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Deliverable "Final Economic Evaluation of Soil Ecosystem Services"

Sub-action B4.3 "Assessment of soil ecosystem services in the study area "

LIFE+ PROJECT Soil4Wine

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1. Introduction: action and sub-action overview

This report presents the main outcomes of sub-action B4.3 "Assessment of soil ecosystem services in the study area". ART-ER is responsible for this action, while the other partner involved is UCSC.

Adoption of soil health improving techniques is expected to generate positive externalities: most important soil Ecosystem Services (ES) connected with soil management tested in pilot vineyards (temporary and permanent grassing, cover crops, underground drainage and green manure) are the following:

- Erosion protection
- Water yield
- Carbon sequestration
- Biodiversity preservation
- Landscape quality

In this sub-action all these ESs have been evaluated using different methodologies, and with reference to the project area when needed.

2. Ecosystem services and their economic evaluation

The Millennium Ecosystem Assessment (MEA) defines the ecosystem services as all those benefits provided by ecosystems to human beings. The starting point is the assumption that every living being on earth depends on ecosystems and their services like food, water, climate regulation etc. (MEA 2005). According to MEA, ecosystem services can be divided into four different categories:

- provisioning: all the ecosystem services that directly provide goods and/or services. Food is the simplest example, but also all those primary products like wood, metals minerals etc.;
- supporting: all those ecosystem services that allow the provision of other services i.e. soil formation and nutrients recycle, therefore availability of mineral elements as nitrogen, phosphorus, potassium and others fundamental for organisms' growth and development;
- regulating: it includes many ecosystem like water regulation, erosion regulation, pollination, regulation etc.;
- cultural: no-material benefits that people can get from an ecosystem trough spiritual enrichment, personal growth, beauty of landscapes.

It is estimated that from 1960 up to now two thirds of ecosystem services are declining due to human actions: the increasing demand for food, water, wood and energetic resources led to an important loss of biodiversity, for example.

In order to protect and therefore to supply an appropriate quantity of ecosystem services, it is very important to be able to understand the economic value of these services, even if for most of them there is no market, for many different reasons.

Therefore, quantifying in monetary terms the value of many ecosystem services is not easy. Over time different methodologies have been developed and tested in order to obtain reasonable estimates of the economic value of different ES in different conditions. The final goal of these methods, is to convey economic resources towards who handles the natural resources in such a way that they are more encouraged to preserve these resources.

The evaluation of economic, environmental and social benefits provided by ecosystems is a complex combination of qualitative, quantitative and monetary estimation of provided services. With reference to the last two ES, i.e. biodiversity and landscape, we have we used the contingent valuation method, a direct method in which, using interviews or questionnaires, a representative number of people is asked to state his/her willingness to pay for maintaining/providing the specified ES. This method is strategic to determine the value of goods that are not commonly exchanged on real market, and the research requires to organize a survey based on a relatively high number of individual evaluations.

3. Measuring the economic value of erosion protection

A vineyard managed with sustainable techniques reduces the soil loss due to sheet and rill erosion on the slope, reducing the inclination to landslide.

This ecosystem service has been calculated estimating the tons of soil that is not eroded thanks to sustainable viticulture.

The calculation method is based on RUSLE "*Revised Universal Soil Loss Equation*" defined as follows:

$$A = R \times K \times L \times S \times C \times P$$

where

A is the annual soil loss due to erosion [t/ha year];

R the rainfall erosivity factor;

K the soil erodibility factor;

LS the topographic factor derived from slope length and slope gradient;

C the cover and management factor;

P the erosion control practice factor.

The ES economic estimation is based on the method described in the 2nd Report on Natural Capital in Italy, published in 2018.

Considering the type of soil – agricultural soil used for vineyard – the Morri et al. (2014) method has been used. This method considers the substitution of lost soil with universal topsoil; its price is about 26 €/ton.

