most human-modified environments, classified according to the CORINE classification in artificial surfaces (CLC_{code}1.0.0.), with a minimum of 2 points for airports, construction sites and roads to a maximum of 16 (of which 11 points only of cultural ES, according to Burkhard et al. 2014) for discontinuous urban fabric (CLC_{code}112). The demand for services is exactly the opposite: anthropogenically modified territories require more ecosystem services, while natural territories are in the last positions. In the middle lie agricultural areas, which have a relatively high demand for regulatory services.

When we attribute the values of Burkhard et al. (2014) to the land cover (a proxy for ecosystems) of the area in question, we obtain the potential supply (together with the demand and subsequent budget) of each ES relative to the spatial configuration under consideration. It is necessary to keep in mind that the results obtained with these matrices are indicative. They do not offer the certainty or accuracy of more in-depth quantitative analyses, but they can provide an initial indication of the potential and criticality of the area. In the case of the Union of Valconca municipalities, it can be seen, for example, that none of the ecosystem services reaches the maximum value of 5 (high relevant potential). The highest ES potential value is obtained by the provisioning service of crop production (3, 12). This result is clearly the consequence of the agricultural vocation of the territory considered. In fact, if we look at the predominant land use, agricultural areas occupy 65% of the territory, of which 78% is non-irrigated arable land. This type of land use is devoted to the production of provisioning ecosystem services, but at the same time requires many regulating services. In fact, if we look at the demand for ecosystem services obtained, in the first 10 places of a hypothetical ranking, we find 9 regulatory ES, where pest and desease control (3.05), Nutrient regulation (2.20) and Regulation of waste (2.13), occupy the first three. Agricultural areas, while not presenting high demands for provisioning and cultural ES, require relatively many regulating ES.

Comparing the potential and the relative demand of ecosystem services (creating an ES budget) provides useful information about the criticalities that may exist in the area. These deficit of ES often translate into environmental, social and economic costs, which should be recognised if long-term sustainability and well-being is the ultimate goal.

Table 4.1 *- ES budget values (Potential - demand) on the territory of the Union of Valconca's municipaities (increasing order)*

REGULATION SERVICES	**budget value**	**PROVISIONING SERVICES**	**budget value**	**CULTURAL SERVICES**	**budget value**
Pest and desease control	-0,97	Fresh Water	-0,92	Religious & Spiritual experience	0,34
Erosion regulation	-0,92	Aquaculture	-0,47	Natural heritage & natural diversity	0,73
Natural hazard regulation	-0,75	Mineral resources	-0,42	Knowledge system	1,40
Nutrient regulation	-0,74	Fish, Seafood and edible algae	-0,41	Landscape aesthetichs & inspiration	1,44
Pollination	-0,65	Livestock (domestic)	-0,28	Recreation & Tourism	1,50
Global dimake regulation	-0,20	Timber	0,41	Cultural heritage & cultural diversity	1,94
Water purifcation	-0,18	Wood Fuel	0,73		

Water flow regulation	-0,10	Wild food & resources	0,84	
Regulation of waste	-0,02	Biochemicals & medicine	0,96	
Air quality regulation	0,04	Abiotic energy sources	1,01	
Local climate regulation	0,16	Biomass for energy	1,64	
		Fibre	2,43	
		Fodder	2,52	
		Crops	2,66	

With regard to ecosystem service budgets, it should be noted that the greatest criticality is found in regulating ecosystem services (9 out of 11 in deficit). In this case, it is possible to identify the land use classes that contribute most to this deficit of regulating ecosystem services, by adding up the budget values of the regulatory services attributed to each land use class and multiplying it by the area of the specific class present in the territory, divided by the total land area.

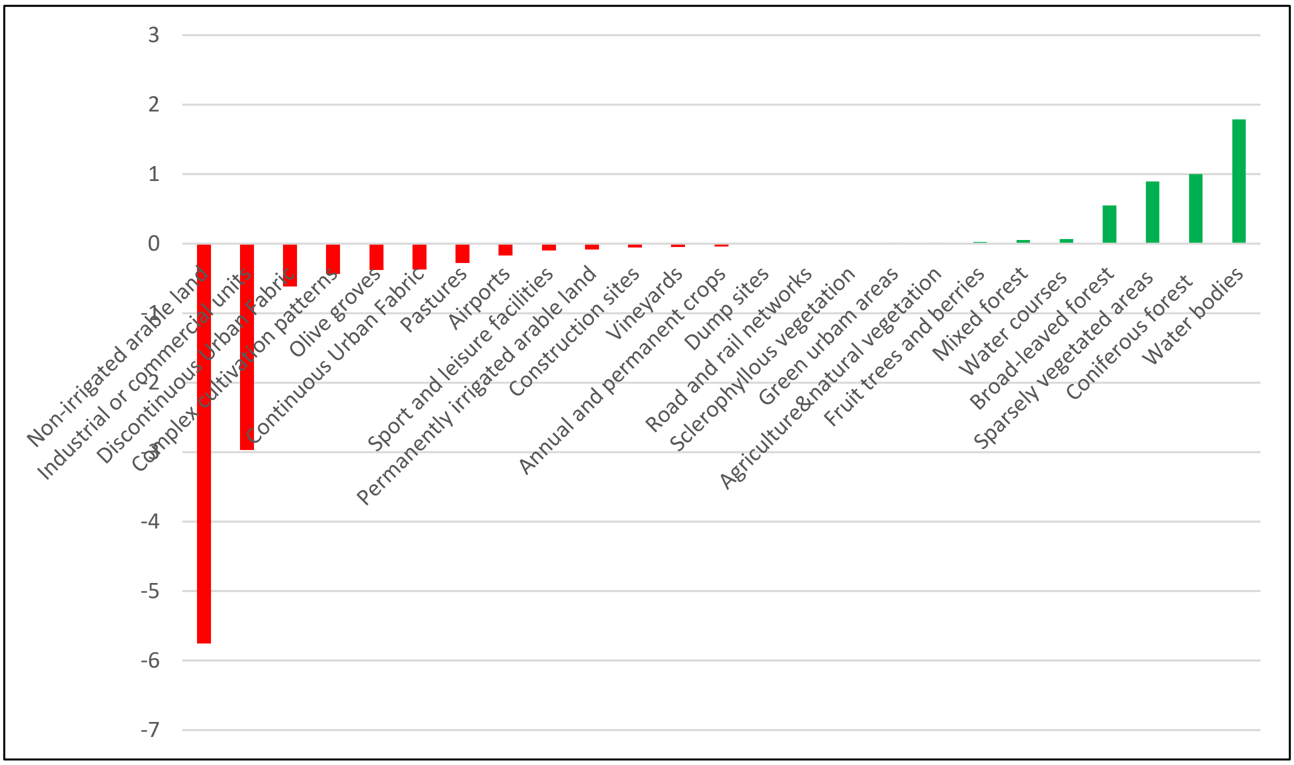


Fig 4.1 - Contributions of each land use classes to the budget of regulatory ecosystem services, in the territory considered.

It is clear from the figure that the land use class that has the greatest impact on regulatory services in the area considered is arable land (non-irrigated). The deficit of this class is nearly double that of the second class, industrial or commercial units. It is clear, therefore, that if we want to act at a territorial level to balance this deficit of regulatory ecosystem services (and thus reduce the environmental, economic and social costs generated), it is here that we should intervene with priority.

