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# MOSYSS Project
# MOnitoring SYstem of Soils at multiScale

*Monitoring system of physical, chemical and biological soil parameters in relation to forest and agricultural land management*

Mauro Tiberi, Giovanni Ciabocco, and Cristina Bernacconi, Francesca Bampa, Martha Bonnet Dunbar, Luca Montanarella

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# MOSYSS Project

## MOnitoring SYstem of Soils at multiScale

*Monitoring system of physical, chemical and biological soil parameters in relation to forest and agricultural land management.*

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## Abstract

MOSYSS is a project launched in June 2010 by the Agriculture, Forest and Fisheries Department [Servizio Agricoltura Forestazione e Pesca] of the Marche Region, Italy. It has been coordinated by the Regional Soil Observatory [Osservatorio Regionale Suoli] as part of the assessment activities of the Rural Development Plan (RDP) Marche 2007-2013 [Piano di Sviluppo Rurale - PSR] as described in the Common Monitoring and Assessment Framework [Quadro Comune di Monitoraggio e valutazione – QCMV].
Among the objectives is the creation of a permanent soil monitoring system for the whole Marche territory, combining technical and scientific requirements (e.g. rigour and representativeness) while at the same time optimising financial and organisational resources. The information obtainable from the monitoring system could potentially be upscaled, on a functional basis, to other existing soil and biodiversity monitoring networks at national and EU level.
The main function of the project is to investigate soils starting from their intrinsic properties (e.g. chemical, physical or biological) in order to obtain a detailed evaluation of their current "quality" status, and to monitor, over time, changes in these parameters by repeating the monitoring campaign at pre-established time intervals.

## Sommario

MOSYSS è un progetto avviato nel Giugno 2010 dal Servizio Agricoltura Forestazione e Pesca della Regione Marche e coordinato dall'Osservatorio Regionale Suoli nel quadro delle attività di valutazione del PSR Marche 2007 2013 previste dal Quadro Comune di Monitoraggio e valutazione (QCMV).
Tra le finalità è previsto l'allestimento di un sistema permanente per il monitoraggio dei suoli dell'intero territorio Marchigiano, che concili esigenze di rigore e rappresentatività tecnico-scientifica e ottimizzazione delle risorse finanziarie ed organizzative. Le possibilità informative del sistema di monitoraggio potranno rappresentare un potenziale inserimento funzionale nelle altri reti di monitoraggio dei suoli e della biodiversità esistenti a scala nazionale ed europea.
Funzione principale è quella di indagare i suoli dal punto di vista delle loro proprièta intrinseche (chimiche, fisiche e biologiche) per ottenere una dettagliata valutazione dello stato attuale della loro "qualità", e di controllare nel tempo i cambiamenti di tali parametri attraverso la ripetizione delle campagne di monitoraggio a periodi prefissati di tempo.

## Acronyms

| | |
|---|---|
| ABEs | Analogous Benchmark Environments |
| C | Carbon |
| CAP | Common Agricultural Policy |
| CMAF | Common monitoring and evaluation framework |
| $CO_2$ | Carbon Dioxide |
| DOC | Denominazione di Origine Controllata |
| DPSIR | **D**riving forces, **P**ressures, **S**tates, **I**mpacts and **R**esponses |
| EAFRD | European Agricultural Fund for Rural Development |
| EC | European Commission |
| EU | European Union |
| FMS | Farm Management Systems |
| GAEC | Good Agricultural and Environmental Condition |
| GSP | Global Soil Partnership |
| $H_2O$ | Water |
| LULUCF | Land Use, Land Use Change and Forestry |
| MEA | Multilateral Environmental Agreements |
| MS | Member States |
| N | Nitrogen |
| RDP | Rural Development Plan |
| RRE | Roadmap to Resource Efficient Europe |
| SOC | Soil organic carbon |
| SOM | Soil organic matter |
| UNFCCC | United Nations Framework Convention on Climate Change |
| UNCBD | United Nations Convention on Biological Diversity |
| UNCCD | United Nations Convention to Combat Desertification |
| UTAs | Farmland Units |
| UTSs | Soil Type Units |

## Introduction

The Marche Region, in accordance with the Council Regulation EC Reg. 1698/2005 and successive amendments (EC, 2005; EU, 2013), has organised a *"supervisory and assessment system"* as a tool to support the implementation of the RDP Marche 2007-2013.

Engine of the *"supervisory and assessment system"* is the "*monitoring and assessment system*" organized in cooperation with the national level to compare and combine information and guidelines developed by the National Monitoring System. The monitoring system refers to the methodology established by the Common Monitoring and Assessment Framework agreed between the EC and Member States (MS), which identifies a number of common indicators that can be applied to each programme, in line with what has been established at national level.

The ability of the Management Authority to prepare, adapt, manage and monitor each phase of the programme's implementation determines the efficacy and effectiveness of that programme. Following the art. 66 of EC Reg. 1689/2005 comma 2, RDP Marche 2007-2013 foresees technical assistance to support the programme's implementation and the assessment activities.

Concerning the protection, conservation and improvement of the soil as a resource, in line with the special attention paid by the Marche Region in the previous programming period 2000-2006 and beyond, the actions to support the assessment provides in particular for **the monitoring of changes in chemical, physical and biological parameters of soils with respect to normal agri-forest activities and the agri-forest activities included in the RDP agri-environmental measures.** Such action has the aim of carrying out timely counterfactual assessments of positive impacts obtained through the implementation of the RDP measures with particular reference to agri-environmental measures.

A more in-depth knowledge of soil and its formation processes also contributes toward improving the regional agri-forest system to mitigate the risks of soil degradation in compliance with the EU's environmental policies and in line with the *EU Thematic Strategy for Soil Protection* (COM (2006) 231final) and (COM(2012)46 final)[1] that outlines the overall strategy concerning soils in the

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[1] In October 2013 the EC elaborated *REFIT*[1] *- the Regulatory Fitness and Performance Programme: Results and Next Steps* (COM(2013) 685 and its Annex). The EU legislation reviews proposed the withdrawal of the pending proposal for a Soil Framework Directive, stalling since 2006. The EC on 30th April 2014 took the decision to withdraw the proposal for a Soil Framework Directive (OJ C 153 of 21 May 2014 and corrigendum in OJ C 163 of 28 May 2014).

European Union (EU). Taking into account these premises, the project activities were developed to meet two main requirements:

- acquire information and data on the status of the soil in the Marche Region, in relation to the management of agricultural and forestland activities and with new approaches introduced and incentivised by RDP measures;
- represent the information collected and gleaned at several levels of assessment: farm, district, region

The project developed for this purpose, entitled **MOSYSS (MOnitoring SYstem of Soils at multiScale)** provides for the realisation of a soil and land monitoring system that through its structure and organisation enables data to be geographically represented at several scales. Moving from a detailed scale to a more generic scale is guaranteed through a careful selection of monitoring sites that are identified on the basis of the variables to be measured and the homogeneous environment they belong to.

The project will involve the proactive work of the Regional Soil Observatory, an operational unit within the Agriculture, Forest and Fisheries Department, has launched and conducted several soil, pedologic and land monitoring and mapping initiatives/campaigns at regional and local scales.

# 1 MOSYSS objectives

## 1.1 Standards and institutional framework

Soil, together with water and air, is one of the key elements of the environment. Soil is defined as the top layer of the Earth's crust and is composed of minerals, water, air and organic matter, including living organisms. It is a complex, mutable, living resource that performs many vital functions: food and other biomass production, storage, filtration and transformation of substances including water, carbon (C) and nitrogen (N). It further serves as a habitat, provides a basis for human activities, landscape and heritage, and the supply of raw materials (EC, 2006a, 2006b, 2009, 2012; Louwagie, S. H., & A., 2009). Soil, like water and air, should be preserved and used according to its suitability and according to sustainable principles.

The recognition of the role of soil as a resource is increasing, not only in relation to food production (i.e. agricultural sector), but also in other areas (e.g. climate change, biodiversity, desertification, contamination, waste and energy-related policies). As early as 1972 the Council of Europe had identified soil as *"…one of humanity's most precious assets. It allows plants, animals and man to live on the earth's surface*". In the early times of the implementation of the three major multilateral environmental agreements (MEA) negotiated in 1992 at the Rio Conference (UNFCCC 1992), addressing respectively three conventions on climate change (UNFCCC), biological diversity (UNCBD) and desertification (UNCCD) very little attention was paid to soils. But in recent years a surge of interest could be observed within the LULUCF negotiations in the framework of UNFCCC (IPCC 2003b and LULUCF, SWD ((2012) 41 final)), by the soil biodiversity within the UNCBD that has recently projected soil and soil organic carbon (SOC) in the global negotiation, further special attention to soils has also been developing within the UNCCD implementation process, especially since the shift of attention from drylands to a more global approach to land degradation. Recently the world leaders gathered at the United Nations Conference on Sustainable Development (Rio+20 – June 2012) to agree on a sustainable goal on land. The proposed Sustainable Development Goal of a "**Zero Net Land and Soil Degradation World**" paves the way towards a renewed global effort on land, soil protection and restoration activities, including food security and poverty eradication. The goal needs to be achieved by 2030 and will require the commitment of both public and private sectors (Ashton 2012). FAO, with strong support of the European Commission (EC), is developing a **Global Soil Partnership**[2] (GSP) to address sustainable management of global soil resources and federate all stakeholders and parties that are willing to

[2] http://www.fao.org/globalsoilpartnership/en/

move on with effective soil protection measures. The partnership should establish a more effective science-policy interface addressing policy relevant scientific and technical issues related to soils (Montanarella and Vargas 2012).

At EU level soil protection and conservation is a relevant resource addressed under different EU policy areas. Already in 2002, with the a **Decision N° 1600/2002/EC** of the European Parliament and of the Council laying down the Sixth Community Environment Action, it has been established the *Sixth Community Environment Action Programme* of the EU Community (EP 2002). The Programme defined the priorities and objectives of EU environment policy up to 2010 and beyond describing the measures to be taken to help implementing the strategy.

With the **EU Thematic Strategy for Soil Protection** (COM (2006) 231final) and its related proposal for an EU Soil Framework Directive (COM (2006) 232), recently reviewed by the EC in an implementation of the EU Soil Thematic Strategy (COM (2012) 46 final) the EU clearly states that soils are a non-renewable resource subject to a series of degradation processes or threats: erosion, decline in organic matter, local and diffuse contamination, sealing, compaction, decline in biodiversity, salinization and landslides. Nevertheless, the EU Soil Framework Directive is one of the elements of the EU Thematic Strategy that also includes the systematic integration of soil protection elements in other related EU legislative instruments, such as the **Common Agricultural Policy** (CAP), the climate change policy, in relation to the **LULUCF** Accounting (Land Use, Land Use Change and Forestry), and the natural resource management – the **Roadmap to a Resource Efficient Europe** (RRE) (COM (2011) 571 final), all highlighting the relevance of soil and the need to protect and preserve the land in many states of the EU.

The Resource Efficiency Roadmap is part of the Resource Efficiency Flagship of the *Europe 2020 Strategy*. The Roadmap aims to set out a framework for the design and implementation of future actions in resource efficiency. It also outlines the structural and technological changes in the EU's economy needed by 2050, including sustainability milestones to be reached by 2020. It proposes ways to increase resource productivity, to decouple economic growth from resource use and its environmental impact, and it investigates how policies interrelate and build on each other. Areas where policy action can make a real difference are of particular focus, and specific bottlenecks, like inconsistencies in policy and market failures, are tackled to ensure that policies are all going in the same direction. The framework for actions comprehends many policy areas, such as climate change, energy, transport, industry, raw materials, agriculture, fisheries, biodiversity and regional development. The soil and land related milestone indicates that by 2020 EU policies must take into account their direct and indirect impact on land use in the EU and globally and that the rate of land take is on track with the aim to achieve zero net land take by 2050, soil erosion is reduced and soil organic matter increased, with remedial work on contaminated sites well underway.

A substantial proportion of land in EU is occupied by agriculture, and consequently this sector plays a crucial role in natural resources protection. An efficient agricultural management can maintain the same rate in food production while having a positive effect on the state of soil. The CAP is the agricultural and rural development policy of the EU concerned with ensuring sufficient food at reasonable and stable prices. Its main goal is to ensure food security, but nowadays the CAP is designed to meet a wide range of needs, including the maintenance of farm incomes and good farming practices, enhancing food quality and promoting animal welfare. In particular, the interaction between agriculture and the environment is integrated by the concept of sustainable agriculture. With respect to soil protection the CAP contributes preventing and mitigating soil degradation in order to build-up of SOM, enhance soil biodiversity and reduce soil erosion, contamination and compaction. The CAP reform process 2014-2020, fruit of three years of reflection, started in 2010 with a public debate. Based on the outcome of this public debate with the Council and the EU Parliament, in 2010 the EC released a Communication on "*The CAP towards 2020*" which outlines options for the future agricultural policy and launched the debate with the other institutions and with stakeholders. The Communication remarked on how farming practices could limit soil depletion, water shortages, pollution, C sequestration and loss of biodiversity. The CAP toward 2020 considered the enlargement negotiations between the candidate countries and the EU, with the aim to strengthen the competitiveness and the sustainability of agriculture, preserving the environment and helping the development of rural areas. The CAP reform process initiated a gradual strengthening of the integration of environmental objectives as part of market policies and for rural development. On 26$^{th}$ June 2013 a political agreement on the CAP reform was reached between the EC, the EU Parliament and the Council. In the revised CAP, all Member States will be asked to develop proven measures to help farmers meet the challenges of maintaining and improving soil and water quality, biodiversity while meeting the challenges of climate change. Specifically, the following elements should promote soil organic matter content:

- 30% of direct payments will be linked to three environmentally-friendly farming practices: crop diversification, maintaining permanent grassland and conserving 5%, and later 7%, of areas of ecological interest as from 2018 or measures considered to have at least equivalent environmental benefits;
- At least 30% of the rural development programmes' budget will be allocated to agri-environmental measures, support for organic farming or projects associated with environmentally friendly investment or innovation measures;
- Agri-environmental measures will be stepped up to complement greening practices. These programmes will set and meet higher environmental protection targets.

The Fischler reform in 2003 introduced a mechanism of **Cross Compliance** as a horizontal tool for both pillars of the CAP and has been compulsory since 2005 with the primary purpose to promote a more sustainable agriculture. Cross compliance is a mechanism according to which farmers are beneficiaries of direct payments must comply with certain common rules and standards as regards environmental protection with particular reference to the protection, conservation and improvement of the soil as well as public, animal and plant health and animal welfare (currently Council Regulation (EC) N° 73/2009). Cross compliance is an important instrument of the CAP that links the support farmers receive to the respect of the environment. It affects the agriculture-soil link either directly (via requirements that directly target soil use) or indirectly (by influencing other resource management decisions that have implications for soil use). The framework of cross compliance includes Statutory Management Requirements and **Good Agricultural and Environmental Condition** (GAEC). Regarding the second one, farmers receiving CAP payments must be compliant with a set of obligations for keeping the land in Good Agricultural and Environmental Conditions (GAEC) designed to:

prevent soil erosion;

maintain SOM and soil structure;

- ensure a minimum level of maintenance;
- avoid the deterioration of habitats;
- protect and manage water, including the protection of water against pollution and run-off;
- maintain the ratio of permanent pastures.

Through the GAEC, three soil issues are recognised as crucial:

**Soil erosion** through a minimum soil cover, minimum land management reflecting site-specific conditions and retaining terraces;

**Soil structure** through appropriate measures and machinery use;

**Soil organic matter** through appropriate measures as arable stubble management and standards for crop rotations.

GAEC constitutes a common policy framework toward certain aspects of agricultural soil protection, and land and landscape maintenance and it is currently the only EU instrument to manage SOC. It is up to the MS to define the minimum requirements regarding soil in accordance within the framework. The Council Regulation, however, does not provide either common 'minimum' standards in the above respects or an indication of what the minimum should be. Some MS have used GAEC framework to compensate for gaps in their existing national legislation on soil protection, whereas other MS already had a legislative basis in place. This means that the extent and detail of the GAEC requirements developed varies greatly across MS so that some technical measures established in some countries might be insufficient and ineffective for some instance and for some others they could well go beyond the scope.

For this reason, cross compliance, and especially its GAEC component can plays an important role in the protection, conservation and improvement of natural resources such as the soil. A farmer's failure to respect cross compliance can result in deductions from, or complete cancellation of, his direct payments and support for some rural development measures (such as agri-environmental measures).

The Fischler reform, as a support strategy, pays also special attention to advising farms (*farm audit*) and assigns a central role to "regional departments' that must provide effective information materials for good land management and compliance. In this regard, knowledge of natural resources and the processes by way of which they change, sustainable management of rural territories, and the realisation of monitoring and information dissemination (*reporting*) activities become particularly important.

The Council Regulation (EC) n° 1698/2005 of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), together with the Council Regulation (EC) 1290/2005 of 21st June 2005 on the financing of the CAP, form the main legal basis for the implementation of rural development policies.

The 2007-2013 programming period reflected the main priorities of the EU, as stated in the conclusions of the Lisbon (2000) and Gothenburg (2001), aiming to achieve practical implementation through new rural development policies.

In addition, the European Conference on Rural Development hold in Salzburg in 2003 identified some fundamental principles of rural development, such as the importance of "*living rural territories, safeguarding the land through* ***multifunctionality****, increasing the competitiveness of the agricultural sector, safeguarding the principles of subsidiarity and pursuing the general interests of society*".