On the basis of pilot vineyards demonstrative activities, the yearly average value of the ecosystem service goes from 27 to 34 ton/year/ha and is strongly influenced by the rainfalls trend.

Therefore the economic value is estimated in 700 €/year/ha (from a minimum of 702 €/ha to a maximum of 884 €/ha).

4. Measuring the economic value of water yield

A vineyard managed with sustainable techniques increases the infiltration of water in soil, increasing the stock of groundwater.

This ecosystem service is calculated defining the cube meters of water infiltrated in the ground thanks to sustainable viticulture.

The calculation method is based on effective infiltration.

$$I_{eff} = P_{eff} \text{ x } CIP_g \text{ x } CIP_{pend/suolo}$$

where

I_{eff} = effective infiltration

P_{eff} = effective rainfall

CIP_g = infiltration factor related to permeability (Civita, 2005)

$CIP_{pend/suolo}$ = infiltration factor related to slpe gradient and soil use

P_{eff} is calculated with the equation

$$P_{eff} = P_a - ET_c$$

with Turc method (1954) and using a crop coefficient (T_c) that considers the average value between grapevine and cover crops.

$$ET_c = ET \text{ x } K_c$$

where

$$ET = P_a \sqrt{0.9 + \left(\frac{P_a}{L}\right)^2}$$

L =300 + 25 Ta +0.05 $Ta3$

P_a = yearly average rainfall (mm)

T_a = yearly average temperature (° Celsius)

K_c values are defined by FAO (*Crop evapotranspiration - Guidelines for computing crop water requirements - FAO Irrigation and drainage*).

The ES economic estimation is based on the cost of water for agricultural use in Emilia Romagna Region. The unit value is 1.2 €/m^3.

On the basis of pilot vineyards demonstrative activities, the yearly average value of the ecosystem service goes from 516 to 518 m^3/year/ha and is strongly influenced by the rainfalls trend and by geologic conditions.

The economic value of this ES is therefore estimated in 600 €/year/ha.

5. Measuring the economic value of carbon sequestration

A vineyard managed with sustainable soil management techniques increases the absorption of CO2 in soil, reducing the Green House Gases emissions.

This ecosystem service is calculated defining the tons of absorbed Carbon in soil, thanks to sustainable viticulture.

The calculation method is based on *IPCC Good Practice Guidance for LULUCF*, Chapter 3.3 Cropland. The case considered is "Cropland remaining cropland".

$$\Delta_{CC} = \Delta_{CClb} + \Delta_{CCsoils}$$

Where

Δ_{CC} = annual change in carbon stocks in soils in cropland remaining cropland

Δ_{CClb} = annual change in carbon stocks in soils in living biomass

$\Delta_{CCsoils}$ = annual change in carbon stocks in soils

Focusing on soils contribute, the formula is:

$$\Delta C_{CCSoils} = \Delta C_{CCMineral} - \Delta C_{CCOrganic} - \Delta C_{CCLime}$$

Where

$\Delta C_{CCSoils}$ = annual change in carbon stocks in soils in cropland remaining cropland, tonnes C yr^{-1}

$\Delta C_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

$\Delta C_{CCOrganic}$ = annual carbon emissions from cultivated organic soils (estimated as net annual flux), tonnes C yr^{-1}

ΔC_{CCLime} = annual C emissions from agricultural lime application, tonnes C yr^{-1}

And

$$\Delta C_{CCMineral} = [(SOC_0 - SOC_{(0-T)}) \bullet A] / T$$

$$SOC = SOC_{REF} \bullet F_{LU} \bullet F_{MG} \bullet F_I$$

Where:

$\Delta_{CCMineral}$ = annual change in carbon stocks in mineral soils, tonnes C yr^{-1}

SOC_0 = soil organic carbon stock in the inventory year, tonnes C ha^{-1}

$SOC_{(0-T)}$ = soil organic carbon stock T years prior to the inventory, tonnes C ha^{-1}

T = inventory time period, yr (default is 20 yr)

A = land area of each parcel, ha

SOC_{REF} = the reference carbon stock, tonnes C ha^{-1}

F_{LU} = stock change factor for land use or land-use change type, dimensionless

F_{MG} = stock change factor for management regime, dimensionless

F_I = stock change factor for input of organic matter, dimensionless

The ES economic estimation is based on the values used in the voluntary carbon market for offset projects developed in the agriculture sector (*State of the Voluntary Carbon Markets 2017*, Ecosystem Marketplace). The value is about 10 €/ton CO2eq.