Pest and desease control

Taking the results obtained in the territory considered, the potential deficit in the ES of pest and disease control (-0,97), for example, necessarily leads to the use of pesticides. The use of pesticides, in addition to involving economic costs for farmers arising from the purchase of the same, can harm the same agro-ecosystems, the surrounding biodiversity (Geiger et al., 2010) and the health of people. Pesticide use can reduce the potential supply of other ES that are critical to agro-ecosystems such as pollination services and nutrient regulation (Tscharntke et al., 2005), which in turn affect agricultural productivity.

While the demand for other ES increases, such as climate regulation (to offset emissions from pesticide production and transport) or water purification (one of the environmental matrices where pesticide residues accumulate most). The human health risks of ingestion and/or exposure to pesticides are well known. Certainly, in recent years, especially in the European Union, their use has been limited and even in the Farm to Fork Strategy (European Commission, 2020) it is proposed to reduce them by 50% by 2030. However, we must consider the risk of multiple residues of “regular” pesticides (Hernandez et al., 2013), found at the Italian level on 60% of fruit, with strawberries and grapes that may contain more than 5 pesticide residues simultaneously (LEGAMBIENTE , 2020).

Erosion regulation

The second regulating service that is in deficit is erosion regulation (-0.92). In general, soil erosion depends on several geo-pedo-climatic factors including specific soil characteristics, slope gradient, and rainfall frequency and intensity. Land use and agricultural practices can also influence ultimate erosion (the C and P factors of RUSLE, Renard et al., 1991). Referring again to the mapping by matrices of Burkhard et al., (2014) the high demand for this ES, thus exceeding the total potential supply, is attributable to the conspicuous presence of typical land uses that massively require this service. In fact, Arable land and vineyards alone occupy more than half of the total land area. These classes have a negative budget (potential less demand) of the specific service. In fact, all the municipalities of the Union of Valconca are above the limit threshold of 5 tons/ha/year of soil loss from surface water erosion (SGSS - Emilia Romagna Region, 2019) (See figure 4.1), with peaks of 100 tons/ha/year. On the basis of these values we have roughly calculated that in the territories considered there would be a loss of soil by erosion from a minimum of 355,000 tons/year to a maximum of about 757.000 tons/year. These values if multiplied by the replacement cost of a ton of soil proposed by ISPRA (2018) equal to 6.10 euros (2017 value), would produce economic costs resulting from erosion, estimated at 2 to 4,5 million euros/year throughout the territory considered.

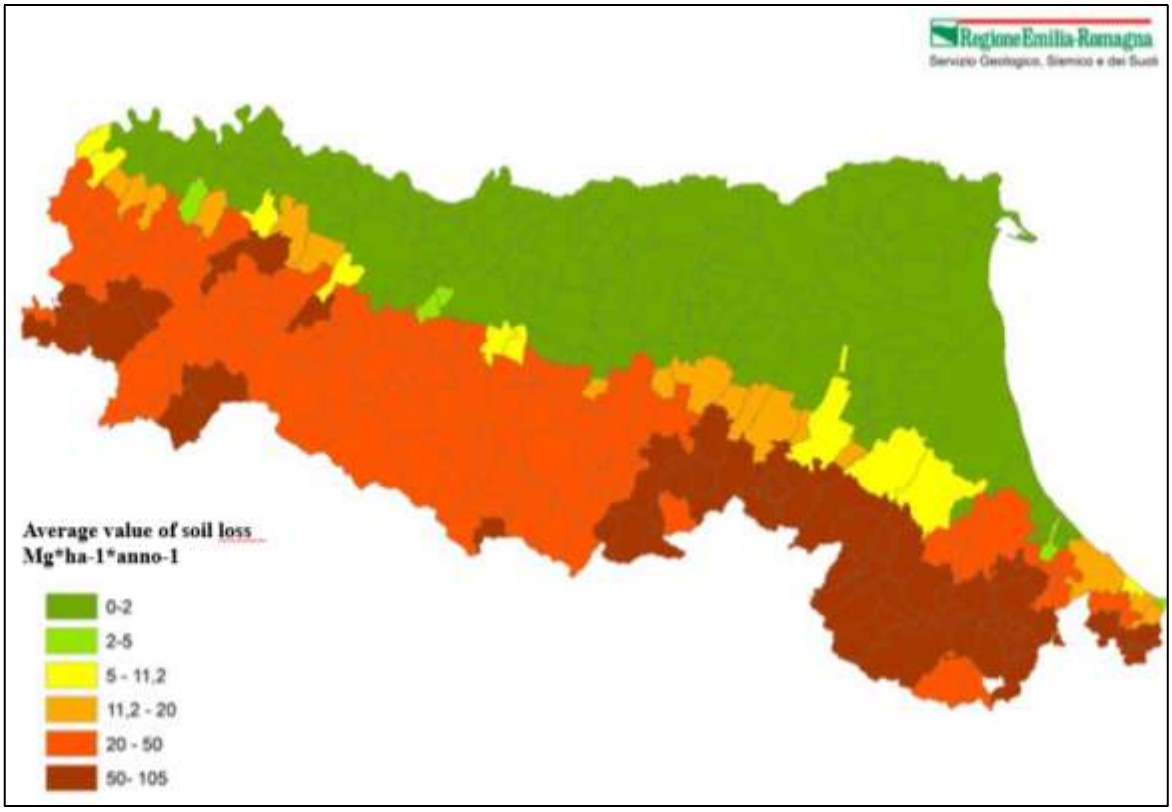


Fig. 4.2 - *Average value of soil loss per municipality weighted on agricultural areas only (modified on SGSS, 2019)*

Pollination

In ES with a negative budget, over -0,5 was also found the pollination ES (-0,65). This ES is most important for stability (low variability) and quantity of crops in agriculture (Garibaldi et al., 2011, IPBES 2016). Pollinators due to pesticide use and loss of natural habitats (Nabhan and Buchmann, 1997) are declining worldwide (IPBES, 2016). The result obtained through the matrices of Burkhard et al. (2014), while not definitive, signals a demand that exceeds the potential of the service in the study area. This result, however, would need to be verified by field analysis or further modeling, deriving the actual flow of the service.

Despite this, an attempt was made to estimate the demand for the service (referring to 2020) (see table 4.2) based on the data of the crops present in Valconca provided by AGREA (2021). In the list provided by AGREA, 55 hectares of orchards are not identified by the precise species, but are grouped under the categories of “promiscal arboric cultivation” and “specialized arboric cultivation” (personal communication with AGREA). Therefore, we opted for an average of the species of orchards presumably present in Valconca, referring to the others present in the aforementioned list. The amount of yield that depends on pollinators are taken from the reliable study of Klein et al. (2007). To calculate the yields, we referred to the average yields per hectare of the hilly environments of the province of Rimini, obtained from the Integrated Local Planning and Development Service of the Emilia Romagna region. While the selling prices per kg of product were extracted from the ISMEA website (2021), and refer to the average prices "at origin" in 2020 by crop type . The prices "at origin" are the prices that are formed in the initial phase of exchange of products by the producer, or in any case as close as possible to production, with the intention of giving an estimate of the revenues of farmers.