In the Council Regulation 1698/2005 on support for rural development by the EAFRD, the challenges of future rural development policy include the *economic, social and environmental* sphere, following the *sustainable development* guidelines, affirming the need to work on the one hand from *a sectorial point of view* and on the other with a *territorial approach*.

Concerning the Gothenburg strategy, the EU Council also noted that the two pillars of the CAP contribute to achieving *sustainable development*, by fostering food security and food quality, organic farming methods, the use and production of renewable raw materials and protecting biodiversity.

In the strategic community guidelines, the Council also states that future rural development policy will be centred on three key areas:

a) *agri-food production economy*

b) *environment*

c) *rural economy and populations*

The mid-term amendments to the CAP *(Health Check - 2008)* established in Regulations n° 73 and 74 of January 2009 confirmed the strategic directions introduced by the Fischler Reform and restated the importance of soil conservation in rural development strategies and policies up to 2013 and also for the subsequent programming period after 2013.

The CAP reform brings with it several innovative components including in terms of tools, implementation and organisational procedures for action. Discussions by many MS, that are critical of the CAP's future, have led to closer attention being paid to the assessment of results obtained and the effectiveness and efficacy of actions undertaken for the practical growth and development of the EU.

The adoption of a strategic approach to programming and greater transparency regarding the plan of 2007-2013 rural development policies focus on **reporting** on results obtained.

The new programming system involves, in turn, the EC, the MS and local authorities and thus requires a common framework of indicators able to perform appropriate assessments ( through **monitoring**) and **verify** results actually obtained.

For this purpose the EC has instituted the Common monitoring and evaluation framework (CMAF), through Art. 80 of Council Regulation (EC) n° 1698/05 related to the rural development programme, which defines common elements and guidelines upon which monitoring and assessments activities are to be structured and managed. The monitoring and assessment systems put in place by individual MS in compliance with the CMAF must be able to provide clear information that can be compared and aggregated, and above all meaningful. The CMAF introduces several new ways to improve the quality and use of information produced by monitoring activities:

- more attention to initial indicators in order to have the best possible information on how to create a rural development programme;
- aggregating physical and economic monitoring data, results and impacts in order to check that goals are met;
- introduction of on-going assessments to support the various phases of the programme's implementation.

These new approaches do not only represent a new method to satisfy the information requirements of the EC, but trace out a new organisation for assessments, based on new basic concepts, which prerequisite should be the quality of results.

The resulting assessment must no longer just be a final product, but should represent an on-going work that supports the programme during its implementation.

An assessment must not be limited to analysing "processes", but must also record, describe and where possible measure the "effects" of implementation of programme measures.

In order to carry out such assessment activities, various types of data and information are required. Monitoring activities and the subsequent availability of data are indispensable for effectively and accurately assessing the effects of actions funded by the RDP. Moreover, such activities, especially when assessing agri-environmental measures, often require observations and direct measurement of phenomena.

The Marche Region, pursuant to Art. 66 of Reg. EC 1698/2005, paragraph 2, as amended, provides, as part of the RDP, for resources to finance preparatory activities, management, surveillance, assessment, information, and monitoring of actions planned under the programme.

With respect to the procedures for technical assistance at regional level, letter "f" provides for specific intervention as part of the programme Monitoring and Strategic Environmental Assessments. Considering the importance of protection, conservation and the improvement of the soil as a general objective of the EC and the Marche Region itself, the Marche programme also provides for special monitoring activities to measure changes in soil quality parameters with respect to normal agri-forest activities and with regard to the agri-environmental measures introduced by the RDP.

This action has the main aim of supporting assessment activities by providing data and information about soils and on agri-forest land management that is vital for counterfactual analysis of positive or negative impacts of the application of RDP measures with particular reference to agri-environmental measures.

Specifically, the aim is to support the work planned in the RDP assessment project by building up "prepared information" themes that are useful for assessment activities in answering the "*common assessment questionnaire*" for Measures 214, 221,223, (225) 226, and 227 and for answers to the *"transversal assessment questions"* relating in particular to the *"soil"* theme and agri-forest land management.

The indirect aim of such work is to increase knowledge of regional soils which can be used to identify the best management strategies for land able to provide the right balance between maintaining soil functions, protection, conservation and improving its quality features, as protection from risks of degradation. Soil degradation risk mitigation is one of the priority goals of the EU Directive "Thematic Strategy for Soil Protection" (COM/2006/231) approved by the European Parliament on 13/11/2007.

## 1.2 General aims

To create a database on soils and agri-forest management of regional land to provide technical and information support for **planning and governance activities in the territory, and assessment activities** relating to the measures adopted with particular reference to the implementation of the Rural Development Plans with agri-environmental measures aimed **at maintaining or improving** land.

Soil monitoring takes place by setting up "ordinary" sites to measure changes in chemical, physical and biological variables and subsequent pedolandscape correlations and by "dedicated" sites to examine specific themes such as those related to degradation risks (e.g. loss of organic matter, risk of water erosion, compaction risks, etc.).

Monitoring of the agri-forest management of regional land requires the identification and delimitation of **Farmland Units** (***UTAs***) representing the area that is being monitored. Regarding the UTAs chosen as monitoring sites, we note:

- situations due to variations in agri-forest management;
- variations due to new information acquired about pedogenetic factors;
- variations due to usage and intended uses;
- variations following public intervention – incentives and planning.

Monitoring soil changes is closely linked to the concept of "**soil quality**" defined by all of the features that can satisfy users, whether for crops, to protect underground waters, the construction of buildings, or maintaining protected areas, etc. According to this definition, it is clear that **quality is specific for each soil type.**

In this regard, the term soil monitoring should be understood as **"the systematic determination of soil variables to identify changes over time"** (FAO/ECE International Workshop on Harmonisation of Soil Conservation Monitoring Systems – Budapest 1993).

The main tool to implement monitoring is defined by **"a group of sites/areas in which changes in soil features are documented by regular analyses, performed using common methodologies, of a set of parameters chosen for the purpose."**

In order to be interpreted in the best way possible, the monitoring system must be identified and linked within a DPSIR (**D**riving forces, **P**ressures, **S**tates, **I**mpacts and **R**esponses) model.

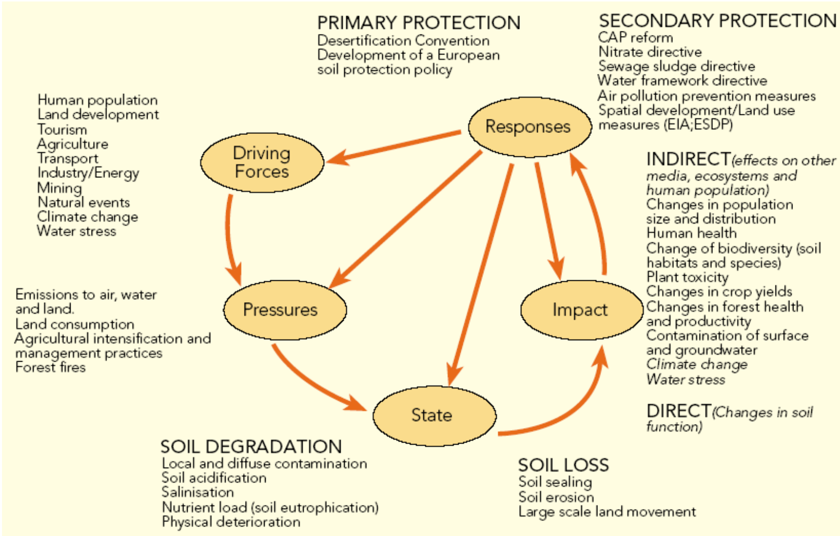



**Figure 1 - DPSIR assessment diagram – driving forces, pressures, states, impacts, responses**

As can be seen from the DPSIR diagram, "Driving Forces" introduce "pressure" conditions into the soil. Pressures can lead to variations in "States" and thus give rise to "Impacts". It is therefore clear that a monitoring system must be able to detect variations not only in the "State" of the item being monitored but also variations in "Pressures" generated by the "Driving Forces".

The goals of the monitoring system cannot be viewed in relation to static concepts but on the contrary based on dynamic concepts able to intercept variations, assess and measure them, or in other words to monitor them.

## 1.3 1.3. - Specific goals

To create factsheets to support assessment activities regarding the *"common assessment questionnaire*" for the Agri-environmental Measures of the Marche RDP 2007-2013, and to provide answers to the *"transversal assessment questions"* relating in particular to the *"soil"* theme and agri-forest land management.

Regarding the common assessment questionnaire, the following Table lists the questions relating to Measure 2.1.4 for which, either directly or indirectly, information about soils and their management are needed and for which the MOSYSS network will be able to provide a useful contribution to formulating answers. Similarly, the common questionnaire identifies points relating to all of the other agri-environmental measures.

| | |
|---|---|
| ***Measure*** | ***Agri-environment payments (Article 36, letter a), point iv), of Council Regulation (EC) N° 1698/2005)*** |
| ***Measure code*** | *214* |
| ***Questions*** | *How have agri-environment measures contributed to maintaining or promoting sustainable agricultural production systems?*<br><br>*How have agri-environment measures contributed to maintaining or improving habitat and biodiversity?*<br><br>*How have agri-environment measures contributed to maintaining or improving water quality?*<br><br>*How have agri-environment measures contributed to maintaining or improving land?*<br><br>*How have agri-environment measures contributed to mitigating climate changes?*<br><br>*How have agri-environment measures contributed to maintaining or improving landscapes and their features?* |

Concerning "transversal assessment questions", the points involving, directly or indirectly, "soil" and agri-forest land management are:

- How has the programme contributed to promoting sustainable development in rural areas? Specifically, how has the programme contributed to the three priority sectors for the protection and improvement of natural resources and landscapes in rural areas:
- biodiversity and preservation and the development of agricultural and forest systems of high natural quality and of traditional agricultural landscapes?
- water?
- climate change?
- How has the programme incorporated environment objectives and contributed to realising Community priorities as regards:
- the Gothenburg undertaking to reverse the decline in biodiversity?

- the objectives laid down by Directive 2000/60/EC establishing a framework for Community action in the field of water?
- the Kyoto Protocol objectives to mitigate climate changes?
- How has the programme focused on the specificity of agricultural activities in the programming area as regards:
- the structural and natural conditions of the programming area?
How has the programme contributed to the integrated approach to rural development?
How has technical assistance increased the capacity of the management authorities and other partners involved in the implementation, management, monitoring and assessment of the rural development programmes?
How has the EU network for rural development contributed to the instigation of good practices for rural development?

## 1.4 1.4. - Strategic goals

a – on-going advances in knowledge of regional soils and the processes of change relating thereto;
b – verify, over time, on the basis of monitoring data, conservation data and/or improvements in **functional quality of soils and land**;
c – verify, over time, determining features related to degradation phenomena that might pose a threat to the natural development of soils;
d- create the prerequisites needed for application of the Soil Thematic Strategy..
e - support the realisation of the non-productive investments laid down in Measures 2.1.4. and 2.1.6.
f - foster and improve the Rural Landscape of the Marche region;
g - disclose orientations and techniques for the proper management of land and soil, differentiated by type of use (i.e. agricultural, forestry, etc.) and by benchmark/reference area.

The acquisition of soil knowledge thus becomes an integral part of a wider process aimed at guaranteeing and maintaining soil functions, including for farming, and, at the same time, can become a factor contributing to sustainable development whereby the three pillars – environment, society and economy become balanced.
The key threats affecting the soils of the Marche Region concern soil erosion, loss of organic matter, desertification, salinisation, compaction and soil sealing due to industrial activities and road construction.

# 2 The soil monitoring system “MOSYSS”

## 2.1 System goals

“**Soil”** must be considered a limited and non-renewable resource insofar as its regeneration through chemical and biological action on bedrock requires a very long time. Soils are continuously changing due to the effects of pedogenesis and human factors (use of soil for farming, landfills, atmospheric repercussions, etc.), and some changes brought about by humans are irreversible, or take a very long time to clean up.

Such situations require information in order to better manage agri-forest activities, not only relating to quality, but also to the description of the dynamic changes in variables.

As well as evolving models for the various soils in an area, it is also possible to simulate and/or prevent issues of strategic importance such as changes in organic matter, biological fertility and other parameters linked to the functional quality of soils.

Monitoring soil changes is closely linked to the concept of "*soil quality”* defined by all of the features which satisfy users in the case of agri-forest crops. According to this definition, it is clear that quality is specific to each soil type and each environment.

To identify the dynamics that require monitoring it is therefore necessary to refer to the farming processes used and to the "*environmental, social and economic sustainability”* objectives specified for each territorial environment that are to be met.

***Monitoring changes in chemical, physical and biological parameters of soil, as well as providing information and data on the farming suitability of specific "land units" provides useful indications to assess the preservation of appropriate guarantees of "sustainability" and "development".***

As a general principle it can be assumed that the less human influence disturbs the natural development processes of a piece of land, and the more the specific uses of the soil are in line with its effective capacity for use and suitability, the more guarantees of protection, conservation and improvement of the functional quality of an area there will be.

The term ***“Land”*** expresses a wider concept than soil. We can state that *“land” is formed of soil in a specific morphological location with a particular climatic situation.* The Land unit does not refer only to soil but also includes the main features of the area: geology, morphology, climate, hydrology, vegetation and fauna including insects and microfauna (Giordano, 2002).

Monitoring development dynamics affecting the soil is thus a tool to check:

-whether there are any unwanted variations in the qualitative features of soils and land;

-the stability of these features' suitability for requirements or expectations;
-the efficacy of action undertaken to preserve/increase quality or to change the functional quality of soils and land.

Taking into account the close link that exists between pedogenetic processes, functional quality of soils and agri-forest activities, it is possible to understand why, when monitoring soils, apart from specific analyses relating to intrinsic soil features, it is essential **to monitor at all times the management methods actually adopted.**

Activities monitoring land and soils therefore concern:

**-"the systematic determination of soil variables in order to identify changes over time"** (FAO/ECE International Workshop on Harmonisation of Soil Conservation Monitoring Systems – Budapest 1993).

**- examining, over time, the land *"management systems"* adopted by agri-forest companies.**

By ***"farm management system" (FMS)*** is meant the set of components allowing the management of cultivated land to be assessed over time.

The system components include crops, soil and other elements that interact and are subject to a specific climatic regime and human effects. (Donatelli, 2006).

The factors used to identify the different FMSs can be summed up in two groups:

- measurable with respect to biophysical aspects (hard);
- difficult to measure relating to socio-economic aspects (soft).

The biophysical factors relating to the environment-plant cycle are soil, climate, technical equipment, crop rotation, management system. Among these factors the most relevant are certainly: crop rotation, ploughing, chemical weed control, non-organic fertilizers, and use of organic soil improvers.

These factors can be measured easily and can generate, by activating biological processes, end products (e.g. foods, raw materials, etc.) and various levels of pressure on the environment (e.g. contamination, erosion, etc.) which can also be measured with quantitative indicators (Borin, 2002).

The socio-economic factors relating, for example, to technological developments, cultural and social aspects, and market policies leading to expectations for personal satisfaction and improvements in the quality of life, farmers' status, etc. are difficult to identify and measure but can have a decisive influence on farmers' choices and therefore on the effects of the management systems adopted.

The identity of an FMS thus derives from an analysis conducted with a "SYSTEM" view to highlight the possible interactions among the various technical and biological components of the FMS guaranteeing a better balance between yields and protection, conservation – improvement of natural resources.

## 2.2 2.2 - System structure

The structure of the MOSYSS network is essentially based on a number of monitoring points chosen as "representative sites" that unlike a fixed-grid network are distributed over the area being measured according to territorial similarities identified through specific indicators. The representative sites network, in addition to limiting management costs, offers additional information that is useful in understanding phenomena and above all useful in making spatial corrections to the measurements taken.

The identification of monitoring sites therefore takes place within areas which are homogenous as regards certain environmental features positively correlated to natural soil development. It should be remembered that the homogenous areas identified can be of different sizes, and subject to different critical environmental issues, different threats and related soil degradation phenomena.

"Tools and equipment for spot and on-going sampling"; "data assessment and storage" units; "pedological interpretation" units; and "distribution and provision of information services" units complete the network's structure.

## 2.3 Monitoring sites

The monitoring system MOSYSS focuses on two types of sites:

**a) ordinary monitoring sites;**

**b) dedicated monitoring sites;**

From ordinary monitoring sites all the variables common to all soils are collected.

Dedicated monitoring sites aim at monitoring specific soil factors or degradation issues.

The choice of ordinary monitoring sites is correlated to the environmental features of the homogenous area being examined and to the presence and distribution of **Soil Type Units** (**UTSs**). The specificity of these systems, with respect to other monitoring networks, relates to the fact that ordinary monitoring sites are always correlated to the environmental features of the homogenous benchmark area and to the UTSs present within that area.

**The number of "static" monitoring sites to be used in order to build the network can therefore vary. Within a regional territory the number accords to financial and operational resources and to the different territorial particularities (e.g. agricultural or forest areas of the Marche Region).**

The dedicated sites analyse soil conditions and variations towards soil degradation risk – in particular organic matter, erosion and soil compaction.

The methodologies for selecting sites are different in the two cases.

Ordinary sites must be confirmed on a pedological basis (i.e. be able to demonstrate the main soil typologies in their characteristic environment). Most of the territory is covered in this way, without excluding significant areas, and there will be no need to adopt spatial criteria other than those of correlation and soil cartography.

The choice of location for special sites, as for ordinary sites, is based on a breakdown of the regional territory into pedolandscape units with their soil distributions (UTSs) intersecting with the distribution within homogenous areas of degradation risks similar to those being examined.