On the basis of pilot vineyards demonstrative activities, the yearly average value of the ecosystem service is 2.8 ton C/year/ha.

The economic value of this ES is estimated in 44 €/year/ha.

6. Measuring the economic value of biodiversity

According to United Nations, ***biodiversity*** is defined as the variety and variability of living organisms and ecologic system where they live. Biodiversity is fundamental because, among other benefits, it also ensures productivity of each single ecosystem. The basic concept is that every species plays an important and specific role in its ecosystem and on the basis of its function contributes positively to ecosystem equilibrium maintenance.

Italy has one of the richest European biodiversity. In particular, our country has about half of vegetal species and about 30% of all the animal species existing in Europe.

There are many factors that cause loss of biodiversity. On global scale, the main factors are disruption of natural habitats, as results of natural disaster and human intervention.

According to FAO, in the last 10 years, on average, 13 million hectares have been destroyed. Many scientists agree that 20% of greenhouse gas emission come from deforestation and consequent loss of biodiversity (source: Ispra-ambiente).

Other threats to biodiversity are:

- climate changes,
- pollution,
- alien species,
- unsustainable hunting and fishing.

As we can imagine, biodiversity and ecosystems provide a wide range of services to society and economy.

A vineyard managed with sustainable techniques increases the consistency of species in soil, improving the habitat quality. This ecosystem service has been calculated measuring the biological quality of soil through micro arthopods or the consistency of microbe biomass. Pilot activities showed that SBQ-ar is higher in vineyards managed with innovative techniques.

During Spring 2019 empirical data have been collected through online questionnaires. The main goal of the questionnaire was to obtain the willingness to pay (WTP) of the interviewed people, indicating an estimate of the potential value of the supplied ecosystem services connected to biodiversity. People have a positive WTP when they agree to pay in order to benefit from an ES and to make sure that these services will be available also in the future. There could be also cases in which the WTP is equal to zero.

The number of people interviewed is 143 for the biodiversity questionnaire.

The survey has been designed for an *open ended* response, therefore without the help of the interviewer (direct contingent assessment), and the respondent performed a self-compilation via mobile or computer.

In order to avoid missing and/or partial answers, all replies have been made mandatory to be able to send the questionnaire.

The survey has been divided into 3 parts:

1. Introduction: the project SOIL4WINE has been described, including the objectives of the project, the aim of the questionnaire and instructions about filling the questionnaire.
2. The most important part: respondent were asked to state their WTP for a one-off payment for the ES in question.
3. In the third and last part some socio-demographic data have been collected from the respondent, in order to understand which group of people participated.

The sample of respondents cannot be considered fully representative of the universe of people that may put a value on biodiversity. In the sample the average age of respondents is fairly low. We expect that, on average, young people have a greater tendency to worry about environmental problems and issues, and as a result, in relation to the sample, this may in some way have influenced the identified WTP.

The questionnaire was administered by email and *WhatsApp*. It is evident that this methodology automatically leads, also for its intrinsic characteristics, to the exclusion of some categories of people: those who do not have the application of messaging and/or the e-mail address, which can be considered, in general, the older ones.

The data collected during spring 2019 has been analyzed, trying to understand the most important relations between the variables and how them influence the WTP that represents our final scope.