***Table 4.2**: Data used to assess the demand for the pollination service and associated results*

Type of crop (1)	**Fraction of yield dependent on pollinators** (2)	**Ha 2020** (1)	**Medium Yields/ha (kg) of the provincial (hilly) areas** (3)	**total yield (Kg)**	**Pollination dependent yields (or the ES demand)**	**Price per kg** (4)	**Total potential revenues Euro (€)**	**Part of total revenues p. Euro (€) dependent on pollinators**
Melon	0,9	0,4	13.600,0	5.891,5	5.302,4	0,4	2.297,7	2.067,9
Apple	0,65	0,3	15.000,0	3.834,0	2.492,1	0,7	2.607,1	1.694,6
Apricot	0,65	0,8	15.000,0	11.811,0	7.677,2	1,3	15.354,3	9.980,3
Cherry	0,65	0,6	3.890,0	2.432,8	1.581,3	3,6	8.806,8	5.724,4
Peaches	0,65	2,6	30.000,0	78.441,0	50.986,7	0,8	58.830,8	38.240,0
Pears	0,65	0,2	6.400,0	1.286,4	836,2	1,1	1.440,8	936,5
Orchards not identifiable *	0,65	55,0	17.470,0	960.850,0	624.552,5	1,5	1.435.509,9	933.081,4
Strawberry	0,3	0,2	20.000,0	4.354,0	1.088,5	3,1	13.584,5	3.396,1
Sunflower	0,3	4,8	2.250,0	10.727,8	2.681,9	0,3	3.432,9	858,2
Tomato	0,05	2,6	29.700,0	78.384,2	3.919,2	0,8	63.491,2	3.174,6
TOTAL		67,5		**1.158.012,7**	**701.118,0**		**1.605.356,0**	**999.154,0**

** The averages of the values of the other identifiable orchards (apple, apricot, cherry, peaches, pear) were used.*

Source: 1. AGREA, 2021; 2. (Klein et al. 2007); 3. Integrated Local Planning and Development Service of the Emilia

Romagna regional (personal communication); 4. ISMEA, 2021

Where:

Total yield = Ha 2020 * Medium Yields/hectare (kg) of the provincial (hilly) areas
Pollination dependent yields = Total yields * Fraction of yield dependent on pollinators
Total potential Revenues (€) = Total yields * price per kg
Part of total potential revenues (€) dependent on pollinators = pollination dependent yields * price per kg

Thus, for the crops considered, on average 60% of yields depend on pollination. This finding can be considered the demand for the pollination service.
Going further, If it is assumed that 0.65 (out of a total ES demand of 2, about 32%) is not met by the potential of the ES, (excluding for now artificial beekeeping) then 32% of the total yield produced by bees is not actually produced, with related consequences on revenues as well. This findings, however, would need to be verified with field studies and/or further modeling by deriving the service flow. With Burkhard's matrices (2014), in fact, we can only affirm that, on average, in the territory considered, the potential of the service could be less than the demand. But precisely where does the supply not meet the demand of the ES? For what type of crop? Is artificially induced pollination used?
These questions remain open for now.

Global climate regulation

The (global) climate regulation service is also in deficit (-0.20).
Before moving on to a more detailed analysis of the result, it is necessary to note that the climate regulation service operates on a global scale. However, it is also possible to analyze the respective budget on a limited area, for example by considering the absorption of CO2 attributable to the vegetation present and the CO2 emissions (and also other GHG) estimated in the area.
With reference to the result obtained in the territory of the UV, it is possible to assume that it is due to the relatively small presence of forest areas (about 20% of the territory of the

UV). Woods and forests are in fact the main responsible for the absorption of CO2, through the photosynthetic process. However, the value is close to zero, because on the other hand artificial surfaces such as industries, houses and roads (the main source of GHG emission) occupy an even smaller area. It is interesting to note that agricultural surfaces, and in particular arable lands, have a higher demand than the supply of the service (1 point), which means that Burkhard et al. (2014) consider arable lands as source (and not sink) of GHG emission. This aspect will be explored further below.

For a first, more quantitative estimate, it is possible to view, for example, the emission inventory produced by ARPAE (2020) on GHG emissions and removals, calculated on a municipal scale. The latest data available are those for 2017.

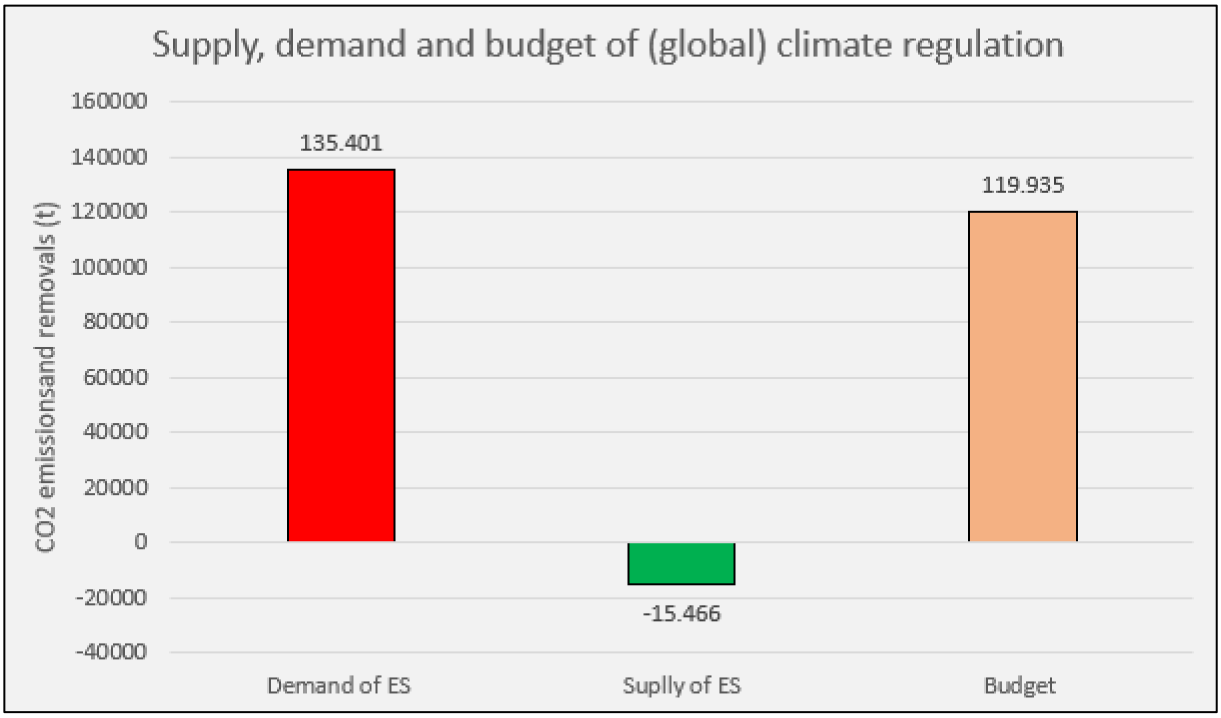


Figure 4.3-*Supply, demand and budget of (global) climate regulation in the union of Valconca municipalities*

As can be seen in figure, the absorption of CO_2 present in the territory does not manage to compensate for the emissions produced. Therefore, demand for the service is greater than supply.