In substance, new information layers are generated which, for each risk class (e.g. erosion, compaction and organic matter, etc.) give dimensions and characteristic seasonal types. Among all of the combinations obtained, the monitoring sites chosen will be the most representative and most common.

## 2.4 Tools and equipment for on-site sampling and remote sampling

Conventional observations on monitoring sites are the following:

- Profile

identifies the excavation or ditch dug up to a variable depth, for the purpose of observing soil (e.g. horizon,

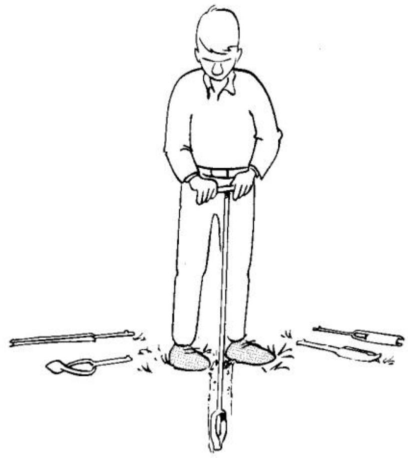
substrate, pedogenetic processes, etc.) . The excavation may be dug either with mechanical equipment or by hand, or using mixed methods.

- Slope

Conventionally, this means a "profile" that has already been exposed (i.e. an excavation or a natural or human slope constructed previously and/or already existing and reused for soil description purposes).

- Bore holes or probes

These are soil observations, including at depth, carried out from the surface using manual tools that can bring material to the surface but not expose a section.



- Surface observations

Thes

the surface, without any or with only minimal excavation (e.g. few cm moved with a spade).

#### 2.4.1 On-site measurements

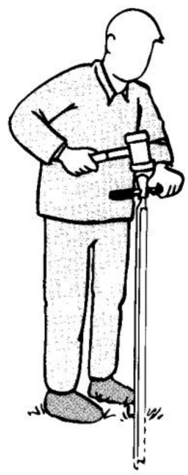
For on-site measurements there is an established set of equipment available.

Basic equipment includes:

- *A small ladder, a measure, a board*
- *Stools, table, parasol, etc.*

These different items make collecting data and recordings easier for those working in the field. The table permits to use laptops to store data immediately on-site.

- *Mechanical digging equipment*



Depending on the soil type, the depth to be reached and the site features (e.g. accessibility and morphology) various types of digging equipment can be used, more or less powerful, cumbersome and heavy. Normally, to dig out earth and fill it in areas that are not too rugged, a small excavator with tyres and a 40-70-100 cm wide tipper is used,

depending on needs, with a bulldozer to fill in ditches quickly. On very sloping and/or slippery land, caterpillars will be needed. A mini-digger is sufficient for fast transport and excavations of up to around 2 metres.

*- Tools for manual excavation – shovels, bores, probes.*

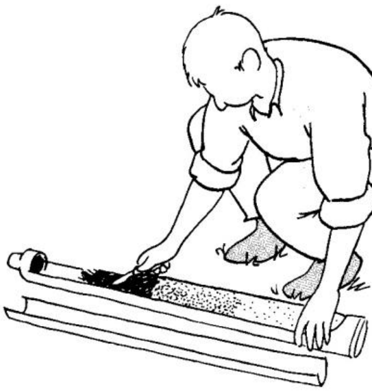
The soil probe is a long sampling tube, with parallel walls for softer land or where the land falls away sharply in a hollow, for harder rocky land. In this second version it cannot generally be used at depths of over 1 metre, due to the considerable torsion exercised during rotation and due to the difficulty of extracting it from more compact soils.


Pile drivers are used, with non-metallic hammers, for limited areas, followed by rotation to break up material and allow the tube to be retracted. It is only extracted once it has been completely driven in. The surface of the material is cleaned with a sharp knife, leaving it in the pipe, and the whole sampled section is examined carefully.

Naturally larger samplers can be used, frames with rotating mechanical bores, or at shallow depths, using pressure. However, they are mainly used for investigations at depth for applied purposes.

*- Tools for examining and sampling soil*

Knives of various shapes, archaeologists' trowels, gardening spades and similar to remove part of the soil, examine it and collect samples. Clippers are useful to clean up soil containing roots. A water spray is needed for damp samples and to determine the texture of material. A 10% solution of hydrochloric acid is needed to ascertain the presence of calcium carbonate in small samples or directly on the walls of the profile.



Over time, certain items have been added to these tools to examine specific variables and features of the soils monitored.

*- Measuring carbon dioxide ($CO_2$) flows in soils (i.e. soil breathing)*

The measuring method used is the method described by Dr. K.J. Parkinson in 1981: a chamber of known volume is placed in contact with the soil and the increase in $CO_2$ inside is monitored. Using this system, air is sampled continuously in a closed circuit, through the EGM or the CIRAS, and soil breathing is calculated, visualised and recorded by the analyst. The air inside the chamber is mixed carefully to allow for representative sampling without creating differences in pressure, which might affect the amount of $CO_2$ on the soil surface.

**Figure 2 – Egm-4 Environmental gas monitor – portable**

The Soil Respiration System is composed of a chamber for soil respiration of SRC-1 type and a gas analyser, either EGM or CIRAS _ ($CO_2$/$H_2O$ analyses).

The EGM-4 Environmental Gas Monitor is a portable or laboratory tool to measure -and record- $CO_2$ including an IRGA analyser and a pump to sample air. The EGM-4 has two openings to connect sensors or cameras produced by PP System. As well as $CO_2$, the EGM can therefore be used to measure and record moisture values, temperature, PAR and soil respiration. The tool can also be used to take measurements remotely.

- *Measuring soil erosion*

To assess the risk of erosion there are two approaches:

-direct measurements in the field;

-modelling.

Direct measuring in the field assesses the actual quantity of soil moved by water erosion. Measuring is usually carried out on experimental plots with a system to collect transported sediment.

Another system used is to artificially recreate precipitation using rain simulators. Once again the transported sediment is collected, together with a measure of the quantity of soil removed by the erosion.

Erosion measuring systems thus provide an assessment of erosion that has actually occurred. It should be stressed that such systems are used to validate or build mathematical models. The parameters of the Universal Soil Loss Equation (USLE) derive from algorithms built using data derived from experimental plots (Wischmeier Plots).

*a) rain simulator*

The *rain simulator* aims to ascertain the sensitivity of soil to erosion, through measurements taken from a sample plot of land.

**Figure 3 – Rain simulator to define soil erodibility.**

There are also faster systems, such as for example simple levelling staffs hammered into the soil and indicating the soil loss. These systems are better adapted to the research sector, while for the monitoring system it is necessary to define dedicated sites to measure erosion. In this way the following goals could be met:

-normal agronomic management of the site must be maintained;

-systems cannot be installed if they hinder normal mechanised farming operations,

-costs must be contained and this also means that the system must have an extremely low maintenance cost, which is not possible with experimental plots.

*b) measuring variations in the profile being assessed*

In order to meet the above goals a monitoring method may be adopted to enable to assess straightforward soil loss due to erosion without creating the hindrances as described above. The system includes the use of a "*total imaging station*" (Fig. 4) with a laser pointed prism to which images from all points surveyed are added.

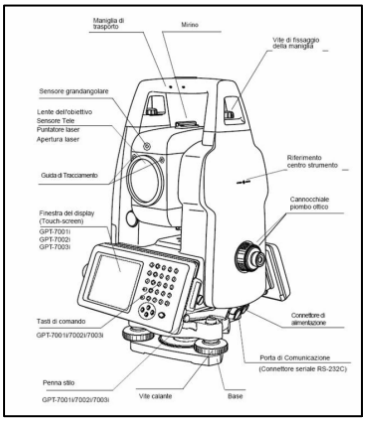



**Figure 4 - Tool used for measuring - Total Imaging Station TOPCON, from the GPT-7000i series**

With this topographical tool and the aid of dedicated software, it is possible to render the land profile and, if applicable, to project images from each tracked point onto the 3D rendering. Using the images associated with the sample is particularly useful when sampling in the field and when preparing data and makes it possible, even remotely between individual samples from the same site, to return to exactly the same sampling point.

*- Measuring hydraulic characteristics*

*a) Infiltrometers - measuring water conductivity*

Infiltrometers are devices that are very simple from a design point of view, measuring the amount of water filtered through a section with a known area. Double ring infiltrometers are tools used to measure the water conductivity of soils *(permeability)*, the double ring ensuring that flows are monodirectional, minimising errors due to evaporation.

*- Measuring physical and mechanical characteristics*

The physical properties of soils involve a number of features derived in part from their physical state and partly from their chemical nature. Changes here affect both plant life, animals and micro-organisms in the land, as well as farming techniques in general.

Composition, texture and structure identify soil from a physical point of view; in order to examine them indirect on-site measurements are used, together with analytical examinations in the laboratory (subsequently), mainly to assess the compaction risk.

*b) Penetrometer - Resistance to compression*

The penetrometer is a tool to directly measure resistance to crumbling in cohesive and semi-cohesive soils and to indirectly measure their structure; there is a static version of the tool "CPT" (*Cone Penetration Test using pressure*) and a dynamic "SPT" (*percussion-type*).

The "penetrometric CPT test" procedure essentially consists of inserting a metal probe in the soil and measuring the resistance of the land to "vertical" penetration, as depth increases From the data obtained in this way various pieces of information can be obtained about the features of the various soil horizons passed through and about their resistance capacity.

"Vertical resistance" – the use of the penetrometer with a dynamometric ring enables measures of resistance to the head's progress (resistance to compression) to be taken on the vertical. This is the most common and simple static penetrometric measurement. Thrust is exerted by the operator who, pressing the lever, inserts the head into the land; the resistance value is recorded by a dynamometric ring. Obviously the test can only be performed in soil of light texture at reasonably shallow depths.

"Horizontal resistance" – This is determined using a pocket penetrometer which can define cohesion and the maximum load for land, applying thrust directly on the soil horizons found on the exposed plane of the excavation or on the sample chosen. The test consists of placing the head on the land identified and pressing gradually until the head has penetrated up to the block clearly visible on the head. The force needed to do this is recorded on a dynamometer and translated on its dial into Kg and Kg/cm$^2$. The 10 mm head provides the Q value from which cohesion (C) is calculated, while the 6.4 mm head directly indicates the specific load in kg/cm$^2$.


**Figure 5 - Data acquisition system for the remote soil station**

*c) Sampling – Bulk density – Porosity*

Density expresses the mass of the land with respect to the unit of volume. We distinguish between actual density, which only takes into account the volume of the solid portion, and bulk density, which takes into account the total volume of land, including therefore spaces.

### 2.4.2 Remote assessment

*- Measuring pedological variables on a continuous basis*

Measuring soils on a continuous basis enables the soil's contribution to the C and $H_2O$ balance to be ascertained. This is because soil, as well as being the most important ecosystem for C storage is also the part of the agricultural ecosystem which plays a fundamental role in regulating gas exchanges – C and $H_2O$, more than plants. Furthermore, soil, when stimulated by temperature and humidity variations, regulates flows of $CO_2$ and $H_2O$. The remote measuring station is thus equipped to analyse moisture on a continuous basis at various soil depths using three probes which allow for three repetitions in the measurements, with two probes to measure oxygen, a useful measure to understand the qualitative condition of the soil, especially in areas subject to compaction such as areas farmed with heavy machinery, and probes measuring temperature – a parameter that is always correlated

to soil respiration and thus to flows of $CO_2$.

*-Measuring tools forming the remote station:*

3 “SENTEK EnviroSmart” soil moisture probes;

1 PT100 soil temperature probe;

2 APO 02S soil oxygen concentration probes;

Data logger to acquire data;

20 W photovoltaic power supply.

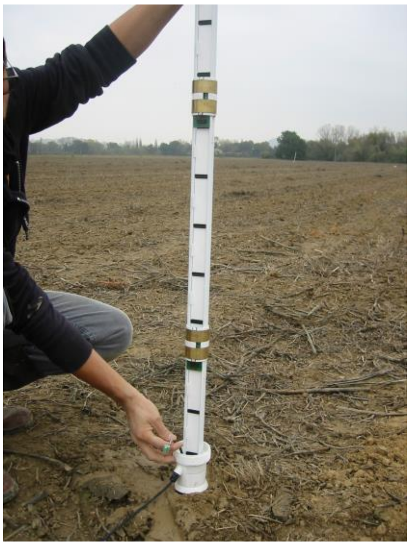


**Figure 7 - Putting in place a probe to measure soil moisture at several depths on a continuous basis**

**Figure 6 -Preparatory phase of the plot of land for the installation of the hollow housing plates to measure moisture content for each soil horizon**

*- Measuring C and N cycles in agrarian and forest soils.*

When measuring biochemical soil cycles, recent EU research and guidelines indicate that it is necessary to include more analyses and measurements in monitored cycles, N and C, no longer considering soil-water and soil-atmosphere as distinct, but as a single monitoring approach.

In view of these prerequisites the monitoring station includes more measurements in the same area: micrometeorological variables; soil variables; variables related to vegetation and management techniques.

The monitoring station equipped with measuring tools using Eddy Covariance techniques allows flows of evapotranspiration and $CO_2$ to be measured between the agricultural ecosystem in question and the atmosphere. The water, energy and C balance involved in farming forms a fundamental part of the overall bio-geo-chemical cycle of agriculture. The tools installed in the Eddy Covariance site allow, using micrometeorological measurements with sensors for $H_2O$ and $CO_2$ concentration and a highly accurate three-dimensional sonic anemometer to ascertain the water and C balance between the atmosphere and the agricultural ecosystem, including from crops and from the soil. The station thus enables C and $H_2O$ exchange with the atmosphere to be better understood - these exchanges are regulated by the structure of the canopy and from the physiological activities of the plant exchange processes at system level - a fundamental activity when managing resources on a territorial scale.

*-Measuring tools comprising the monitoring station:*
$CO_2$ Li-Cor Mod. analyser; Li-7500;
Gill Instruments Mod. sonic anemometer; Wind master 3D;
Industrial PC APLEX;
350 W photovoltaic power supply.

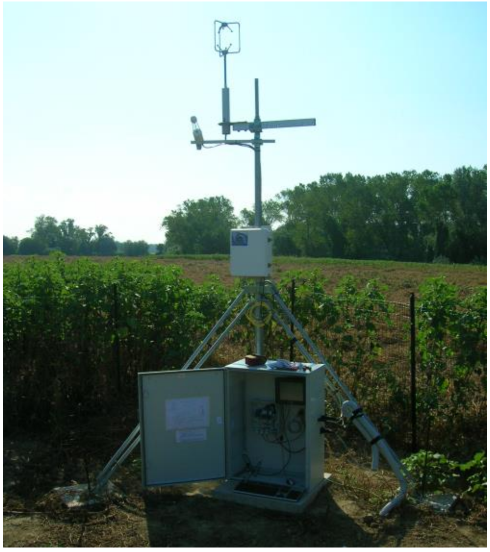


**Figure 8 - Tripod with a $CO_2$ & $H_2O$ analyser, a sonic anemometer and an industrial data acquisition and processing PC**

**Figure 9 - Data acquisition and processing panel**

### 2.4.3 Portable station with a coaxial metric camera

The *GPT-7000i with coaxial metric camera* total stations using new "*reality capture*" technology supplement traditional topographical measurements with an incomparable granularity of information contained in the images associated with the measurements. This function significantly increases the range of usage in the topographical field. Specifically it makes possible applications which until now have been impossible with old generation stations, especially in the agri-forest domain.

The acquisition function is quite simple – while the topographer records data, coloured lines and dots are traced over the image shown in real time to remember what has already been recorded, for example during other acquisition sessions. Each measurement is memorised together with the photograph taken with the coaxial camera. The superimposed image can also be used in a "*virtual reality*" situation, loading demarcation data and/or obstacles and/or reference grids for sampling (i.e. using geographical coordinates). They can be superimposed on the video to align demarcation lines, which can be used to "virtually" reconstruct surface movements and thus assess either visually or digitally *loss/acquisition* in the volumes identified (i.e. soil in this case).

Once the data has been acquired on site, it will then be possible using special office software to reconstruct and take precise 3D measurements from the photographs taken with the digital camera.

### 2.4.4 Validation and storage unit

The main purpose of this unit is to check data quality. The inspection method includes computerised procedures and specific direct assessments by experts. The system is divided into two sections as regards monitoring data provided automatically and non-automatically by the various instruments used and obtained by direct sampling.

The validated data is then stored in various storage units within the Regional Soil Information System managed by the Regional Soil Observatory.

The main records are:

- farm management records;
- soil samples archive;
- pedolandscape archive;
- photographic archive;
- laboratory analysis archive;
- geographical data archive.

### 2.4.5 Soil interpretation unit

This is the interface between soil information and use. It concerns the development of interpretative models on the behaviour, suitability and limitations of regional soils, checking their soil management, and the preparation and application of maps generated.

The interpretation of soil data and maps, derived using the application of provisional models, would permit to assess soil suitability (i.e. capacity for agricultural and forest use, etc.), as well as limitation (e.g. vulnerability).

### 2.4.6 Tools and units to disseminate information

The purpose of this unit is:

To supply technical and documentary support to decision-making bodies at various levels – local, and regional, in order to implement various programmes on agriculture, forests and environment.

To organise and put into practice strategies for the results obtained and information acquired with the various monitoring activities.

To foster comparisons with educational and training units to disseminate knowledge.

To create tools for widespread dissemination (e.g. audio-visual tools, regional collection of soil monoliths, etc.);

Training and updating non-specialised staff and technicians in order to create an effective interface between soil information and more direct users (e.g. farms, urban planners, agricultural organisations, etc.).