Main results of the statistical analysis are shown in Table 1. Some considerations can be obtained from these data.

i. The age range has been very important: the highest WTP observed is in the range <25 years and 25-45 years. This can be explained by the higher environmental awareness acquired by the new generations.
ii. With reference to education, respondents with a higher level of education expressed higher WTP.
iii. Income: also in this case, there is a positive correlation between this variable and WTP (higher income means higher WTP).
iv. Presence of son in the household: respondents with son(s)/daughter(s) have a WTP significantly higher respect the ones without sons/daughters.
v. The geographical area of residence, showed differences that do not appear to be significant.

Based on the average WTP, and considering all other information collected in table 2 with reference to the area of the case study (province of Piacenza and Cremona), we have obtained an average WTP €/ha-year-per capita equal to 60,75 €.

This value is not very high even but neither negligible; we must consider that in this case biodiversity was not clearly measured and was referred to micro-organisms and not nice small animals or birds that could have pushed the perception of the relevance of this ES towards higher values.
If we consider this specific characteristics of this case study, the final value is quite interesting, and, at the same time, quite reasonable.

Table 1: significant variables for WTP and relative averages for sample variables: biodiversity

Variable		**WTP (€/per-capita)**
Age	<25	7,65
	26-45	8,44
	46-60	3,00
	<60	2,57
Education	Elementary school	-
	Middle school	1,72
	High school	5,12
	Degree	8,61
	Post-degree	8,54
Income (€/year)	<15.000	6,60
	15.000-30.000	6,30
	30.000-60.000	5,38
	>60.000	15,02
Sons	yes	8,19
	no	2,53
Area of residence	City	Not significant
	Countryside	Not significant

Table 2: data used for estimation of WTP for improvement in biodiversity due to sustainable management scheme of soil in vineyards in the study area.

	Case study area PARMA AND PIACENZA
Avg WTP (€/per capita)	10,07
POPULATION (01/01/2018)	737.037
Tot ha of vineyard	6.110
Value of WTP €/ha	1215,09
WTP for grassing (€/ha-year-per-capita)	**60,75**

7. Measuring the economic value of landscape quality improvement

As confirmed by MEA many people appreciate natural landscapes and this fact reflects itself in preferences (and higher willingness to pay) to live in pleasant environment, visit parks and drive along panoramic roads, for example.

The beauty of landscape represents maybe the less discussed ecosystem service at the scientific level. According to OECD (2011) the evaluation of a landscape requires to identify and separate characteristics and their value, if possible.

Characteristics can be identified in the objective components of landscape, while the value depends on functions that the landscape is able to provide. If people can obtain benefits (monetary and not) it is possible to speak about value of landscape (Tempesta e Thiene, 2006).

A vineyard managed with sustainable techniques improves the landscape quality, with benefits that, to some extent, can also be of interest for tourism. In our case, however, the objective was to evaluate the value of ecosystem service as an aesthetic one without any a physical quantification. It is important to underline that in this study we did not evaluate the aesthetic value of a vineyard but of the modification of soil management in the vineyard (grass cover, of different type, with respect to soil without any cover).

The ES economic estimation is based on the results of a survey (206 contacts) aimed at defining the willingness to pay for this specific landscape improvement by stakeholders.

During Spring 2019 empirical data have been collected through online questionnaires. The main goal of the questionnaire was to obtain the willingness to pay (WTP) of the interviewed people, indicating an estimate of the potential value of the supplied ecosystem services. People have a positive WTP when they agree to pay in order to benefit from an ES and to make sure that these services will be available also in the future. There could be also cases in which the WTP is equal to zero.

The survey has been designed for an *open ended* response, therefore without the help of the interviewer (direct contingent assessment), and the respondent performed a self-compilation via mobile or computer.

In order to avoid missing and/or partial answers, all replies have been made mandatory to be able to send the questionnaire.

The survey has been divided into 3 parts:

1. Introduction: the project SOIL4WINE has been described, including the objectives of the project, the aim of the questionnaire and the instructions.
2. The most important part: respondent were asked their WTP for a one-off payment for the ES in question. Examples pictures were also used in the questionnaire.
3. In the third and last part some socio-demographic data have been collected from respondents, in order to understand which group of people participated.