Just as the computation with the matrices of Burkhard et al. (2014) had indicated. Note, however, that the corresponding budget found with the matrices approach is only -0.20, i.e., demand slightly exceeds supply. In the data obtained from ARPAE, on the other hand, demand for the service is much greater than supply, such that supply only manages to offset 11% of total demand. In this sense, this disproportion between the two results, could be explained (only in part) by the fact that the modeling of ARPAE (Forest model, INEMAR) does not take into account the absorption of shrubs and permanent crops (such as orchards, olive groves and partly vineyards). On the other hand, Burkhard's ES potential matrix does not take into account the specific forest management adopted (e.g. stand or coppice), so it could overestimate the real CO_2 uptake. This issue needs further investigation.

Going further, by investigating more deeply the causes of this deficit in the service, it is possible to investigate which are the main emission sources present in the territory. Again referring to the data made available by ARPAE, the main CO2 emissions are attributable to non-industrial combustion, followed by emissions produced by motor vehicles and similar on the roads in the territory. Non-industrial combustion results from the use of boilers with thermal output less than 50 mega watts (MW), 56% of which are used in residential installations and 46% in commercial and institutional installations.

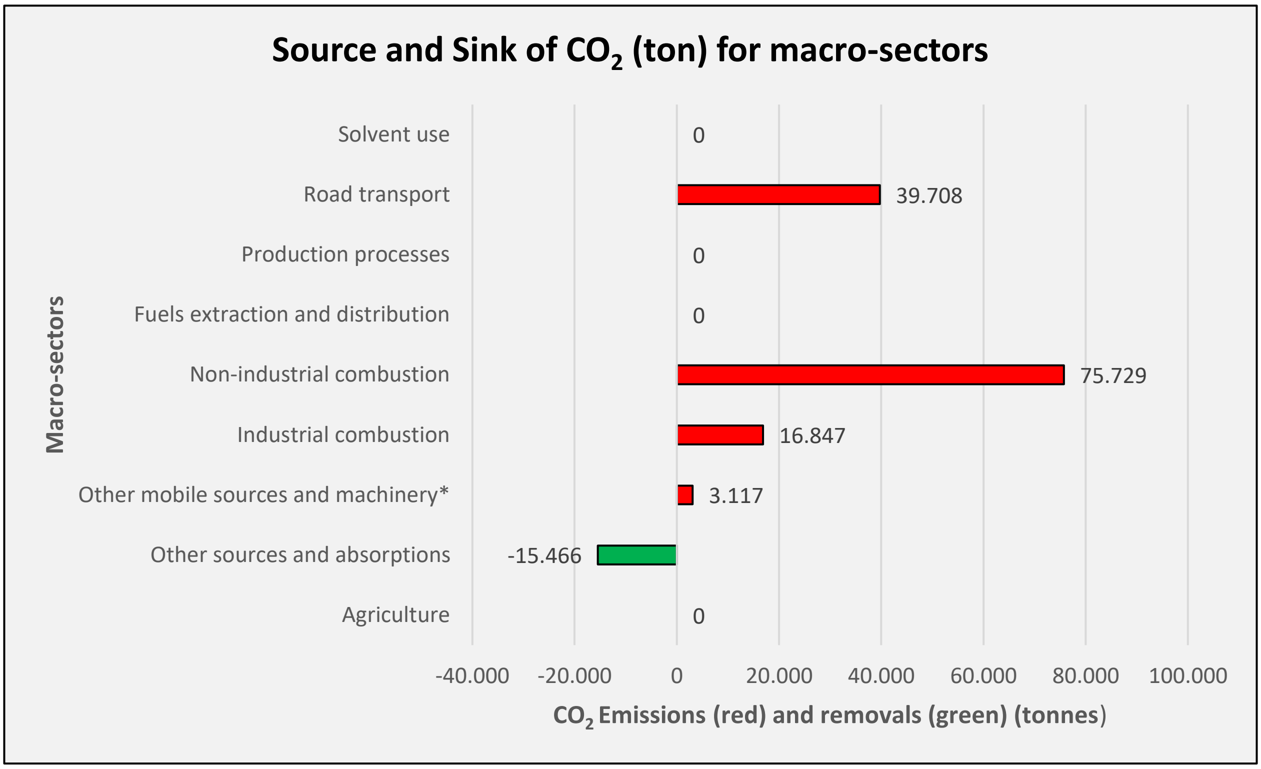


Figure 4.4*- Source and sink of CO2 (t) for macro-sectors of activities (own elaboration on ARPAE, 2020).* Note: “other mobile sources and machinery” include mostly equipment used for agricultural practices

These emissions could be avoided by implementing, where possible, the use of renewable resources such as solar panels and heat pumps. This desirable action could decrease demand for the specific service. The combustion produced by these boilers, moreover, are sources of another GHG such as nitrous oxide (N_2O) and particulate matter (particularly harmful to health).

Finally, it is possible to attribute an economic cost to this service deficit. Using, for example, the country-level social cost of carbon (CSCC) differentiated by nations, as proposed by Ricke et al. (2018) (see also the introductory chapter of this thesis), we see that it is possible to attribute a cost to each tonne of CO_2-eq emissions. This cost is the result of a complex elaboration based on the possible damages attributable to one tonne of CO_2-eq emitted. This value for Italy is between 1 and 10 dollars per tonne. So if we multiply the CO_2 emissions absorbed in the considered territory, we can find an estimate of the avoided costs, due to

CO_2 removals by forests.

4.2 The potential of agro-ecological practices and the creation of a bio-district

Agro-ecological practices (see for example Weezel et al., 2014), of which organic farming is one of the representatives can have fewer impacts on the provision of regulating ecosystem services (Boone et al., 2019) by preserving the integrity of natural capital and regenerating it. Associative forms linked to organic farming supply chains such as bio-districts (https://aiab.it/biodistretti/) can foster participation and decision-making capacity of local actors, preserving and regenerating the social capital of a territorial community (Careri et al., 2008; Chiffoleau, 2009). Organic farmers also, on average, have higher incomes than their colleagues dedicated to conventional farming, suffer less from natural variations in productivity because they differentiate their agricultural activities more and are supported by a growing demand for organic products (BIOREPORT, 2019).

For these reasons we believed that one of the solutions to territorial regeneration, intended here as an increase in the social, economic and natural capital of the territory studied, may be to consolidate the trend of conversion to organic farming and moving in the direction of creating forms of association such as the bio-district.

First of all, an attempt was made to find out the current degree of organic cultivation out of the total land cultivated. As explained in the chapter on methodologies, data on the total utilised agricultural area (TUAA) at municipal level are not available.

It was then decided to consider data from CAP applications, recognising that the TUAA is slightly underestimated (about 90% of farmers apply for this type of subsidy, personal communication with SAS), so the values of organic UUA are on the contrary, slightly overestimated.

However, from the values found (and some initial interviews with the population) it can certainly be deduced that farming practices are already in place. There is a percentage of about 18% of organic UAA on the total UUA, with an average increase rate of 9%. This data certainly shows that organic farming practices are in full expansion. Consider that in 2010 there were only around 300 hectares (ISTAT, 2010) of organic crops in the area in question, while in 2020 there will be over a thousand.

Is it possible that this trend will continue over the years?

It is certainly possible and we even think probable: european policies show that organic farming is one of the integrated solutions for the development of territories. The Farm to Fork strategy (European Commission, 2020) has set a national utilised agricultural area of at least 25% by 2030. Organic farming will also be further promoted through the new CAP starting in 2022 and in March 2021 the “Action plan for organic farming was published by the European Commission (2021a). Interviews with the comunity report an interest in sustainable agricultural production, such as organic farming.