## 2.5 Network management

The technical staff within the regional administration is the most significant part of the Regional Soil Observatory and forms the basis of the guarantees of continuity of monitoring activities and the provision of soil information services over time.

Network management takes place in three main strands:

- managing the monitoring stations and carrying out observations;
- administering the CED and managing the Soil Information System as well as the archives related thereto;
- preparing information products and information services.

Management of the stations and data collection includes installing, maintaining and inspecting the operation of tools and equipment for continuous and remote measurement; making soil observations directly; rapid measures on site using specific tools and direct observation; collecting data about the management systems, use of fertilisers, plant health products, irrigation management, etc.

As regards data collection and soil cartography the management system provides for description and classification methodologies, cataloguing and correlation of typological regional soil units.

The administration of the CED includes inspecting and checking all computerised procedures for data delivery, data validation and storage, checking and updating all data collection procedures and tool calibration, and checking and updating official benchmark standards.

The use of data directly acquired through the soil monitoring network, or from other sources or generated by preparatory activities requires data security through daily back-up procedures, and the use of computer systems to check data quality.

On the basis of distribution standards predetermined and agreed with end-users or according to occasional requests, that might occur during activities, the management system provides for the creation of IT media and the generation of products for users.

## 2.6 Information services

The core of information services consists of the technical staff of the Regional Soil Observatory which provides the basis for guaranteed continuity of soil information service provision. The team includes an internal and interdisciplinary group of experts which fulfils the basic and routine tasks and from time to time is assigned, quickly and efficiently, to a wider skills system which can be deployed according to specific objectives and requirements. In this regard, the continuing professional development of the human resources involved is key, as is constant contact with all players involved in various ways with regional soil management. Between the activities run: producing printed materials and written documents, organisation of technical training sessions either during seminars and conferences or during demonstration days in the field, web services (i.e. official website, email, or others).

# 3 Analogous Benchmark Environments (ABEs)

The study and knowledge of the physical environment are indispensable to the rational use of land and farming resources, to valorise them and ensure that they are safeguarded over time.
The typology of an agricultural product is closely linked to what French authors define using the term "*terroir*" – i.e. the integration of the environmental features of an area and the adaptation of a certain crop to those features. From this union original and high quality products are obtained which, in another "*terroir*" may be just as high, but definitely different.
The current methodology to determine such links and the differentiation and delimitation of the various territories is based on a close examination of the parameters characterising the agro-environment such as soil, climate and microclimate. These parameters, together with the specific requirements of plants and specific farming techniques, guarantee high quality products.
Soil is a natural body derived from a long process of geneses, which have determined its development according to ecological factors, which behave differently at each point of the land surface. Knowledge of the soil means, substantially, knowing its intrinsic features, result of a combination of various factors contributing to its formation and development. Generally, climate,

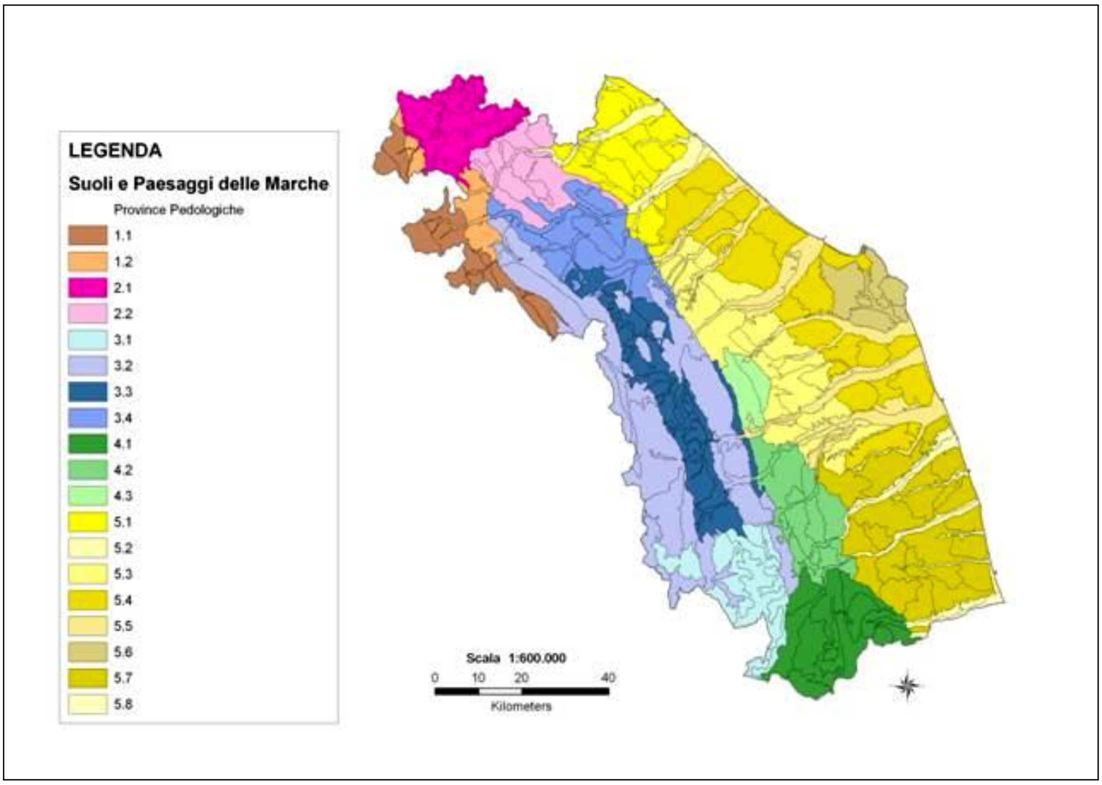



**Figure 10 - Map of Soils and Landscapes in the Marche Region – scale 1:250.000 (*source: Servizio Suoli A.S.S.A.M.*)**

lithology, geomorphology, hydrology, vegetation, fauna, and human activities are considered to be pedogenetic factors. Interdisciplinary study of the formation processes involving different subjects (e.g. climatology, geology, physics, chemistry, botany, agronomy, etc.) explains the difference between an area's soils with morphological, chemical, physical, and biological features. In soil mapping there is a close link between soil typologies, pedogenetic factors and landscape features (e.g. morphology, vegetation, lithological substrate, etc.).

In this context it is clear how agro-silvopastoral activities are gradually acquiring a new purpose and new functionalities, going over and above simply production aspects.
More and more attention is being paid to "*how it is produced*" rather than "*what is produced*".
The management of agricultural and forested areas and farming practices adopted must also meet environmental protection goals, safeguard and valorise the rural landscape.
Land use and management at the moment and in the future must satisfy the requirements of food production, soil protection and promotion of the landscape.
ABEs identification is supported by the data available in the **Soil Information System** (SIS), managed by the Regional Soil Department – ASSAM.
ABEs concern "*pedological landscape units*"[3] between the most representative soils. "*Key ABEs* have been identified through their intrinsic features (i.e. soils, climate and morphology) and have shown to have indirectly influenced the development of the management systems now adopted.

## 3.1 - "Analogous Benchmark Environments"

The region is divided into 11 *Analogous Benchmark Environments (ABEs)* for the purposes of defining land management guidelines that are adopted to the specific features of the various regional landscapes *(detailed description "ABEs" - Annex 2*).
Their identification relates firstly to physiographic criteria, (i.e. altitudes of 300 - 600 m) taking into account their relationship with the distribution of typical "crop systems". The latter are determined by identifying hilly environments, divided into 4 different sections from north to south.
The boundaries of the ABEs correspond to the landscape boundaries defined for the soil interpretation of third and of fourth level hierarchies - as shown in Figure 11.

3 Pedolandscapes or pedological landscapes: defined as environments with analogous environmental features such as: climate, geology, morphology, land use and soil features.

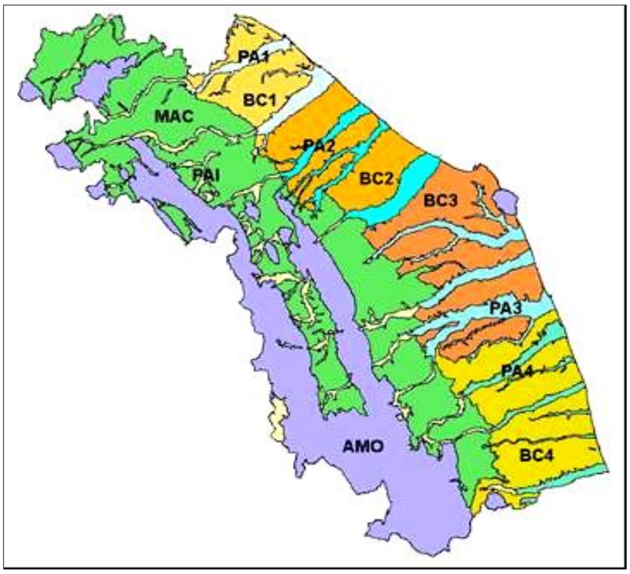



**Figure 11 - Distribution of Analogous benchmark Environments in the Marche**

| Map codes | Relationship with ABEs. |
|---|---|
| PA1 | PA_FM |
| BC1 | BC_FM |
| PA 2 | PA_CE |
| BC2 | BC_CE |
| PA3 | PA_MCe |
| BC3 | BC_MCe |
| PA4 | PA_TT |
| BC4 | BC_TT |
| MAC | MAC |
| PAI | PAI |
| AMO | AM |

**Table 1 – Environmental Benchmark Environments in the Marche**

# 4 Farm Management Systems (FMS)

## 4.1 Definition of "Farm Management System"

By "farm management system" (FMS) we mean the set of components allowing the management of cultivated land to be assessed over time.

The system components include farming, soil and other biomes that interact with each other and are subject to a specific climatic regime and human effects. (*Donatell, 2006i*). Human intervention has the purpose of producing a positive effect on crops, soil and microclimates (e.g. irrigation, etc.) and also to foster farming with respect to other plant organisms and animals which coexist in the same area (e.g. weeds, insects and pathogens).

The FMS differs from natural ecosystems since it is influenced by human activities and has the purpose of producing food, energy, materials, etc.

This type of definition is solely based on biophysical components which as such can be classified, analysed and described to subsequently plan or simulate behaviour.

These components are often insufficient to assess over time the complex issues arising in actual conditions. For example, when applying new management models to a determined rural territory, they can, even if valid from a technical and scientific point of view, be unacceptable to those directly involved (*USDA 1993*).

For integrated and comprehensive assessment of the management models adopted in a rural territory the FMS must form part of a wider context that is open to verification of factors that are external to farm units such as agricultural policies, the market, the socio-cultural environment, developments in available technologies, changes in human behaviour.

*"Agrarian management"* refers to the single farm and includes all of the structural and organisational roles that the farmer plays to meet expected yields.

The concept of management goes beyond the meaning of crops linked to the actual farming cycle in terms of techniques adopted and yields obtained. Management relates to the whole farm over the long term and as part of a specific territorial environment (i.e. land unit). Assessments and crop management choices, as well as individual farming techniques take into consideration "technical itineraries" applied on various parcels of land (Farmland Unit - *UTA*) that over time must guarantee that production capacity is maintained, the functional quality of natural resources preserved (e.g. soil, water, air, etc.) and if possible better environmental conditions.

Agro ecosystem management can be identified from the following main components:

- **structural appropriation** : the land surface being farmed; land improvements (e.g. road access, agrarian hydraulic systems, availability of water for irrigation and related supply systems, etc.); equipment and machinery available; availability of labour;
- **organisational structure** related to the type of business – whether owned or leased (or other forms), the type of sales organisation (processing and direct sales, traditional primary crops, sales of additional services, etc.);
- set of *management systems* adopted whether family, shareholding, through casual workers

These very diverse factors in the agricultural sector of the Marche, together with external factors due to the market and agricultural policy initiatives, give rise to the set of management systems chosen and adopted by farmers.

There are various cases: extremely specialised units with a single or few crop systems, those aimed a crop diversification with several management systems being adopted (arable crop rotation, vines, olive groves, etc.).

## 4.2 Identification of “Farm Management System”

As defined in paragraph 2.2.5, farm management systems (***FMSs***)” are the concept chosen for multiyear analysis of sustainable territory management, here specifically rural, in a territory where several types of farming interact.

Identifying the typical management systems in the Marche Region does not take into account individual crops and the related production techniques. Taking into account crops and their succession over time in a correlated manner, all types of crop alternation are associated with the ”technical itineraries” applied to areas consistently from an agronomic point of view.

The identity of a management system thus derives from an analysis conducted with a “SYSTEM” view to highlight the possible interactions among the various technical and biological components of the FMS guaranteeing a better balance between yields and protection, conservation – improvement of natural resources.

The integrated assessments needed to identify the various management systems refer to a specific site and thus considerations and assessments must always refer to a specific environment.

The various management systems intersect at farm level with the various environmental, climatic and soil conditions.

Knowledge of soils and their distribution at farm level is of fundamental importance to define the most suitable soil management strategies that must maintain the best balance between farming needs and preservation of the environment. So-called sustainable agriculture means, in substance, managing the "soil", and maintaining, unaltered, fertility and yield potential in a balance with the ecosystem.

A soil can be suitable for one crop and not for another, a certain usage may be damaging for the genesis of the soil but another might keep initial fertility intact.

Similarly, in a wider area, soil knowledge at farm level is seen through identified Farmland Units (UTA) which specify parcels with the same type of soil, and the same crop rotation. Parcels or sub-parcels belonging to the same UTA have the same type of soil use (crop rotation, single succession, tree crops, fallow), a comparable level of fertility as regards farm ownership (thus some using slurry and others not using slurry are included in UTAs, parcels where correctors have been systematically and regularly used and parcels where this has not occurred, irrigated and non-irrigated areas), similar physical-chemical or chemical features (e.g. texture, permeability, pH, lime), drainage (groundwater, drainage network) and topographical position (morphology, slope).

A UTA is therefore an "*analogous management unit at farm level*". Significant differences in one of the features described above should lead to a different differentiation of UTAs within the farm.

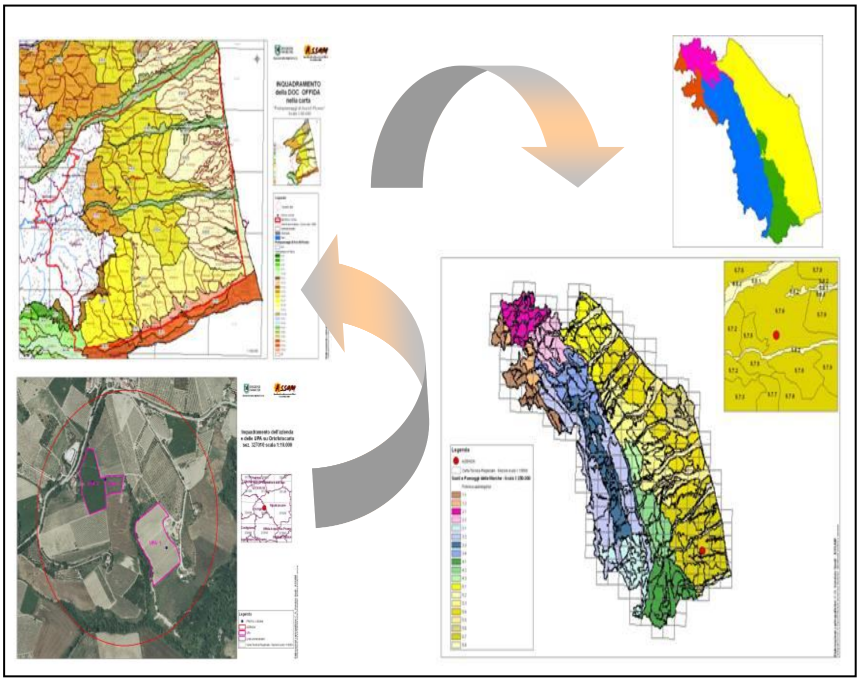


**Figure 12 - Example of *upscale* from UTA level to management system level and Analogous Benchmark Environments.**

As part of the SoCo project, although UTAs may appear to be an excessive level of detail, they represent rather the last line of analysis. The application of policies and their effectiveness will indeed be manifested at this level. UTAs are also a fundamental assessment element when examining conservation practices.

During the So.Co. project analyses were carried out using continuous *downscaling* and *upscaling* as shown in Figure 4.5.

The results of this approach were then aggregated and identified at management system and Analogous Benchmark Environment level.

### 4.2.1 The Marche Region management systems following the Fischler Reform (2003)

Agriculture in the Marche is based on small-sized farms and is spread throughout the regional territory. Considering the highly dynamic use of land, according to changeable market conditions and influences dictated by the application of Community policies, it is very difficult to ascertain which management systems have been adopted and their distribution over Marche agricultural areas.

Data from the general agricultural census, used to summarise the economic situation and production capacity in the regional agricultural sector, cannot be used to identify management systems insofar as: data were updated in 2000 and referred to territorial environments in "*Comuni*" they are not suitable to represent the specific morphological formation of Marche region.

With the aim of verifying the effects on the management systems adopted following the Fischler Reform, the "*AGEA*"[4] database was used, concerning the crops produced in the agrarian year 2006200707 by farms that had received CAP 2007 subsidies.