Even in this case, the sample of respondents cannot be considered fully representative of the universe of people that may put a value on aesthetic value of the landscape. The average age of respondents to the questionnaire is fairly low. We expect that, on average, young people have a greater tendency to worry about environmental problems and issues, and as a result, in relation to the sample, this may in some way have influenced the identified WTP.

As already noted, the questionnaire was administered by email and *WhatsApp*. It is evident that this methodology automatically leads, also for its intrinsic characteristics, to the exclusion of some categories of people: those who do not have the application of messaging and/or the e-mail address, which can be considered the older ones.

The data collected during spring 2019 have been analyzed, trying to understand the most important relations between the variables and how them influence the WTP that represents our final scope.

As can be noticed from data presented in table 3, the variables that influence the WTP of people result to be: age, level of education, income and presence of sons or not.

More in detail, for what concern the study of the beauty of landscape, it is possible to make some considerations:

i. With respect to age range, the 45-60 years was the one with the highest WTP (8.94 €), while the category with less propensity turns out to be over 60 years. This can be explained in the less environmental awareness that on average this category of people can have also related to the type of education received.

ii. Education is also a very important variable, in this case the higher WTP has been recorded in the respondents with a high level of education, such as graduated and post graduates. Follows high school, middle school and finally elementary, even if in this last class the number of observations was much less than in the other classes.

iii. For what concerns income, the largest WTP (14.00 €) was expressed, as forecast, for the higher income classes, that is to say income of >60,000 € per annum. With a clear separation from those who instead belonged to the other income classes.

iv. For the category number of sons, in the study related to the beauty of landscape, the difference between who gave positive response and negative response wasn't particularly significant.

v. Same for area of residence.

Table 3: significant variables for WTP and relative averages for sample variables: landscape beauty

Variable		**WTP (€/per capita)**
Age	<25	5,79
	26-45	4,75
	46-60	8,94
	<60	2,25
Education	Elementary school	1,75
	Middle school	2,33
	High school	6,65
	Degree	7,97
	Post-degree	7,66
Income (€/year)	<15.000	5,70
	15.000-30.000	7,16
	30.000-60.000	8,21
	>60.000	14,25
Sons	yes	7,14
	no	6,64
Area of residence	City	6,75
	Countryside	6,85

The estimate of the average WTP was necessary to give an average value to the willingness to pay of each person, expressed in one-off euro payment that has been and converted into euro/per-capita-year-ha.

Table 4: value of annual per capita WTP for 1 ha of area planted with vines using grassing as an agronomic technique

	Case study area PARMA AND PIACENZA
Avg WTP (€/per capita)	8,64
POPULATION (01/01/2018)	737.037
Tot ha	6.110
€/ha	1041,92
WTP for grassing (€/ha-year-per-capita)	**52,10**

8. Conclusions

Since the end of the 1990s, the economic evaluation of ESs has become of increasing application importance, gaining strategic importance in those environmental processes aimed at safeguarding goods and services which are functional to the well-being of man and his activities. Nevertheless, ESs are generally not included in land-use planning criteria, in which they do not take into account the costs arising from the loss of services.

However, if recognised economic instruments and methods are used, results can be achieved and shared. Monetary judgment it is a common estimation method that facilitates cost-benefit analyses and is useful in order to judge the criticalities or potentialities associated with particular management measures and helps public and governmental bodies to possible interventions.

Overall the completion of this sub-action has made possible, not without difficulties, to obtain a reasonable estimate of the economic and monetary value of the 5 most important ESs provided by a sustainable management of soil in vineyard (mainly based on grassing).

The final values obtained using different methodologies, are the first step for the next activity planned in sub-action B.4.4 Innovation in soil conservation policies, focused on the development of Payments for Ecosystem Services (PES).