The possible advantages of continuing the conversion to organic farming and the creation of a bio-district are summarised below, with particular attention to the main criticalities found in the territory.

Ecosystem services

The literature reviewed reports in the majority of cases a higher provision of regulatory ecosystem services by agro-ecosystems cultivated with agroecological practices than by conventional ones. The only relevant trade-off is the volume of production, which seems to favour conventional agriculture (see table 4.3).

Table 4.3 - Main differences found in scientific literature regard the provision of ecosystem services between conventional farming practices and agro-ecological practices (classification of ES based on Burkhard 2014).

Regulating services	**Conventional**	**Organic/ agro-ecologic**
Global climate regulation		+
Local climate regulation		
Air quality regulation		
Water flow regulation		+
Water purifcation		+

Nutrient regulation		+
Erosion regulation		+
Natural hazard regulation		+
Pollination		+
Pest and desease control		+
Regulation of waste		+
Provisioning services		
Crops	+**	
Biomass for energy		
Fodder		
Livestock (domestic)		
Fibre		
Timber		
Wood Fuel		
Fish, Seafood and edible algae		
Aquaculture		
Wild food & resources		
Biochemicals & medicine		
Fresh Water		
Mineral resources		
Abiotic energy sources		
Cultural Services		
Recreation & Tourism		+*
Landscape aesthetichs & inspiration		+
Knowledge system		
Religious & Spiritual experience		
Cultural heritage & cultural diversity		
Natural heritage & natural diversity		+

(Based on: Boone et al., 2019; Silli & Ciccarese 2015, Boone et al., 2019, Reganold & Wachter, 2016; Sandhu et al., 2008. Note: ** On average 20% in the short term, but higher in the long term; *due to the higher propensity for multifunctionality of organic farms, as ecosystem services are often co-produced by the ecological system and the human system).

We can therefore assume that agro-ecological and organic farming practices can make a substantial contribution to balancing the deficit of ecosystem services found in the area in question. For example, for erosion protection, several studies show that less ploughing of the soil, the use of cover crops and intercropping, as well as the addition of permanent crops in the field margins can significantly reduce soil erosion (see for example Boatto et al. 2008; Boone et al., 2019; Seitz et al., 2019). A study in the Veneto region, for example (Boatto et al., 2008 - SABIO project) reports an average 30% reduction in erosion following conversion to agro-ecological practices. If we roughly apply the same reduction to the erosion values present in the Conca Valley, there would be an annual saving from a minimum of 600,000 euro/year to a maximum of 1,350,000 euro/year.

The pollination service can also benefit significantly from the adoption of agricultural practices that respect natural processes. Reducing the use of pesticides, greater crop diversification and the presence of perennial margins are all practices that can increase the habitat suitability of pollinating insects. Referring to the previous calculations, we have that 32% of the pollination demand could not be satisfied, which would be equivalent to about 320.000 euro loss on the resale of the products, every year on the whole territory. These costs could be lowered by increased adoption of agro-ecological practices.

We can speak of regeneration (or restoration) of natural capital in this case as there is an increase in ecosystem services (Blignaut et al. 2014) due to the increased integrity of the natural capital present in agro-ecosystem in these case.

The first natural asset benefiting is soil. But agro-ecological practices also benefit biodiversity and indirectly water (less polluted) and air (less fossil fuel machinery, more pollutant sequestration e.g. by hedged margins). This regeneration (or restoration) of natural capital reduces the environmental (and consequently social) costs of conventional farming practices, increasing the resilience of agro-ecosystems, which is also closely linked to the resilience of the communities that inhabit and care for them. The wellbeing of the rural communities living in the Conca Valley (and in particular the farms and farmers, but also the categories indirectly linked to agro-food such as tourism) are in fact directly influenced by the state of the agro-ecosystems.

The yield trade-off

The major limitation of the agro-ecological approach to agriculture is the (temporary) decrease in production following conversion. Many studies show however that in the long term, organic farming reaches production levels similar to those of conventional farming. However, it does not degrade the soil, it does not pollute water (or at least less), it is not totally destructive of biodiversity and ecosystem services derived from agro-ecosystems. There are also a number of 'agro-ecological' practices such as 'intensive organic farming' (Jeavons, 2001), a improved variation of traditional organic farming, which promises to produce even more than conventional, while using less agricultural land. One must certainly be careful in making a snap judgement about these kinds of practices, but it is certainly worth giving them a chance. It is also necessary to continue to invest in relevant academic and other research. The clock is ticking. Some of the planet's boundaries (Rockstrom et al., 2009) have already been exceeded, and we do not yet know the full consequences we can expect from these overshoots.

The possible economic and social effects

In addition to reducing 'environmental costs' and increasing the provision of supporting and regulating ecosystem services, agro-ecological practices, and in particular the certified organic supply chain, have in recent years been gaining more and more space on the agri-food market. In 2020 the organic market reached 6.9 billion euros, of which 4.3 billion related to the domestic market, with an increase of +142% since 2010 (Nomisma, 2020). These data are in addition to those relating to the comparison with conventional agriculture, which show a higher average income of organic farmers, greater agricultural multifunctionality (and therefore resilience) and younger farmers on average (Abitabile, 2019).

These last three aspects can be very relevant for the investigated territory, as reported in fact the average income of the inhabitants of the Conca Valley is lower than the provincial and national average. In addition, the trend towards greater agricultural multifunctionality of organic farms can fit well into a local context where tourism can be relaunched and supported, even more so with respect to the renewed greener and more authentic desires of tourists and travellers.

Finally, the attraction that this type of agriculture exerts on young people (22% of organic farms have the head of the farm between 20 and 39 years old, FederBio 2018) can encourage young people in the area to stay or young people from other territories to move to these areas, preventing the abandonment of these territories.

The creation of the bio-district

From the analysis of the area (interviews + ecosystem services), we believe it is appropriate to propose to the communities living there that they consider creating a bio-district. A bio-district is in fact an agreement between farmers, private citizens, associations, tour operators and public administrations, with the aim of sustainable management of natural resources, focusing in particular on the organic sector (AIAB, n.d).

The first interesting feature of the bio-district, from the point of view of local development, is the open participation of all local actors in the creation of this agreement. The participation of local actors in the management of natural resources and in production and consumption processes is a determining factor in endogenous development processes (Obe, 1998; Rodríguez-Pose and Palavicini-Corona, 2013; Rogerson, 2014; Velazquez-Barquero and Rodrıguez-Cohard, 2016). Indeed, according to the endogenous development paradigm, improvements in living conditions are achieved once local resources have been recognised, controlled and used to create value locally (Nemes and Fazekas, 2006). Furthermore, according to Diaz Puente et al. (2011), for communities to truly prosper, they must be agents of their own development. This element of participation could well support the desire for participation that emerged from the community interviews and foster social cohesion and a sense of belonging.

Secondly, many of the biodistricts already present in Italy constitute a real pact for the development of the territory, incorporating local instances and vocations (see, for example, the biodistrict of social agriculture in Bergamo, https://www.biodistrettobg.it/) and thus favouring not only the aforementioned participation from below, but also the creation of a sense of identity and belonging of the territorial actors. These development plans can in some cases take into account different territorial instances and set their own territorial objectives to be achieved. Since public administrations are also involved, such governance can potentially contribute to solving many of the problems on the territory by adopting a bottom-up approach of listening and sharing among the territorial actors (Sturla et al., 2019).