The work of identifying the management systems in the Marche required an assessment of the factors described in the previous paragraph, i.e.:

- crops planted, in their crop rotation schedule;
- the technical itineraries adopted with a view to an integrated farm management system;
- the balance guaranteed between farming needs and environmental sustainability;

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**4** - AGEA (*Agenzia per le Erogazioni in Agricolture*) was created as a Coordinating Body and a Paying Agency, by Legislative Decree No 165/99. AGEA deals with paying out funds earmarked by the European Union to support agricultural production in Community countries, by paying aid, subsidies and bonuses to producers. AGEA, as a Coordinating Body, is, *inter alia*, responsible for oversight and coordination of Paying Agencies; checking consistency of their activities with regard to Community guidelines; promoting harmonised application of Community standards and related authorisation, payment and accounting procedures for Community aid by Paying Agencies, monitoring such activities.

- the spatial distribution of Management Systems at regional level and in each Analogous Benchmark Environment.

On the basis of the presence of management systems within Analogous Benchmark Areas, an integrated assessment of environmental sustainability will be provided in the next chapter, with particular reference to soil conservation.

The integrated assessment will be performed on the basis of the following factors;

- technical operational aspects in relation to the applicability of conservation practices;
- effects on the environment and risks of soil degradation;
- the standards and other situations that can influence the development of sustainable agriculture in the Analogous Benchmark Environment and in relation to the management systems present therein.

On the basis of the integrated assessment, suggestions and forecasts for sustainable agriculture and soil conservation have been put forward.

A detailed description of the FMSs and of the identifying elements for each FMS, cited earlier, are presented below

*Arable crop rotation excluding fodder (MS1)*

It is the most common MS in the region, characterised by crop rotation using annual plants with a spring or autumn cycle. There are 211 crops surveyed which fall into this crop system, which can be divided into two groups:

-autumn-spring cycle;

-spring-summer cycle.

*Arable crop rotation including fodder (MS2)*

MS2, mainly found in inland areas of the Marche Region, is characterised by crop rotation similar to MS1, with annual grass crops - spring cereals - and the inclusion, to different extents, of forage crops.

The common meaning of the term "fodder" is all plant species whose main product is suitable for and used to feed livestock. Generally by the word "forage" is meant only the product of plant activity – thus the grass or soil derived from it, hay and silage.

The presence of forage crops is important because it is an indicator of the presence of animal husbandry and of the management quality of the land, due to:

- more extensive rotation with positive effects on soil conservation and the sustainability of the farming techniques used;

- availability of animal husbandry effluent, particularly manure, with positive consequences not only for the reduction of chemical fertilisers but generally on the improvement of the physical, chemical and biological quality of soil.

*Pasture (SG3)*

From an agronomic point of view, an area used for "pasture" identifies a parcel of land where biomass production is grazed directly by animals.

Normally, there is pasture in land where the only alternative is natural or artificial forest. The reasons may derive from steep slopes, shallow soil depth, surface rocks, or high proportion of stones. On such land, notwithstanding forests, the only fruitful use is pasture, considering the difficulties of working with machinery and in particular of ploughing the land.

Both grass, tree and bush species cohabit in pastures. All of the grass plants together make up the grass pasture, formed of a vast range of botanical families.

From an agronomic point of view, understanding pastures, as well as the flower species contained there, is related to the contribution made by the various families to the production of biomass together with suitability which is distinct for each genus and species. It is important to underline the difficulty to define the concept of *fodder*. Generally, each plant species can be used as feed for grazing animals and thus considered to be fodder. In practice, not all species are used equally and indistinctly by sheep, cows, goats, etc.

*Arable crop rotation for horticulture (MS4)*

MS4 is a crop rotation system characterised by a considerable proportion of horticultural crops. It is well known that the horticulture sector can potentially have a significant impact on the environment due to the substantial input needed to maintain production levels.

Horticulture is indeed characterised by high usage of technical equipment related to highly dynamic crop rotation, due more to market forces than agronomic reasons. This trait, applying both to protected crops and main crops, leads to frequent and repeated ploughing, and an excessive use of fertilisers, agrochemicals and water for irrigation. Less intensive horticulture also exists, with potatoes and tomatoes for industry that, when rotated with traditional arable crops, require the soil to be left to rest for a long time, exposing it to risks of structural loss, erosion, loss of fertility, loss of fertilisers or other chemical components by leaching.

*Fruit trees (MS5)*

As regards fruit growing, at national level, we are seeing an increase in all crops compared to the previous year, and specifically the fresh fruit harvest was up by 22%.

Between 2000 and 2004 retail vegetable purchases went down by 16% in quantitative terms. Surface areas on the other hand, based on ISTAT economic data, have, overall, slightly shrunk since 2003.
In the Marche Region, after 2003 which was marked by a general and for some crops significant fall in harvests, production of all of the main species cultivated increased. This can be seen mainly in increased yields, because there is general shrinkage of surface area being cultivated.

Actinidia (MS6)
This plant, originally from South-West China and commonly called kiwi, has been developed mainly in New Zealand, the USA, Japan, and France. In Italy it is principally found in Emilia Romagna, Piedmont and Lazio.
In the Marche region it is not very common, occupying around 6% of agricultural land, but is nevertheless a management system which contributes to crop differentiation and to maintaining the identifying features of Marche agriculture.
Actinidia is a ground cover plant, growing in a disorganised way. For farming purposes it is therefore necessary to use supports.
The most common forms are "*doppia pergola*"[5] , "*tendone*"[6] o a "*fusetto*"[7] or "contre-espalier".

*Vineyards (MS7)*
The Marche produce 1,200,000 hl of wine (average for the last 5 years).
There are now 27,440 farms involved in wine growing in the Marche while there were 40,000 in 1980. Vineyards and wine growing in the Marche is in third place after cereal farming and market gardening.
Production is divided into:

- 18 % table wine
- 47 % I.G.T.

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5 - Double pergola: planting distances of 5 x 4 m amounting to 500 plants/ha comprising two permanent cordons on which the fruit-bearing branches are replaced each year

6 - *Tendone*: planting distance 5 x 5 m, 400 plants/ha, several permanent training wires, generally 4, on which the fruit-bearing branches are attached

.

7 - *Fusetto:* main structure composed of a central axis bearing lateral branches.

- 35 % DOC.

Vines are the main tree/shrub crop in the Marche with around 23,000 ha, of which around 50% is officially registered for the production of wine classified as *Denominazione di Origine Controllata* (DOC). They have always been grown throughout the regional territory and their presence in agricultural land is irreplaceable, especially in hilly areas. The area with the most vineyards is the province of Ascoli Piceno with 50% of regional land dedicated to vine growing, then the province of Ancona with around 30% and the provinces of Macerata & Pesaro Urbino with 10% each.

*Short Rotation Forestry –SRF (MS8)*

*Short Rotation Forestry* is recognised by the CAP as an energy crop and thus giving rise to entitlements to subsidies. It, can be considered a useful option as part of the diversification of production in agricultural areas, useful to obtain better economic results and above all better environmental sustainability of agricultural activities.

The advantages can be manifold:

- $CO_2$ emissions footprint zero, since through photosynthesis tree crops accumulate SOC, removing it from the atmosphere, which is then released in the form of $CO_2$ during combustion. The C footprint is therefore balanced.
- Improvement of chemical and physical conditions of soils; increase of SOM through root systems and autumn leaf fall, improvement of physical conditions of soil due to a lower impact of mechanical equipment in the field and a structuring action of the soil by the root systems, improvement of hydrological conditions.
- Response of the agricultural industry in the Marche to the demand for agri-energy with a reduction in production costs. In this case the socio-economic structure of farms in the Marche should be taken into consideration, as well as the territory's intrinsic features, in relation to the real potential of biomass production.

*Timber plantations (SGP)*

The planting of trees for timber on agricultural land was, in previous years, a specific orientation of the EU's agricultural policy, aimed on the one hand at the reduction of arable areas, to deal with the problem of overproduction. On the other hand, incentives to increase set aside land were mainly aimed at promoting the farms' environmental function – generally considered able to produce not only goods but above all services, insofar as they could meet the community's specific needs. The creation of wooded areas also meets therefore the aim of improving the quality of the environment.

We should start by saying first of all that most forestry investments made in the Marche Region and financed by the EU Community during the last 15 years, ("*Support measures*" of the CAP, "*Structural Funds*" and "*Rural Development Plan*"), are almost all plantations with specific production aims: timber plantations and truffle growing.

*Woods (MS 10)*

Wooded areas in the Marche are almost all found along orographic relief, with a significant amount in the Monte Conero area and the narrow valleys between the Ascoli hills. They are almost exclusively composed of broad-leaved trees.

The regional forest inventory also includes 256 thousand hectares of regional wooded areas, amounting to 26.4 % of the overall area -the national figure is 26.51%.

Olive groves (MS 11)

The Marche Region is found at the northern edge of the olive cultivation area, with a risk of frost, particularly in the most northern areas and inland. A demonstration of this is the terrible events of 1929, 1956, 1985 and 1996, signs of which can still be seen in several areas in the region.

Nevertheless, the area of cultivated olive trees in the Marche is increasing all the time. From the last ISTAT data (2001) we see that there are 10,450 hectares in specialized production, of which 42% is in the province of Ascoli Piceno, 26% in the province of Macerata, 19% in the province of Ancona, and 13% in the province of Pesaro Urbino. Olive growing in the Marche is mainly found in hilly areas both on the coast and inland, with an annual production of approximately 40,000 hundredweight of oil, subject to variation from year to year due to alternate fruit bearing and recurrent frosts.

The olive growing area is highly fragmented, divided into a total of almost 30,000 farms, with a very small area for each unit. This leads to a fragmentation of supply, and therefore much of the production is still for consumption by growers themselves or for the local market.

Olives are processed in around 165 olive mills in the region.

Traditional systems are still to be found, but with an increasing percentage of two- and three-phase decanters.

Cultivated truffle plantations (FMS13)

The succession of programmes to implement Community regulations – from measures to supply the CAP to Structural Funds and the Rural Development Plan have led to a certain reduction in investment in timber plantations to the benefit of truffle growing and more specifically *edulis* fungi (*"cultivated truffle plantations"*).

With Council Regulation 2080/92, truffle growing represented just over 10%; the implementation of the 2000-2006 Rural Development Plan in this sector was 40% of surface area funded.

Minor management systems (SG14)

| |
|---|
| **PERMANENT CROPS UNDER GLASS** |
| **GLASSHOUSE FLOWERS** |
| **MARKET GARDENING UNDER GLASS** |
| **INDOOR PLANTS** |
| **NURSERIES - OTHERS** |
| **TREE NURSERIES** |
| **OLIVE NURSERIES** |
| **VINE NURSERIES** |

# 5 Farmland Unit as a "monitoring site"

## 5.1 Definition of a Farmland Unit

As for larger areas, soil knowledge at farm level is seen through identified Farmland Units (UTAs) – parcels with the same type of soil, and the same crop rotation. Parcels or sub-parcels belonging to the same UTA have the same type of soil use (crop rotation, single succession, tree crops, fallow), a comparable level of fertility as regards farm ownership (*thus some farms using slurry and others not using slurry are included in UTAs, parcels where correctors have been systematically and regularly used and parcels where this has not occurred, irrigated and non-irrigated areas*), similar physical-chemical or chemical features (*texture, permeability, pH, lime*), drainage (*groundwater, drainage network*) and topographical position (*morphology, slope*).
A UTA, therefore, is a "*homogeneous management unit at farm scale*" and significant differences in one of the above categories should lead to a differentiation of UTAs on the farm.

## 5.2 Identifying UTAs

In order to identify farm UTAs correctly, the following information and work phases are required:

### 5.2.1 Phase 1: Information about the farm

The first objective, when looking at soil management issues at farm level, consists of identifying and collecting facts about the farm's characteristics, its agronomic and productive potential, and the "agronomic history" of the parcels making up that farm.
In this phase, the characteristics and typologies of work carried out in the farm should be established, but in the next phase (i.e. phase 2, farm mapping) the focus should be on whether and where such characteristics and work can differentiate areas with specific properties and behaviours. Most useful information can be collected directly by the farmer.
Establishing a relationship of trust and raising the farmer's awareness, aimed at an active and on-going collaboration fostering continued and systematic communication of all of the technical information and data relating to the crops and the parcels is of fundamental importance. It is also essential not to neglect consulting and, if necessary, to talk to the farmer about, all of the documentation that they hold – such as land registry certificates, "history" of the farm and its crops (i.e. including, where possible, news about any land purchases, re-parcelling, leases, rights of way, levels, prohibitions, sales relationships, type and cost of labour, etc.), documents of irrigation associations, plans, councils/recommendations, surveys carried out and kept, etc.
Particular attention should be paid to fertilisation practices.

The productivity and profitability of a farm and of the agricultural system overall depend to a great extent on safeguarding and improving soil fertility. This can be significantly determined by the distribution of organic or mineral matter, whether or not derived from animal husbandry or fertilisers as defined and regulated by the laws in force. Fertilisation practices are aimed at improving chemical, physical and/or biological fertility of agrarian land, and contribute to nourishing and in any case to the improved development, of plant species cultivated. However, fertilisers, soil improvers and correctors can, if used badly, represent an additional cost for the farm and have negative effects on the environment and on soil productivity.

In the first phase of carrying out a soil investigation at farm scale it is therefore important to collect basic information that can give direction to more detailed investigations at later stages. Basically the following should be noted:

- if the farm produces animal waste and if so what sort: manure, slurry, and where it is spread;
- if waste produced by other farms is used and if so in what quantities - if there is any production of green manure;
- if any urban sewage sludge is used; - which fertilisers are normally used;
- what other management intervention characterises the various parcels on the farm (e.g. ploughing, weed control, crop rotation, etc.).

A significant, different and proven grade of fertility or type of fertilisation practice can point to a need to distinguish between two or more Analogous Management Units (UTA, see phase 2).

Last but not least, when outlining UTAs it is important to ascertain, using official maps, whether there are any environmental protection restrictions in the farm area (e.g. nitrate vulnerable zones; buffer zones near water courses, special protection zones for the conservation of natural flora and fauna "ZPS" and "SIC"; etc.).

### 5.2.2 Phase 2: Farm mapping

Once preliminary information gathering about the farm has been completed, the investigation should then identify the Farmland Units (UTAs). UTAs are portions of the farm area that are analogous due to soil type and management; they are thus the result of a different combination of soil factors and crop factors that significantly influence the soil-crop system and require differentiated management techniques.

This phase, together with the next phase, will be crucial in the farm investigation; the more carefully it is carried out the better the farm's soil-crop system will be characterised and the more precise, rational and productive subsequent choices made on the farm.

In order to identify UTAs it is, basically, necessary to:

- take as much of the information obtained at phase 1 as possible, localise that information on the farm, and compare it with what is directly observed in the field, and stated by the farmer;
- explore the farm, examining the soil carefully, both on the surface and at depth, comparing the observations made with the map documentation collected;
- transform all of these observations and information into a map: this will lead to a UTA map being produced, which constitutes the basic reference when programming intervention on farm soil and is, therefore, a fundamental document in the methodology proposed;
- map all of the information so as not allow not only for computerised storage of alphanumerical data, but also their integration with a geographical information system.

## 5.3 The UTA as a monitoring site

Monitoring soil changes is closely linked to the concept of "soil quality" defined by all of the features that can satisfy users, whether for crops, to protect underground waters, construction of buildings, or maintaining protected areas, etc. According to this definition, it is clear that quality is specific for each soil type.
Soil dynamics are influenced by environment factors, so-called pedogenetic factors. In areas with agri-forest activities, man's influence over changes in qualitative features of the soil is added to these environmental factors.
At a time when agriculture and forestry activities were linked to the local economy and often destined for local consumption, variations in land use took place over the relatively long term and thus allowed for a better assessment over time of their effects on soil.
In modern times, the extremely dynamic nature of agri-forest management due to current market forces (globalisation, etc.) creates more difficulties in controlling the balance between changes in soil quality and good land management.

**These are the main reasons why in soil monitoring activities, apart from specific analyses relating to intrinsic soil features, it is essential to monitor the management methods actually adopted at all times.**

Monitoring activities for land and soils therefore concern:
"the systematic determination of soil variables in order to identify changes over time" (FAO/ECE International Workshop on Harmonisation of Soil Conservation Monitoring Systems – Budapest 1993).
- checking, over time, the "management systems" of the land used by agri-forest companies.

The monitoring sites that will form the regional network for the verification and control of land management and the dynamics of soil changes are represented by *"a set of Farmland Units (UTAs)"* that are specifically identified, and where the following have been documented in detail:
the agronomic operations performed (agrarian land Management System);
changes in soil features through regular analyses, performed using common methodologies, of a set of especially chosen parameters.

### 5.3.1 Identifying monitoring sites

The monitoring sites that will be chosen for the verification and control of land management correlated to the dynamics of soil changes are represented by "a set of Farmland Units (UTAs)" that are specifically identified and where the following have been documented in detail:
- the agronomic operations performed (agrarian land management system);
- pedogenetic processes affecting soil through direct analyses in the field, performed using common methodologies, of a set of especially chosen parameters;
- the main features of soil quality.

To identify monitoring sites, we refer to the method used and trialled in the project SOCO realised as part of a wider initiative involving ten other EU MS and decided by the EU Parliament in the package of initiatives implemented for the "Health Check" of the CAP 2007-2013.
This method includes the following phases:

- identification of Analogous Benchmark Environments (ABEs);
- assessment of agri-forest farm management systems (FMSs) adopted for ABEs and their spatial distribution;
- assessment of farms and classification according to the prevalent and representative FMSs adopted;
- choice of representative farms and identification of Farmland Units (UTAs) that are suitable to be considered as "monitoring sites"

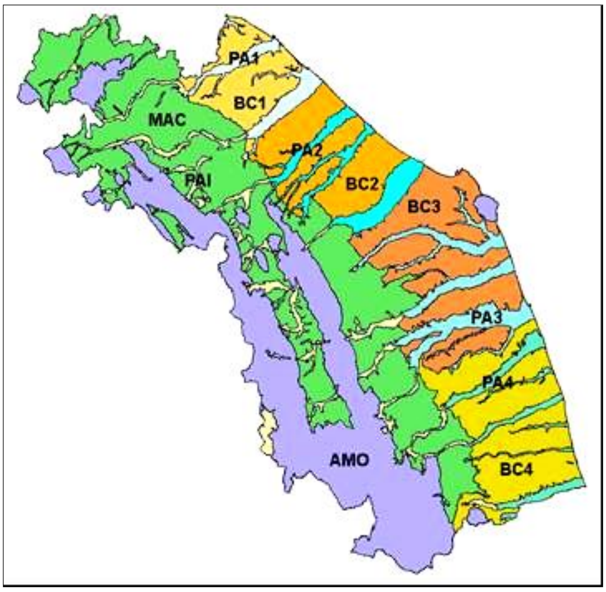



**Figure 13 - Distribution of Analogous Environments in the Marche Region**

***source: Soil Department – Assam)***

#### 5.3.1.1 Identifying ABEs

ABEs break down the Marche territory into environments that can be defined (at a scale of 1:250 000) as analogous due to pedoenvironmental features (e.g. geology, climate, morphometry, soils) and due to the Management Systems adopted.

Their identification relates at a first level to physiographic criteria, altitudes of 300 - 600 m, considering their sensitive relationship with the distribution of typical "management systems". The latter are determined by identifying hilly environments, divided into 4 different parts from north to south.

The boundaries of the ABEs correspond to the landscape boundaries defined for pedological interpretation of third and of fourth level hierarchies.

For further information about ABEs, please refer to the monographs ASSAM *"Project So.Co. Agricolture sostenibile e conservazione del soil – Caso studio marche" and "Soils e paesaggi delle Marche"*.

### 5.3.2 Farm classification according to the FMS adopted

As part of each ABE, data collection is aimed at identifying the most representative combinations between management systems adopted and the number of active farms. In order to assess SGs, inventory data on land use has been used, at a scale of detail (i.e. land registry parcels) found in the "AGEA farm file" for the last period available - 2006/2007. The sample refers to all farms in the Marche region, as found on the AGEA database, divided by ABEs on a geographical basis, using the geo-location on land registry sheets. Using an *Overlay* analysis in ArcGIS the "land registry sheets" have been extracted in geographic form relating to each ABE and, subsequently, assigned each farm to the relevant ABE.

The sub-samples of farms within each ABE were grouped together in three typologies (group or cluster) using cluster analysis or grouping by similarity with respect to the percentage distribution of FMSs adopted by the farm. In order to attribute the management systems adopted, we classified the crops grown to then identify the management system ordinarily adopted considering among the key factors: crop rotation, ploughing and fertilisation. Subsequent assessment related to the characterisation of the farm overall using the weighting of the FMS adopted in terms of land area occupied by the farm. The clustering algorithm used in this case as a calculation variable was the % of FMS per farm.

The ultimate purpose of this preparation using the cluster algorithm K-Means was to create the best combination of farm groups which minimises variance within the group (and thus minimises differences within the farms belonging to the same group) and maximises variance between groups (and thus maximises the difference between groups). The farm universe included in this case approximately 46,000 units.

For further details see Annex 2.

### 5.3.3 Choice of representative farms for each ABE (assessment grid)

Having obtained the sub-samples of farms for each ABE with a criterion of representativeness with regard to the management systems adopted, we then proceeded to classify the farms, assessing how closely they corresponded to the average behaviour in their group. That data was available as output from the cluster analysis.

On the basis of that classification, we obtained a list of farms ordered by the best combination of factors for the choice of a monitoring site.

Based on some assessments of the size of the farms and their representativeness within the territories being examined, we decided to make a first approximation to limit the subsequent analyses using the first ten from the classification.

### 5.3.4 Choice of "monitoring sites" from candidate farms

The farms classified according to the assessment criteria described in the previous paragraph were subsequently analysed taking into consideration internal variability in order to identify a sub-sample of farms that were even more suitable to host a monitoring site. For this last screening process, we used a specially prepared "assessment matrix" which takes in consideration the following factors:

- geographical location;
- prevalent soil types;
- functional quality of soil;
- level of risk of soil degradation with particular reference to the loss of SOM and the risk of water erosion;

- geographical location of the farm with respect to the territorial environments outlined for the purposes of environmental and landscape preservation.
- geographical location of the Farmland Units with respect to the existing "reference grids" for other monitoring activities;
- availability of previous soil information and data.

The identification of the geographical location is at the same time the central and indispensable element for all environmental assessments and the most different and labour-intensive part given the difficulty of converting land registry boundaries into computerized geographical delineations.

For the purposes of the MOSYSS project, detailed geo-referencing of all Farmland Units is required in order to be able to correlate the detailed information at the smallest local and regional scales.

For practical operational reasons, in these first phases of the project we chose to adopt more generic data available which refers to the wider farming centre or land registry area such as the "*Foglio*" [cadastral sheet] and the "*quadro d'union*" [farmer's union]. As the project goes on, we will increasingly need to obtain more precise data by using new tools and data structures available.

As regards the soil types officially recognised in the Marche Region, a catalogue of soil typologies at a scale of 1:250,000 is available, prepared as part of the Soil Map of Italy – Marche area. The soil type provides indications of the main intrinsic features of the soil, its classification in officially recognised systems (USDA; WRB-FAO), the pedo-landscape features that have influenced pedogenetic processes, the main functional qualities and indications on proper agronomic use. By carrying out an analysis in a GIS environment, it was possible to connect the territorial information available with the farmland units using a traditional geographical overlay.

Using an overlay of the UTAs with specific thematic maps relating to the distribution and presence of phenomena such as water erosion of soil, loss of SOM, and increase of compaction it was possible also to assess the representativeness of the farms that were candidates for monitoring in relation to such topics.

A last filter was introduced to examine the significance of the monitoring site with respect to areas with environmental restrictions imposed by EU standards and regulations or by other national and local rules. In particular, "Natura 2000" sites were assessed (SIC, ZPS), PPAR environments (*Piano Paesistico Ambientale Regionale*), and areas in natural parks and reserves.

Another assessment of not negligible importance related to the geographical location of the Farmland Units with respect to existing "reference grids" for other monitoring activities. Specifically we assessed the framework of new monitoring sites on the LUCAS *(Land Use Cover Area Frame Statistical Survey)* and INSPIRE *(INfrastructure for SPatial InfoRmation in Europe)* grids managed by the EU to acquire and disseminate information on an EU scale.

Reference to these monitoring networks, in addition to providing a further source of information and data, offers an opportunity to compare and check the results of monitoring on a national and EU scale.

A further component of the assessment matrix relates to the availability of previous soil data to calibrate as finely as possible the data collection protocol and to improve our understanding of the dynamics of pedogenetic processes.

Having concluded this part of the work solely by default on the basis of data available, the last check in order to commence the operational construction of the monitoring site takes place directly in the field with the direct involvement of the farmers. Availability for access to private land is usually agreed with the farmer, and agreement to provide information on the activities carried out during previous agrarian years and on the usual running of the farm, as well as acceptance to host other measurements repeated over time. The "*Servizio Agricoltura Forestazione e Pesca*" of the Marche Region, through its Regional Soil Observatory, provides all of the information needed to clarify the purpose of project activities, undertakes to guarantee the confidentiality of farm data disclosed in aggregated form, and oversees all activities at the farm in close collaboration with the farmer without provoking crop damage and in general without interfering with the farmer's ordinary activities.

## *Example of a monitoring site - Farm in Valle del Musone:*

The area identified for the monitoring site is within the territory of the *comune* of Osimo in the province of Ancona. The site is in the alluvial plain of the river Musone around 14 km from the estuary on the Adriatic Sea.

The distinguishing factors of the management system in the area around the site chosen are: high productivity, fertile soils and the possibility to irrigate the main intensive agricultural management systems.

The site, due to its specific location, is characterised by a strong and growing urbanisation, and consequently the site is also representative of regional areas where there is a higher risk of soil loss due to increasing industrial activities and urban settlements.

Considering the hydrogeological nature of the substrate, most of these areas fall into the Nitrate Vulnerable Zones (NVZs) established pursuant to EU Directive N° 676/91.

Since the 2005 Fischler Reform, it is compulsory for farms in these zones to apply a specific "Action Programme" aimed at avoiding contamination damage to groundwater. The most widespread *"Management System"* in the alluvial plain is arable crop rotation without fodder crops, with land coverage of around 71%, and there is also a minor presence of forage of around 8-9%. Horticultural crops are also found, at the same percentage (8-9%). The area's climate is in line with averages for the Marche hills: from 700 to 800 mm annual rainfall, going from the coast inland, and average temperatures of between 13.7 and 14.7 °C.

As for soil features, the soils were formed on geological substrates of alluvial matrices, with sandy-stony matter or finer sandy-silt matter. The main soils on the site are the Inceptisols fine clay, xerepts, and fluvanna which are the most widespread soils along the valley floor of the region, not affected by recent floods. The soils characterising the site are of great interest for the study of C cycle dynamics, in relation to the agricultural management practices used in the area. Indeed the soils in question are among those with the highest content of SOC in the mineral horizons in the first 100 cm, at 128 T ha$^{-1}$.

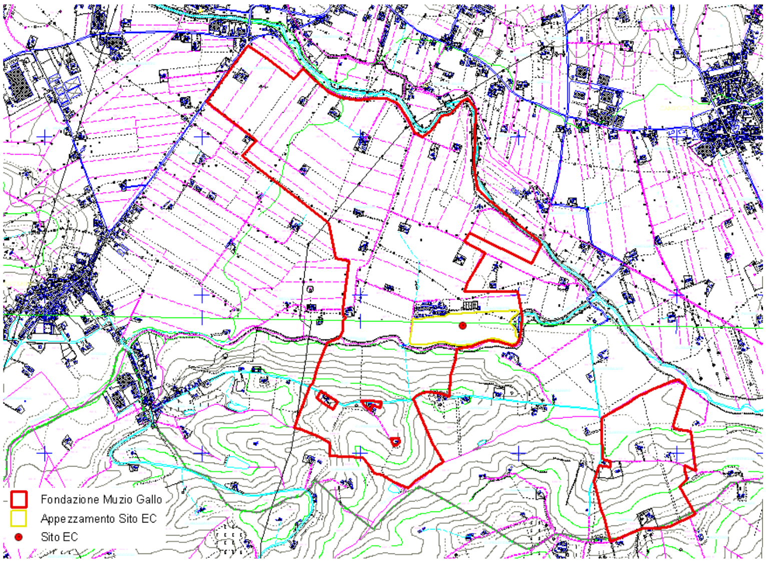



**Figure 14 - Geographical overview of the monitoring site on C.T.R. 1:10,000**

In addition the interest of these soils is related to the fact that they have the highest energy inputs, due to intensive agricultural use, and therefore more susceptible to imbalances in biogeochemical (i.e. C, N) cycles. Hereafter are some map extracts that summarise the basic and minimum information needed to characterise a monitoring site.

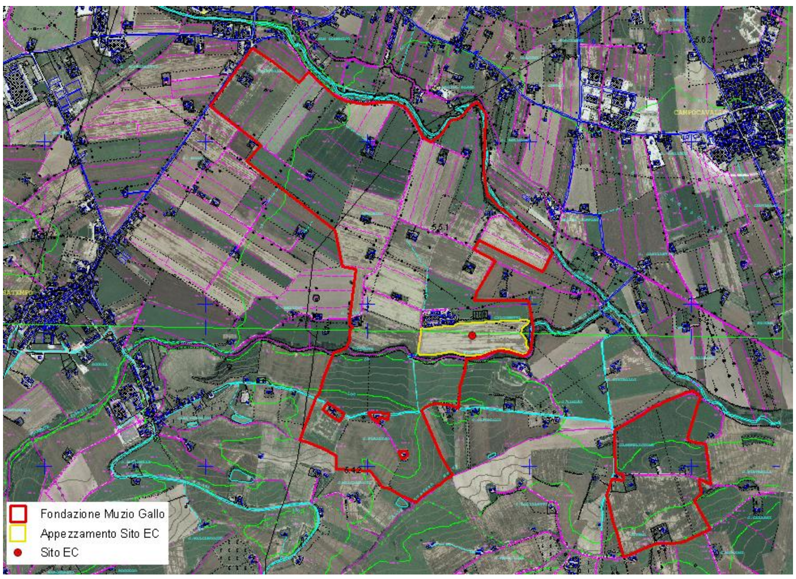



**Figure 15 - Geographical overview of the monitoring site on orthophoto map 1:10,000**

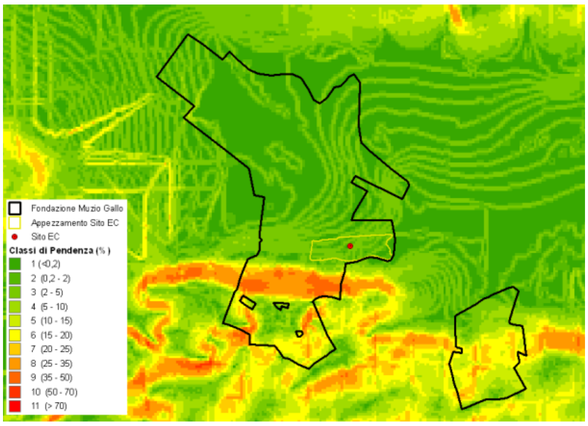



**Figure 16 – Distribution classes – slope**

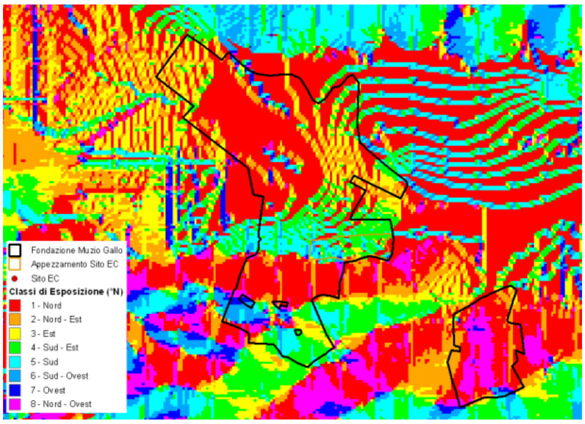



**Figure 17 – Distribution classes - exposure**

Once again the environmental factors correlated to soil formation processes were identified, as was the distribution of soil types present, in order to be able to define the sustainability of the agricultural management systems adopted and existing soil quality.

Data collection activities from farm soils were scheduled using the Soil Information System.

Hereafter is an extract from the "Land subsystems" involved in the monitoring site Muzio Gallo.

As for soil features, the soils were formed on geological substrates of alluvial matrices, with sandy-stony matter or finer sandy-silt matter. The main soils on the site are Inceptisols fine clay,

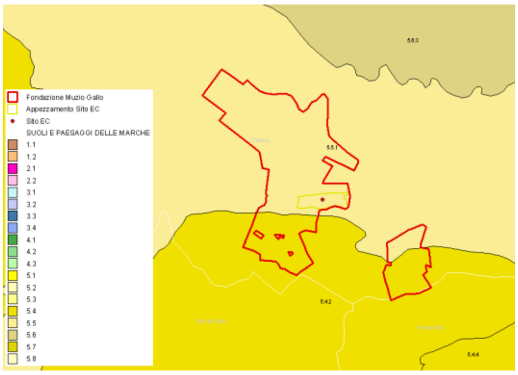



**Figure 19 - Monitoring site and *"Land subsystems"***

xerepts, and fluvanna which are the most widespread soils along the valley floor of the region, not affected by recent floods. The soils characterising the site are of great interest for the study of C cycle dynamics, in relation to agricultural management practices used in the area.

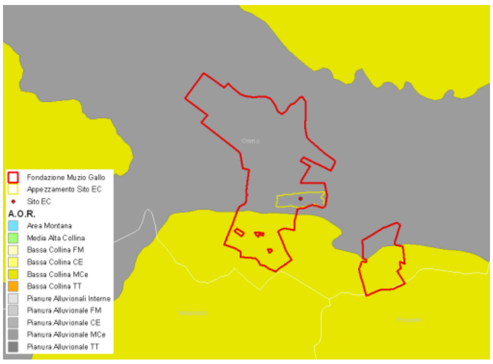



**Figure 16 - Monitoring site and "Analogous Benchmark Environments"**

Indeed the soils in question are among those with the highest content of SOC in the mineral horizons in the first 100cm, at 128 T/ha. In addition the interest of these soils is related to the fact that they have the highest energy inputs, due to intensive agricultural use, and therefore more susceptible to imbalances in biogeochemical cycles.

### 5.3.5 Monitoring site update

The location and the structure of the monitoring site is not set in stone over time, but adapts to the territorial context in question. Territorial dynamics can be measured and monitored on the basis of two main factors:

- land management at district level (e.g. reforestation, urban expansion, uncultivated areas, etc.);
- the variation in pedogenetic factors and/or the occurrence of phenomena that pose a potential threat of degradation (see climate changes, structural changes to the territory following human intervention; introduction of environmental restrictions; etc.).

# 6 Sampling design

Within the monitoring site identified, that can be represented by a single or several UTAs, using the method described, the *parcelling of land* and the *sampling-PC points* are identified to take measurements and other samples.