With reference to the investigated community, this factor could resolve the disjunction found (or at least perceived) at the territorial planning and promotional level.

Thirdly, the attention given to short and locally integrated supply chains, together with the possibility of certifying the biodistrict, could contribute to the local economy. Short and locally integrated supply chains can help farms, especially small ones, to resell their products locally, increasing their profit and reducing purchase costs for local buyers. This type of integrated supply chain can help create virtuous cycles of circular economy, reducing waste of materials and energy (and the associated costs), with the possibility of shared purchase of agricultural machinery, as highlighted by the analysis of two Italian bio-districts by Dara Guccione et al. (2021).
The possibility of integrating the agri-food chain with tourism, for example by means of agreements between farms and restaurants, is a further successful element that can be transferred to this area, also in view of its strategic location, i.e. near well-known tourist centres. This integration occurs in many Italian biodistricts also with agreements between public canteens, which are supplied by local organic producers (Sturla et al., 2019). The accommodation facilities of important tourist centres (such as Rimini, Cattolica, Riccione) could enter into commercial agreements with the realities of the area, both in terms of supplies of organic agri-food products but also as integrated tourist offers that include food tasting, excursions in nature, etc. (Sturla et al., 2019). This would increase the Riviera's tourist offer and revitalise the local economy of the Conca Valley area.
It is worth remembering that projects of this kind already exist in some cases (see Strade dei Vini e dei Sapori, http://www.stradavinisaporifc.it/) and are promoted by the local LAG. The operation of these projects demonstrates that the way of promoting the territory goes well with the safeguarding of local peculiarities.

Fourthly, Dara Guccione et al. (2021) report that in the bio-districts they analysed, the possibilities for training on agroecological issues, but also for assistance with organic certification, increased after the creation of the bio-district. In the Valle Camonica and Terre degli Elmi bio-districts, the bio-district organises training and dissemination events on agro-ecological principles and organic certification. These practices have the dual effect of helping farms to convert and at the same time spreading the principles of sustainable development and agro-ecology to the local population. In this regard, there is also evidence in the literature that organic supply chains are able to share and disseminate the values of sustainable development throughout the supply chain (Marsden and Smith, 2005), as well as foster active ecological citizenship by promoting consumer education (Seyfang, 2006).

Although no explicit reference was made to the bio-district in the community interviews, in the table 4.4 are some phrases that may be indicative of the alignment between the community's wishes and the creation of the bio-district.

In addition, for both mayors and stakeholders, “sustainable agriculture” ranks second in the ranking of priorities for action in the macro-category related to the territorial economy, just after tourism.

Tab 4.4 – Stakeholder sentences extracted from interviews supporting (indirectly) the creation of a bio-district (the numbers given to the interviewees are indicative and do not respect the order of the interview).

Interviewee num. 1	“It would be necessary to create a project for the development of quality agriculture, perhaps community agriculture, the current one is poor".
Interviewee num. 2	"More value should be given to environmental tourism (introducing local producers, e.g. beekeepers, encouraging hiking)".
Interviewee num. 3	"Citizens should be involved by the municipality and the province in public works, or in interventions that the town needs based on what they know how to do. They should be listened because they often know more than those who have studied in books. Those who live and experience the territory know what it needs".
Interviewee num. 4	“"We need to promote typical products (oil, piadina, wine, Fossa cheese). The real added value is to make our experience and tradition known".
Interviewee num. 5	"Small shops cannot survive on management costs and rents and are therefore forced to close, or almost close, as they cannot stand up to competition".

Interviewee num. 6	"A territorial network of entrepreneurs could help everyone's activity a lot, because it would pool both knowledge and opportunities.”

4.2.1 Agricultural practices and greenhouse gas emissions and removals

This study further investigated the effect of certain agricultural practices on the balance of greenhouse gas emissions from soil. In particular, the behaviour of the “soil pool” under conventional or organic farming practices was studied. Within organic farming practices, the use of the conservative practice of no-tillage was also included. In fact, organic farming has a statutory commitment to soil health, preferring practices with at least reduced tillage. However, we believe that with the increasing awareness of the danger of climate change effects, together with the benefits, which from the literature analysis derive from no-tillage practices, a part of the farmers, if well informed and prepared, could adopt these practices. The results of the elaboration with the EX ACT tool of FAO, clearly indicate that conventional practices, net of the use of pesticides, machinery, etc. result in GHG emissions from the soil. These emissions are mainly due to i) the use of ploughing or full tillage, (ii) the reduced use of cover crops and/or crop rotations (iii) the non-use (or reduced use) of animal manures and/or compost (green manure) in some cases.

Ploughing the soil, for example, removes organic matter particles and allows carbon to volatilise into the atmosphere. In addition, ploughing the soil induces the removal of soil biota, which plays a key role in soil humification and in and in many cases nitrogen fixation.

The use of cover crops increases the nutrients in soil, available for subsequent cultivation. In addition to this, thanks to photosynthesis, they are an additional ally in carbon fixation. Plants absorb carbon from the atmosphere, store it in their biomass and transfer it to the soil through root exudates. Often in conventional farming practices, soil is left bare after the production period of the specific crop is over. In this way, the potential carbon sequestration and contribution of nutrients and biodiversity due to the use of cover crops is lost. Furthermore, by leaving the soil uncovered, soil erosion is not prevented. Animal manure and compost naturally contain large amounts of carbon and organic matter, releasing it into the soil.

Modelling with the EX ACT tool, first shows that organic farming practices allow the soil to act as a carbon sink, absorbing CO2 from the atmosphere. If no-tillage practices are added, the potential uptake increases. The “mitigation potentials” from the "optimistic" and "very optimistic" scenarios, calculated over 10 years and compared to the BAU scenario (calculated on the trend of conversion to organic in the last 5 years) amount to about 2.000 tonnes in the optimistic scenario to about 100.000 tonnes (about 10.000 each year) in the "very optimistic" scenario. These scenarios, when compared to the pessimistic scenario, which assumes a halt in the organic conversion trend and thus an organic area of 2020, have even greater mitigation potential. The analysis carried out with the EX-ACT tool therefore clearly demonstrates how agro-ecological practices can be an additional solution in the fight against climate change.

Possible further developments: the creation of a voluntary carbon market

One of the possible advantages for farmers associated with the adoption of agro-ecological practices in the Valconca territory is the possibility to certify the tons of CO2-eq subtracted or not emitted over time. In this way, it would be possible to create a so-called “voluntary carbon market” (Bayon et al. 2012; CREA 2020) where farmers certify the reduction of CO2 emissions from the change of agricultural practices and resell carbon credits to companies that want to reduce their carbon footprint instead. Particularly interesting in this sense is the model of the 'agricultural livestock and forest district' (Chiriacò et al., 2020), where the major emitters of greenhouse gases within a territorial district (usually livestock farms) commit to reducing their emissions through less impactful practices and to purchasing CO2 credits (this time generated by the virtuous farmers of the district), in order to compensate for the emissions that they were unable to reduce. The creation of a voluntary carbon market could therefore have the dual effect of reducing emissions and increasing income for virtuous farmers.

It is worth remembering that for the creation of a carbon market and the generation of credits, a series of principles must be respected, including: additionality (additional commitments to normal management practices), permanence (in time and space of the credits that can be generated to various types of risks), leakage (no risk of generating negative externalities) and double counting (carbon fixation already accounted for by the State for the purposes of the Kyoto Protocol or double sale of the same credit to two different beneficiaries) (CREA, 2020).

With reference to the hypothesized scenarios, for example, we note that organic and conservation farming practices act as carbon sinks in the soil, as opposed to conventional farming practices which typically act as carbon sources in the atmosphere.

In this case, the difference in CO2-eq emissions between the different scenarios can be useful in identifying the economic return that can be derived in 2030 from a possible resale of accumulated carbon credits.

In this case, it is possible to take the pessimistic scenario as an emission baseline, which gives the emissions (and removals) that would be generated in 2030 without further changes to agro-ecological practices compared to 2020. It is then possible to compare the emissions generated by the other scenarios (BAU, optimistic, very optimistic) where the possible changes in agricultural practices for the coming years are included. Finally, the difference in emissions generated can be converted into certifiable credits for farmers and sold on the voluntary carbon market. The price of a carbon credit (where a credit is equivalent to a tonne of CO2eq not emitted or subtracted), if we take as a reference the one related to forest carbon markets in Italy, is variable (Maluccio et al. 2019), but the latest projects for the creation of a voluntary carbon market report a suggested price of 20euro/tCO2eq (ARPAE 2020, GECO2 project).

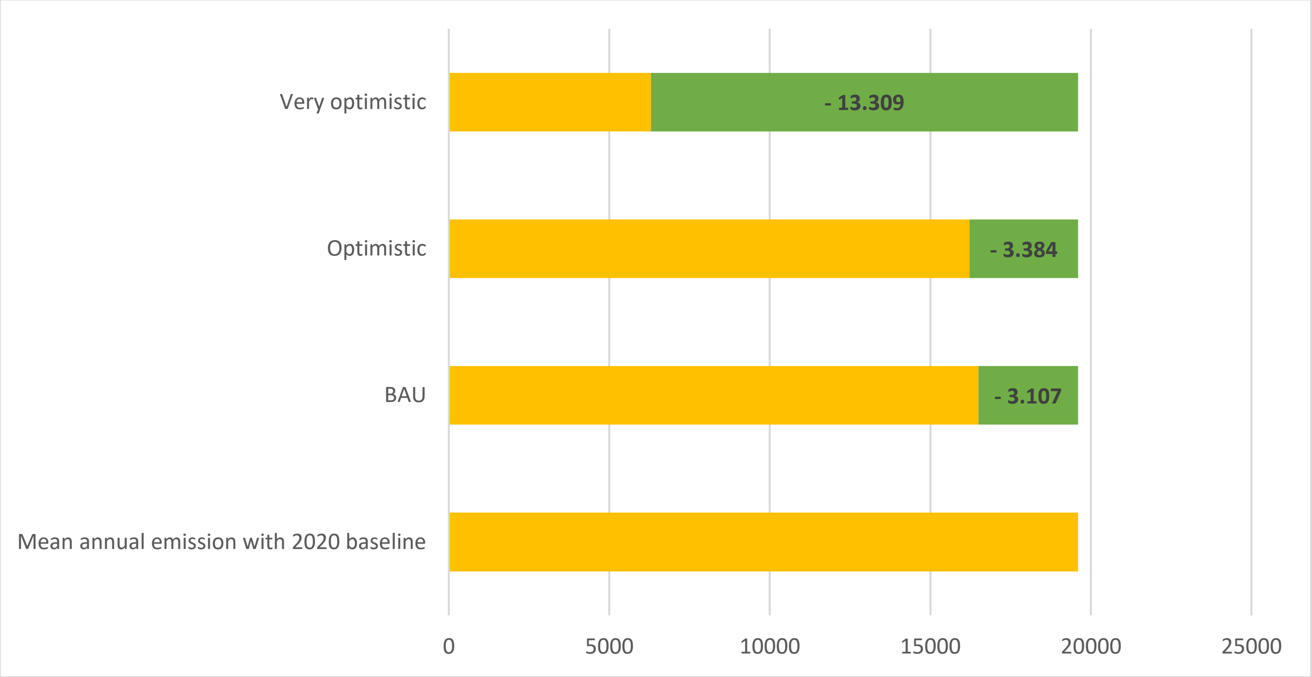


Fig. 4.5 *- Annual carbon credits certifiable by the change of agricultural practices to 2030 in arable land for the Valconca territory (own elaboration).*

In the following we associate the target price of 20 euro/tCO2eq with the difference in average annual emissions between the pessimistic scenario (the baseline from which we would start) and the scenarios with increased conversions: BAU, optimistic and very optimistic.

Tab 4.3 *- Carbon credits generable by conversion to agro-ecological practices and potential gains from their resale*

Baseline: annual tCO_{2}-eq emission (2020) to 2030	**Annual tCO_{2}-eq emitted in the scenarios to 2030**	**Generable credits** (Difference in tCO2-eq emissions between baseline and scenarios)	**Potential annual revenue (€)** from the sale of credits (1 carbon credit = 20 euro)
19.601 tCO_{2}-eq/year	BAU: 16.494 tCO_{2}-eq/year	3.107 carbon credits	62.140 €
	OPTIMISTIC: 16.217 tCO_{2}-eq/year	3.384 carbon credits	67.680 €
	VERY OPTIMISTIC: 6.292 tCO_{2}-eq/year	13.309 carbon credits	266.180 €

It should be noted that the difference between the annual emissions produced by the baseline and those produced in the very optimistic scenario could largely compensate for the CO2-eq emissions produced by livestock farms (especially methane and nitrous oxide) in the territory considered (about 5.915, for the year 2017, source: ARPAE 2020). Further validating the hypothesis of a plausible local carbon market on the model of the 'agricultural livestock and forest district' proposed by Chiriacò et al. (2020).

Finally, the price for the voluntary carbon market has been used in this calculation, but if with the new CAP, the carbon credits generated in agriculture will also be resaleable in the regulated market of the Emission Trading Scheme (ETS), the price could be considerably higher and even as high as 50 euros per tonne (Ember, 2021) of CO_2 equivalent removed or not emitted into the environment.
The new CAP is expected to include in the ecoschemes the so-called "carbon farming" (European Commission 2021b), i.e. measures to encourage and reward economically the adoption of a series of agricultural practices aimed at preserving/sequestering carbon in the soil.

4.3 The change of perspective introduced by the ecosystem services approach

The concept of ecosystem services, in addition to its practical usefulness, allows for a change of perspective: the environment seen as almost a container from which to take or into which to throw useful material (at the moment of extraction) and no longer useful (once it has ceased to be used) becomes instead an ally in the search for the well-being to which human beings aspire.