As we have already stated, the monitoring system has the purpose of meeting local goals and at the same time representing valid information summaries that are useful on both small and larger scales (i.e. regional, national and EU).

The opportunities to use the information and data obtained with monitoring at different scales of intervention are closely linked to the method used to identify the sampling points. Accurate identification of the point(s) is a *sine qua non* condition in order to be able to extend data at spatial level and to aggregate date on a scale that is different to that of the data collection. To this end, the methodology used for the MOSYSS network provides for the integration of two methods respectively for the choice of monitoring sites (SMs) and for sampling points (PCs). In the first case the methodology provides for a multi-criterion assessment of a geographical and semantic type to identify representative areas (criterion for representative sites). In terms of the land parcel selected, identification of the sampling points (PCs) similar to and related to other existing networks on a smaller scale (national and EU), we used "close-knit" grid points (a criterion for regular square grid points of predetermined dimensions)

Another condition introduced into the network structure concerns management, regarding the need for systematic analysis of soil variables, or those related to its use and management, in order to highlight changes over time, take measurements at the right time to bring to light the dynamics occurring - regarding both soils and land management techniques. For this reason it is of fundamental importance to be certain to repeat sampling over time at the same point, thus excluding spatial variability at field scale.

To this end, having prepared the sampling grid using the chosen method at field scale, the land points are identified using a last-generation topographical tool which can guarantee against repositioning errors to the nearest few millimetres (portable station with a metric coaxial camera GPT-7000).

## 6.1 Identifying sampling points (PCs)

The use of "close-knit" grids to identify sampling points has already been used when setting up monitoring networks in Europe (for example France and United Kingdom) and also in Italy with previous experiments performed at national and regional scales (e.g. Apat, Ctn_tes, 2004 - Cenci *et al.*, 2006 in Lombardy).

At EU level the benchmark was introduced with the monitoring survey LUCAS (Land Use/Cover Area Frame Statistical Survey) launched in 2001 by DG Eurostat of the European Commission, in collaboration with DG Agriculture, with the aim of monitoring land use, land cover and implementing a soil survey at European scale (LUCAS, 2011; Tóth, Jones, & Montanarella, 2013).

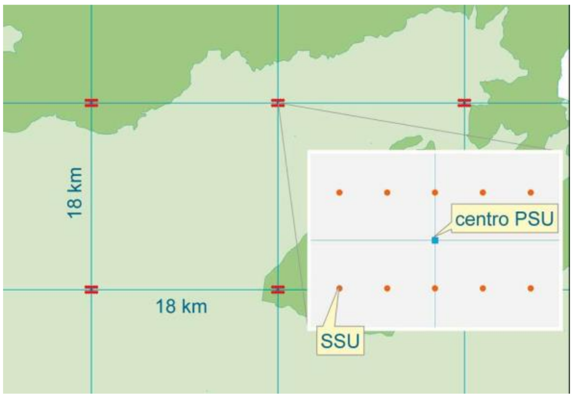



**Figure 17 – LUCAS network defining PSUs and SSUs *(Source: Ersaf – Quaderni di ricerca N° 110/2010)***

The LUCAS network is based on a square grid 18x18 km in size, a detailed spatial resolution at EU scale. Using the LUCAS monitoring system, each node of the grid constitutes the centre of the ***psu*** (primary sample unit), according to which 10 observation and data collection points are identified, each known as an ***ssu*** (secondary sample unit) (Figure 20).

In Italy, ***ssu*** points are 250 m apart and are arranged symmetrically with respect to the ***psu*** point, five on each side, along two lines oriented east-west and 500 metres apart. The ***ssu*** points are numbered 11, 12, 13, 14, 15 on the upper line and 21, 22, 23, 24, 25 on the lower line; the two figures represent respectively the line to which they belong (1 for the upper line, 2 for the lower line) and the sequence from west to east.

The LUCAS grid and its sampling points can be identified on regional territory using an Italian geographical referencing system, defined by the Hayford international ellipsoid oriented at Rome Monte Mario. In that referencing system, the positions of a point are expressed in geographical coordinates, with a longitude calculated with respect to an origin in Monte Mario, or expressed as cartographical coordinates according to the Gauss-Boago projection in the national "fuso" west. The nodes to be found in the Marche Region are fundamental and are the correlation link between local level and EU level.

For the MOSYSS network, the choice of sampling point, according to the indications provided by the LUCAS system where integrated with local networks, does not follow strictly the close-knit criterion, but as stated follows the representative site criterion. The proximity or distance of the sample from the European monitoring point is of assistance when correlating the information which is sent to supra-regional levels with local data.

### 6.1.1 Choice of parcel within the farm UTA

As stated, farm areas within the same UTA have follow the same agronomic management method. This does not mean that a UTA can only host a single crop – on the contrary an "arable crop rotation without fodder" system can be composed of several parcels cultivated either with winter crops or spring-summer crops. The choice of *"parcel"* where sampling is to take place complies with representativeness criteria within the UTA on the basis of some key variables:

- soil distribution and intrinsic features;
- size and shape of the parcel with regard to typical UTA values;
- proximity to/distance from other monitoring networks' points (LUCAS);
- proximity to/distance from other sampling points already used;
- what knowledge needs to be collected about the area and degradation phenomena under way;
- accessibility to the site;
- management system(s) adopted.

Within the parcel, the positioning of the measuring point can be identified using two configurations:

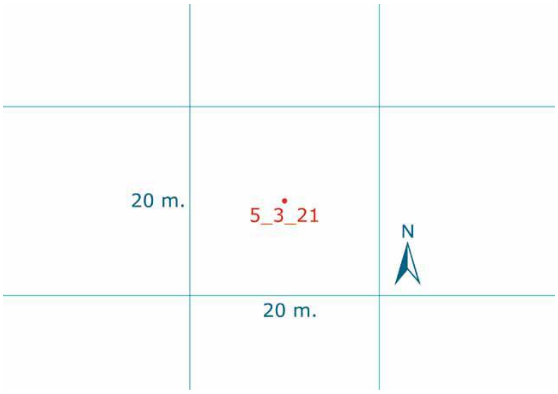
***- "L-shaped" configuration*** – sampling takes place in three areas 20x20 m arranged at the points of a right-angled triangle. This configuration is adopted in agricultural management areas;

***- "single plot" configuration*** - sampling takes place in a single area 20x20 m near the soil profile. This configuration is adopted in forest and alpine sites and in all cases where it is not possible to apply the "L-shaped" configuration.

#### 6.1.1.1 L-shaped configuration

The "L-shaped" configuration consists of an adaptation of the method known as *"area-Frame randomized soil sampling (AFRSS)"*. This method defines a practical procedure for soil sampling, combining collection of mixed samples using random geographical positioning techniques from the collection point (Stolbovoy *et al.*, 2005). The "L-shaped" configuration provides for three measuring areas within a single sampling parcel.

The three areas coincide with three cells of a regular close-knit grid spaced at 20 metres centred on the soil profile point (as shown in Figures 21 & 22) identified according to the "*Manuale di rilevamento pedologico della Regione Marche*" drafted by the Regional Soil Observatory on the basis of references provided by MIPAAF– CRA - ISSDS;



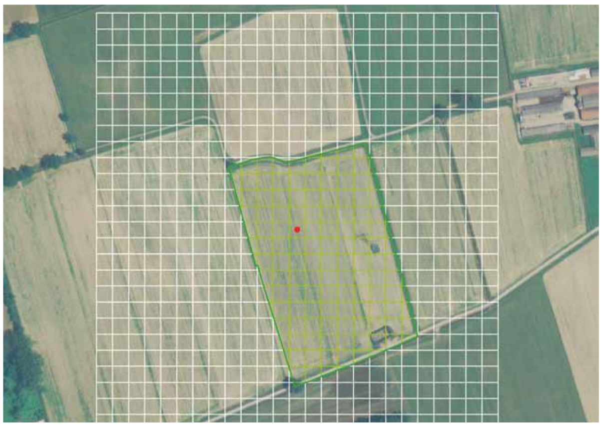



**Figure 18 – 20 x 20 reference grid**

**Figure 19 – Intersection of the 20 x 20 m SM grid with the area of the farmland unit *(Source: Ersaf – Quaderni di ricerca***


The three 20x20 m areas are arranged on the points of a right-angled triangle according to the following criteria:

• the first area, defined as area rtK, corresponds to the vertex of the right angle of the triangle; as a rule, and adjacent to the cell centred on the Pedological Profile (PP) point. Going clockwise from north, the farthest distance from the agricultural parcel will be considered to be the best;

• the second area, defined as area X80, localised along the direction PP-rtK such that:

- its centre is 80 metres from the centre of area rtK;
- the PP point is outside the segment formed by the centres of areas rtK and X80;

• the third area, defined as area X40, and localised along an axis that is perpendicular to the axis rtK-X80; its centre is 40 metres from the centre of area rtK; there are two possible solutions - priority is always given to the cell located in the most central position with respect to the agricultural parcel.

**Figure 20 – Identifying sampling points in an "L-shaped" configuration *(Source: Ersaf – Quaderni di ricerca N° 110/2010).***

### 6.1.1.2 Single-plot configuration

This configuration uses the methodology adopted by *"INRA-Institut National de la Recherce Agronomique - unite infosol"* in the soil quality monitoring system set up in France (Jolivet *et al.*, 2006). The single plot configuration includes only one sampling area within the parcel, which coincides with a cell on a regular grid spaced 20 metres apart centred on the opening point of the pedological profile (Figure 24). This sampling area, defined as area Fra, is localised in a cell next to the cell centred on the pedological profile (PP) and identified, as for area rtK in the "L-shaped" configuration, going clockwise from north.


**Figure 21 – Identifying a sampling point in single-plot configurations *(Source: Ersaf – Quaderni di ricerca N° 110/2010).***

## 6.2 In-field positioning of grid references

Having chosen the representative farm and prepared the geographical data to build the grid at field scale, and geographically identified the measuring points, the next step is in-field positioning of the *"sampling point"* within the Farmland Unit and the parcel chosen. This operation can take place using two methods depending on the type of monitoring station.

On ordinary sites a less precise but faster method is used, sufficiently precise for the measurements to be taken in these monitoring sites: the portable eTrex GPS by Garmin.

The GPT-7000i, a highly precise tool, is used in monitoring system sites where it is necessary to monitor very complex phenomena such as water erosion of soil.

### 6.2.1 Portable eTrex GPS

The eTrex GPS by Garmin is one of the most common and widespread products used by ramblers. This type of GPS, independently of the producer, has in common a function to *record our position as we move around*. This is why they are also called **GPS trackers**. GPS trackers record our position at certain variable time intervals while we move around (approximately tenths of seconds). The points, called **trackpoints**, are then joined to form, with a good approximation, the path that we have followed, called **trace** or **track**. One important point to stress is that the GPS has a level of precision of a few metres that can be improved according to the location and meteorological conditions. During data collection in practice, it is easy to further reduce this margin for error by combining, in the same day, measures using known coordinates (geodetic points nearby or those points that are easily recognizable from aerial photographs). As stated with this type of GPS it is possible to load or directly pre-set the so-called "routes" composed of geographical points - "***routepoints"*** that in our case refer to points on a grid and sampling points. These points can thus be found in the field using a comparison between the track being following and the pre-set points.

### 6.2.2 GPT – 7000i

The total imaging station GPT-7000i, using new "reality capture" technology, as already noted, supplements traditional measurements with the incomparable granularity of information contained in the images associated with the measurements. This function increases significantly the range of usage in the topographical field; specifically it makes possible applications which until now have been impossible with old generation stations, especially in the agri-forest domain on erosion issues.

Each measurement is memorised together with the photograph taken with the coaxial camera. The superimposed image can also be used in a "virtual reality", loading demarcation data and/or barriers (using geographical coordinates). They can be superimposed on the video to align demarcation lines, which can be used to "virtually" reconstruct the profile and thus assess either visually or digitally loss/acquisition in the volumes identified (soil in this case).

Once the data has been acquired on site, it will then be possible using special software programs to reconstruct and take precise 3D measurements from the digital photos taken with the digital camera.

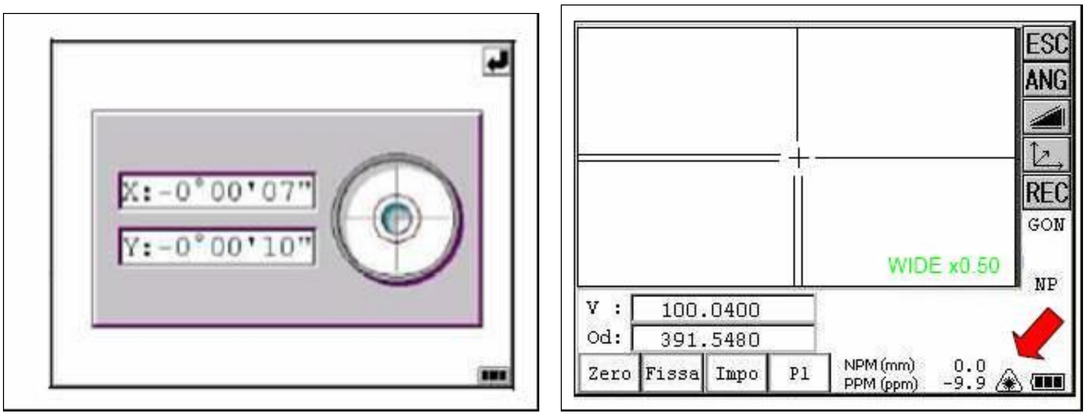



**Figure 22 - Display and calibration device - Total Imaging Station TOPCON, from the GPT-7000i series**

Furthermore, the data have a high level of reliability and precision, because the station works with a recording tolerance of less than one mm. The site survey also involves connecting three fixed points on the edges of the site; the three fixed points involve first of all building a small plinth in cement, to form the zero point of the site. One of the fixed points must be the point where the total imaging station is installed. The data collected in the field is processed and the output will be the topographical profile of the land. Measures in situ need to be taken from points where the land is bear with no crops.

Preparing for marking out and measuring.
When the tool is levelled, use the eyepiece of the telescope to find points of interest.
Look through the viewfinder towards the section containing the prism to approximate the right position; once the right vertical has been defined (using the air bubble), look through into the optical triangle <u>inside</u> the viewfinder and, moving the tool on the vertical only, focus/centre the prism (thus defining the alignment of the tool/prism).
Focus the sights using the <u>smallest</u> ring. When the sighting line and the symbol e + ∞ (on the left) and - ∞ (on the right) can be seen in the viewfinder, the eyepiece is focused. The next stage is actual focusing, using the focusing screws (larger ring, around the eyepiece) turning it as required.

## 6.3 Profile observations

Actual soil data collection is based on universally recognised measurements that nevertheless need to be organised and planned according to the particularities of each investigation.
In this regard the MOSYSS network leverages the experience acquired during soil collection activities carried out by the regional department and uses as its reference the "*Quaderno tecnico*

*di campagna*" that sets out in technical and practical terms the data collection procedures applying to the regional territory.

Hereafter readers will find a number of general principles and descriptions. For further details please refer to the document cited above.

**Profile**

This term usually identifies the excavation or open ditch dug for the purpose, up to a variable depth, to study and observe the soil. In fact the profile is not the excavation, but the observation of the soil as a whole, and its substrate on a vertical wall.

The excavation/profile may be dug either with mechanical equipment or by hand, or using mixed methods.

**Escarpment**

Conventionally, this means a "profile" that has already been exposed - i.e. an excavation or natural or human slope constructed previously and/or already existing and reused for soil description purposes.

**Probing**

These are soil observations, including at depth, carried out from the surface using manual tools that can bring material to the surface but not expose a section. Pedological bores or probes are used, or mechanical sampling probes.

**Surface observations**

These are observations carried out from the surface, without any exploration at depth or with a minimum amount of exploration (e.g. few centimetres dug out with a spade).

**Mixed observations**

These use mainly profiles and escarpments together with manual bores or probes, or, in very special cases, profiles or bores together with deeper probes.

# 7 Monitoring variables

For each site selected the *"data collection protocol"* identifies the variables to be collected, means of collection, tools to be used and organisational structures suitable to carry out work within the time allotted. The data collection protocol, different for each site, takes into account the possible various combinations of environment, soil and management factors. Defining the protocol generally involves the following operations:

- preliminary phases assessing land and soil to have a territorial overview of the site in question;
- scheduling soil data collection in the field;
- identifying any tools in situ and to be used remotely;
- determining agronomic data on agri-forest management systems involved;
- determining laboratory analysis.

Data collection in the field includes in all cases the acquisition of basic data (physical, chemical and biological variables) applying the official benchmark methods and with regard to the functional quality of the soil**.**

To this basic data acquisition is added specific data collection relating to any degradation phenomena affecting the soil on the investigation site.

Degradation phenomena affecting the soil and the related protection strategies are listed in the Soil Thematic Strategy, Considering the situation in the Marche Region also identified as part of a "*contextual analysis*" under RDP Marche 2007-2013, the risks of degradation for the Marche Region are erosion and a decline in SOM.

## 7.1 General sites

### 7.1.1 Pedological variables

All of the points describing the soil, the site and environment, the horizons and the layers are known as variables. By variable we mean a feature, an attribute which can have different values in a predetermined set, called the domain of the variable. A variable can be indicated with the term observation when it is directly collected (measured or classified) on a statistical unit extracted from the population.