While it is true that the appreciation of nature in itself necessarily depends on the subjective component (personal experience, education, cultural context, etc.), the ecosystem services approach makes it possible to objectify (though not totally) the contribution (also expressed in economic value) that nature is able to provide to the well-being of human beings. If it is true that the well-being of all human beings (present and future) is the ultimate goal of sustainable development, the ecosystem services approach provides a valuable contribution in terms of methodology and knowledge. When we focus on the benefits offered by nature, and especially on those benefits that often go unnoticed or are taken for granted, be they air purification, soil erosion control, regulation of the carbon cycle, etc., the change in perspective becomes evident. This becomes even more obvious if one assigns a value that can be understood even by the non-specialist, such as economic value, with all its technical approximations. From this perspective, nature is no longer just something to be transformed in order to extract value or admired for its aesthetic beauty, but is reconfigured as an ally in the process of seeking well-being and prosperity that is gradually accumulating more and more individuals in the world. In fact, nature can be seen in itself as a large, self-organising organism that seeks, through the mechanism of natural evolution, the most efficient forms and processes, or those that are best suited to existence itself.

The moment we manage to understand this structural and processual complexity and imitate it, or use it (in a deliberately utilitarian way) to our advantage, we reduce the costs (economic, social and environmental) that are often associated with its replacement and destruction. In this sense, I see a new form of cooperation, that of cooperation with nature. And “human development” cannot take place without recognising in nature a fundamental ally, even for purely human objectives such as the search for an income, a safe haven or beauty.

5. CONCLUSIONS

In this work, an attempt was made to explore some of the dynamics of a rural area in the province of Rimini. First of all, an analysis of the investigated context was carried out by means of secondary data and direct interviews with mayors and local stakeholders. These initial analyses reveal a situation that is mostly in line with that reported in the literature for rural areas: the presence of a high environmental and cultural heritage, accompanied, however, by a general trend towards depopulation, a lack of some essential services and a general crumbling of community life .

Central to this study was an analysis of the potential, demand and budget (potential minus demand) for eco-system services in the area. through the expert-based matrix method (Burkhard et al., 2014).

In particular, the potential, demand and relative budget of some ecosystem services generated by the environments (and the socio-economic component) present in the territory were analysed through the expert-based matrix method (Burkhard et al., 2014). Although the results obtained with this method cannot be considered "absolute", they can provide an initial screening of the potential and criticalities inherent in the territory. The results clearly show that most of the regulating ecosystem services are in deficit, most likely due to the massive presence of agricultural land, and in particular arable land. These territories, which have a vocation for production, offer many provisioning services but require just as many, particularly regulating ecosystem services. The deficit of these services can lead to (often hidden) environmental costs, which have an impact on the economic and social spheres of the resident populations. An attempt has been made to estimate the cost of some of these deficits in ecosystem services. In particular, erosion could have very high annual costs of around €3 million per year (on average). Pollination, on the other hand, is crucial for this type of agricultural land. We have estimated that if this service were to fail, around 1 million euros would be lost annually due to lost production, particularly in orchards.

Finally, with regard to CO_2 emissions and absorption, it was noted that, according to ARPAE's findings, a hypothetical goal of climate neutrality (based on the example of the province of Siena) would not be within reach. In fact, the wooded territories (20% of the total surface of the area, in 2017) absorb only 11% of the CO2 emissions produced, with a deficit of approximately 120,000 tons of CO2. And the other climate-changing gases have not been taken into account, with a weight of around 17,000 tCO2eq for methane and 6,500 tCO2eq for nitrous oxide, for a total of almost 150,000 tonnes (tCO2eq) emitted in 2017.

But there is a possible solution for the integrated development of the area. Indeed, from the literature consulted, agro-ecological practices, thanks to the techniques adopted, can rebalance these deficits in services to a large extent, thus avoiding their costs. Organic farming practices, for example, can reduce soil erosion and allow the soil to act as a carbon sink, absorbing CO2. Moreover, these same practices can reduce farmers' dependence on pesticides and fertilisers, regenerating the biodiversity of agro-ecosystems (including pollinators). A key issue has been the lower yields of agro-ecological practices compared to conventional ones. On this point, the literature is discordant, but it seems that in the long run the difference disappears. Furthermore, there are already agro-ecological practices such as intensive organic farming (Jeavons, 2001) that aim to overcome this gap. Not to mention the issue of food waste: if we have to produce more because we can afford the luxury of wasting more, isn't it worth managing the food chain better, producing the right amount and reducing waste? This is a point that certainly needs further investigation.

The potential of organic farming, however, as found in the literature, is not limited to a reduction in environmental impacts, but also pervades the economic and social spheres, integrating with the development of the territory. The demand for organic products is growing and on average organic farmers have higher incomes than conventional farmers. Cooperative forms such as the bio-district have the advantage of influencing territorial social capital, strengthening the sense of identity and social cohesion that are so fundamental to the resilience of a community. For these reasons investigated in this work, it is believed that for the territory considered, consolidating the growing trend of organic farming and moving in the direction of forms of governance such as the bio-district may be a strategic direction to pursue for a possible regeneration and sustainable development of the territory.

APPENDIX

APPENDIX 1. Integral model interview used in the “Valconca Next” project by the “Piano Strategico Srl”.

RESPONDENT

INSTITUTION (if any)

DATE

PROFESSION/ROLE/
AFFILIATION

1. From the perspective of the sustainable development, what do you think are the main critical points in the Valconca areas today?

2. What are instead the main strengths of the Valconca areas?

3. Select a maximum of three sub-themes for each category of listed macro-themes:

3.1 TERRITORY

☐ Urban regeneration
☐ Land use and consumption
☐ Historic villages
☐ Hydrogeological instability and seismic concerns
☐ Landscape and river
☐ Depopulation

3.2 ENVIRONMENT

☐ Renewable energies
☐ Climate change mitigation and adaptation actions
☐ Management of natural resources (water, forests, etc.)
☐ Air, water, soil pollution

☐ Waste reduction
☐ Biodiversity protection

3.3 MOBILITY AND ACCESSIBILITY

☐ Cycle paths and cycling routes
☐ Local public transport
☐ Connections to the coast
☐ Policies to reduce private mobility
☐ Roads
☐ Road infrastructure (e.g. bridges)

3.4 WELFARE AND SERVICES

☐ Health, well-being and healthcare
☐ Needs of the elderly
☐ Migrants and refugees
☐ New poverties
☐ Equality and equity
☐ Differently abled

3.5 ECONOMY / ENTERPRIRE / INNOVATION

☐ Innovation and business competitiveness
☐ Social innovation
☐ Tourism
☐ Sustainable agriculture and animal husbandry
☐ School, training and employment
☐ Digital infrastructures and technologies

3.6 CULTURE / EDUCATION

☐ Enhancement of cultural institutions
☐ Events and cultural programming (exhibitions, theatre, music, cinema, art)
☐ Active citizenship
☐ Legality
☐ Security
☐ Systems/places of aggregation and local representation

3.7 OTHER (please specify) ______________________________

4. In 2015, the UN - United Nations Organisation, established 17 Sustainable Development Goals (SDGs) to be achieved by 2030, to respond to major global issues. Individual communities can also contribute to the achievement of these goals by taking action in their own specific areas.

Which priority objectives do you think should be addressed in order to ensure sustainable development in your area?

Note: here sustainability has a triple dimension, i.e. social, environmental and economic (tick maximum 3 objectives)

5. Use 1 to 3 words to describe the Valconca today

6. Use 1 to 3 words to describe how you would like the Valconca of the future to be (in a perspective of sustainable)

7. Could you suggest other people from the area to be interviewed? Which other subjects should, in your opinion, be involved in the participatory process of the Valconca Next project?

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