Variables can be divided into qualitative and quantitative variables. We speak of a qualitative variable when observations can be classified (or classed) on the basis of the way in which they are presented (e.g. as an aggregate): in these cases the variable is not measured, but classified into

categories (i.e. classes). On the other hand we speak of a quantitative variable if the attribute can be measured.
Variables can also be single or composite. By single variable is meant all of the variables (whether measured or classed) that describe a feature using a single measure (or class attribution), such as for example the height of the site above sea level. By composite variable is meant all of the variables (whether measured or classed) that describe a feature using two or more measures (or class attributions), i.e. a set of single variables, such as for example structure (STRUCTURE, AGGREGATION, PEDALITY, etc.).

The single descriptive variables may be:
CODED: these are predefined codes; numerical (Cn), alphabetical (Ct), alphanumerical (Ctn).
UNCODED: when they refer to unclassified quantitative variables. The number of figures requested are indicated as are any use of decimals (the variable domain), the unit of measurement (metres, millimetres, percentage weight or volume, etc.), and the definition or meaning of the variable. For some variables the taxonomic or application classes are indicated (where they exist) in order to have a reference for the threshold values to which attention should be paid and if possible should be avoided. If the value of a no-coded variable is nil, 0 (zero) should be used, except where otherwise indicated. Numbers (N) or text (T) can be used.
IN NOTE FORM: the description of the variable is open, and is not necessarily quantitative or codified. Some variables can be compiled solely in the form of notes, and other variables on have a codable part and another part in the form of a note.

To facilitate some choices of the person collecting the data, it is essential, for CODED variables, to use certain codes with an unambiguous meaning, in the following cases:

| | | |
|---|---|---|
| **Y** | numerical not detectable<br>not detectable<br>textual | variable that has proved impossible to describe at the time of data collection, but is not necessarily absent. The code is used for mandatory fields, non-mandatory fields can be left blank; |
| **Z** | absent | variable that is absent for fields in text format. The code is used for mandatory fields, non-mandatory fields can be left blank; |
| **0** | absent | variable that is absent for fields in text format. The code is used for |

| | | |
|---|---|---|
| | | mandatory fields, non-mandatory fields can be left blank; |
| **X** | Not relevant | variable that is sometimes not collected. The code is used for mandatory fields, non-mandatory fields can be left blank. |

Mandatory fields are indicated in the form with a grey colour. Mandatory fields are to be understood as necessarily completed with a numerical or textual value. Mandatory fields can be increased depending on the specific project.

The main variables identified can be divided into five groups:

- variables relating to a description of the site and the environment;
- variables to describe the actual soil in organic horizons and litters;
- variables describing mineral horizons;
- variables describing the M layer (bedrock);
- variables describing the soil as a whole.

The description of the site includes data on morphology, origins of forms and materials, substrate and parent material, consistent mineral materials, inconsistent mineral materials, organic materials, erosion and lay, risk of flooding, surface aspects, surface stones, management of waters and the water table, water management, soil usage (vegetation and land use), forest bearing§.

Regarding the organic horizons, the variables describe the depth, thickness and lower limit of the soil, colours, organic substances, patterns and shapes of pedo -biological origin, spaces, structure (aggregation), roots, and reaction.

In mineral horizons observations relate to various complex and articulated factors, consolidated over many years' experience worldwide and commonly described in soil observation manuals adopted at international level. In summary we can note: the designation of horizons/layers; the depth, thickness and lower limit; structure and consistency; fissures, macro pores and channels; roots, colour, pedogenetic patterns; presence of animals and fungi; texture of land; fines and granulometric distribution; stone content; organic materials; HCL effervescence, sampling for laboratory analysis; analytical tests on disturbed§ samples.

Other measurements relate to soil assessment overall and in particular: trans-horizon crevices; roots, drainage and permeability; internal drainage and permeability.

For further details we refer readers to the "*Manuale di rilevamento di campagna*" for the Marche Region made available by the Regional Soil Observatory, on basic observation standards supplied by competent authorities at national and supranational levels.

### 7.1.2 Management system (FMS) adopted

Chapter 4.2 describes the points identified in agri-forest management systems measured using variables relating to biophysical aspects (hard) and socio-economic aspects (soft).

The variables relating to the soil have been described in detail in the above paragraph and are collected indiscriminately on all monitoring sites. They constitute a knowledge base that is indispensable for any subsequent interpretation.  To these variables in dedicated sites or in other special situations can be added further analyses for special cases.

As for the climate in ordinary sites no regular meteorological data is planned for. Reference is made to the values monitored for the district. In dedicated sites, considering the importance of the microclimate and understanding its variability, the option to carry out meteorological monitoring through small mobile weather stations is provided for.

In conclusion, the measurable variables more specifically aimed at characterising the management system adopted by the farm being monitored relate to the use of technical equipment.

Among these factors, those distinguishing the management system adopted by the farm are: crop rotation; ploughing, use of fertilisers, use of chemical products.

The agronomic data collection sheets and the database structure available to archive monitoring data can be found in the Annex.

## 7.2 Dedicated sites

In dedicated sites, however, collection of all variables identified for ordinary sites is planned. This meets practical needs aimed at obtaining the best cost-benefit ratio and is related to specific technical aspects for the themes involved which, in order to be examined, require an extensive understanding of the factors at stake. In dedicated sites, then, in addition to ordinary data collection, further measurements and checks are carried out concerning the phenomenon under investigation. In the case of the MOSYSS network, a choice has been made to include dedicated sites to keep under observation the key threats to soil conservation such soil erosion and the loss of SOM. These two threats, unknown until a few years ago prior to the industrial age, are now at centre stage, not due to an extraordinary change in regional soils, but the introduction of farm management systems that take little account of soil requirements and consequently cause a gradual loss of fertility and hence production capacity in the land currently cultivated. Changes in management systems with an abandoning of animal husbandry and simplified crop rotation now mean that it is necessary to begin using sites dedicated to another aspect that we cannot yet consider an actual threat to soil but which could represent a serious problem for the environment and for mankind – the loss of soil biodiversity. In these sites it is important to remember that no research and/or experimental activities must be performed. Farmers in these stations, which, as described earlier, might occupy large or small areas, must behave in the same way as on the rest of the farm and must be able to manage the soil in any ordinary way without impediments or obstacles.

The various measurements are taken during the production season and during the year, depending on the factors leading to the undesirable phenomenon.

### 7.2.1 Soil erosion

In sites dedicated to measuring soil erosion, data collection with a total imaging station is planned, as a basic measure, each year. It will however be possible to plan for dedicated measures, to be carried out at the same time as special events such as for example serious weather events.

The choice of key monitoring sites arose due to the results of applying predictive models on the risk of soil erosion and on the basis of the definition and delineation of the Analogous Benchmark areas discussed earlier.

For lands in agricultural use, we have experimented in the field with using the previously described tachometer, for the purposes of obtaining an altitudinal section of determined measuring points.

The use of the tool has enabled both angular and metric measurements to be taken, in various different acquisition campaigns (two of the most representative results will be presented below), because it allows altitudinal measuring points to be found with a precision to the millimetre.

We can summarise the method as follows:

1. Choice of land parcel where measuring is to take place;
2. Choice of altitudinal section to be examined;
3. Positioning of the tachometer at a fixed data collection point (stake 1);
4. Choice of the start and end points of demarcation or measuring (stakes 2 and 3);
5. Measuring, recording data;
6. Loading data and creating an altitudinal section.

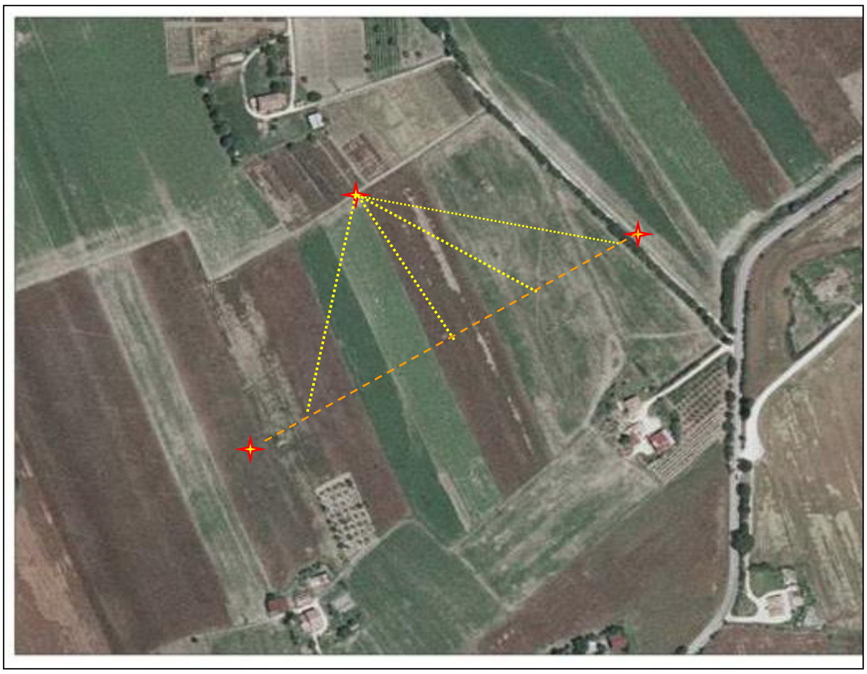


**Figure 23 - Location and demarcation Testing station with a GPT-7000i tachometer**

The challenge is to return, after a certain period of time that could be from a few days to a few years, to exactly the same spot for data collection along the line joining stakes 2 and 3, and measure the altitude of the same points with respect to the position of the tachometer (stake 1). A check can thus be made as to whether there is an accumulation of matter in the section chosen and thus land erosion above the demarcation line.

Measurements taken in the field experiment described in the Figure above were recorded a few months apart and led to the creation of two almost identical altitudinal sections, bringing to light only a slight loss of soil from the site (Fig. 28); it was interesting to note that measuring points were exactly relocated, indicating that the tool can be really useful for the intended purpose – that is to give precious assistance to ascertaining the risk of soil erosion.

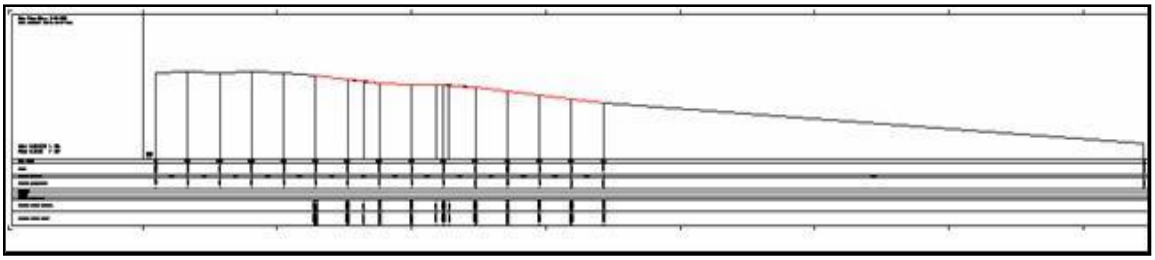


**Figure 24 - Altitudinal profile from two campaigns *(Experimental station with a GPT-7000i tachometer)***

This type of station can be used in monitoring sites with water, to understand erosion dynamics in such areas, data which is correlated to the transport in surface water of the nutrients used in agriculture (principally N).
Since this was a mobile monitoring site, permanent positioning was not needed, but it provides support for other sites where water is found.

### 7.2.2 Loss of organic matter

Soil organic matter (SOM) is a key factor for the functioning of bio-geo-chemical cycles. Soil fertility is dependent on it, and thus a capacity to provide and maintain over time the other soil functions and food security.
The C cycle to which dynamics affecting SOM are linked has gained attention in recent years also regarding climate change issues and their effects. Capture and release processes occur simultaneously in soil. Some of the C contained in dead plant and animal tissue is oxidised, returning as $CO_2$ in the atmosphere. This partly follows the processes of OM fixation and in the end becomes part of the stable portion of the soil. In certain environmental and farming situations the SOM cycle may be unbalanced, tending towards consumption and the mineralisation phase, to the considerable disadvantage of the phase in which organic residues are accumulated and humus is formed.
By means of good land management it is possible to maintain the delicate balance in soil between accumulation and consumption of SOM, which is indispensable to not compromise over time the best conditions for soil fertility.
For this reason, in monitoring activities, in addition to observing the level of SOM present in the various horizons composing the soil, some activities are aimed at understanding and measuring the dynamics of variables describing the C cycle and agronomic practices adopted that may have a direct or indirect influence on SOM dynamics.
In these sites measures relate therefore to:
- monitoring changes over time of organic carbon content in it's more labile and stable forms over time;
- indirect measuring of soil fertility through the monitoring of the so-called "soil respiration" which quantifies the flow of $CO_2$ in soil;
- measuring other variables correlated to the C cycle such as soil temperature and moisture. Such measures can be made for each soil horizons, continuously and remotely using sophisticated electronic devices;

- management practices adopted with particular reference to crop rotation, fertilisation and ploughing.

### 7.2.3 Loss of soil biodiversity

More than a quarter of all species living on land live in the soil. Most of the species in the soil are microorganisms like bacteria, fungi and protozoans, the so called "*chemical engineers*" responsible for decomposing organic plant matter into nutrients available for plants and animals.

Confirming an increasing focus in Europe on the importance of soils and the conservation of "soil biodiversity", in February 2010 the EC - DG Environment disseminated a document with the title *"Soil biodiversity: functions, threats and tools for policy makers"* aimed at highlighting current levels of knowledge about soil biodiversity, its functions and its relevance for the sustainability of human activities.

In order to be able to monitor soil biodiversity over time, some indices of the biological quality of soils have been developed, based on quali-quantitative analysis/measurement of certain groups (taxa) of soil organisms. Another is based on an analysis of the structure of the community of micro-arthropods in the soil (BSQ-ar, index).

At both EU and national levels, in order to standardise analytical methods and subsequent interpretations, specific parameters have been identified and indicators and indices to measure biological quality features in soils have been proposed. References for Italy are listed in Ministerial Decree 23/3/2000 suppl. Ord. O.J. N° 87 of 13/4/2000 – "microbiological analyses of soil".

On dedicated sites the variables and parameters that are measured relate to:

- the biomass and microbial content of the soil;
- microbial activity in the soil.

The measure of biomass defines the relative abundance of microorganisms in the soil. Microorganisms can then be identified and grouped according, for example, to their metabolic features.

The second group contains measures that can define the current and potential functional activity of soil microorganisms. An example is the test to measure soil respiration.

# 8 Data storage and management

The validation and data storage phase includes data processing with partly automated inspection procedures to check correctness, quality and representativeness. Validated data subsequently go on to the computerised data storage phase using a geo-referenced storage system with several records: a soil observations database; a pedo-landscape database; an agri-forest management agronomic data set; and data sets specific from instrumental storage systems.

The data storage system gives easy access to the data for subsequent phases of work and above all allows monitoring data to be integrated with the existing Soil Information System managed by the Regional Soil Observatory. (**See Annex 2 and 3)**

# 9 Spatial data representation

Monitoring data recorded can also be represented at spatial level if linked with the common benchmark "grid" INSPIRE (Infrastructure For Spatial Information in the European Community).

The INSPIRE standard (acronym of INfrastructure for SPatial InfoRmation in Europe) was introduced in EU by the Directive establishing an Infrastructure for Spatial Information in the European Community which entered into force on 15 May 2007.

The Directive seeks to create, through common standards of implementation integrated by Community measures, a common structure which makes territorial information from different States compatible and usable in a cross-border context, so as to overcome problems relating to the availability, quality, organisation and accessibility of data.

The INSPIRE Directive requires, in particular, an indication for each territorial data set data of the relevant “Metadata” for the interoperability and sharing of information.

Metadata must contain “*information which describes the territorial data set and the services relating to territorial data which enable such data and services to be searched, catalogued and used*" at various scales of representation.

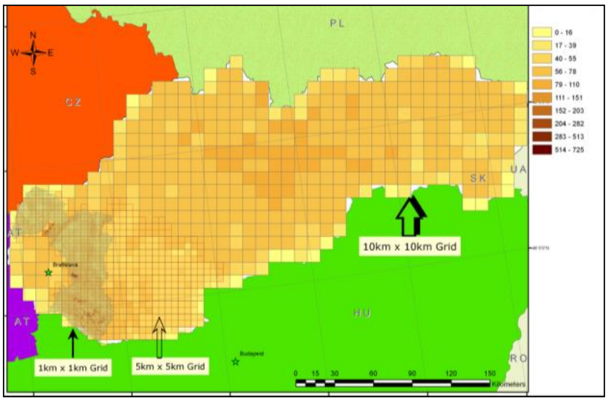



**Figure 25 – Example of cartographic representation at different scales**

The representation of territorial data on common grids enables the problem of different data frames and structures within the EU, between authorities and procedures of data to be overcome.

The use of the reference grid to create new multiple and submultiple networks facilitates representation and the use of different reference scales: farms (scale 1:2,000) local (scale 1:10,000) regional (scale 1:250,000).

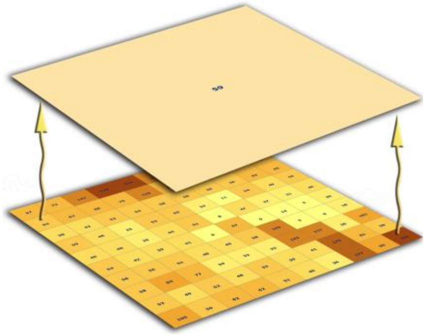


**Figure 26 – Example of information of maps rasterised on differently offset grids**

The representation of data on grids also facilitates the dissemination of data and opportunities for its use, guaranteeing at the same time the respective property rights and harmonization of information.

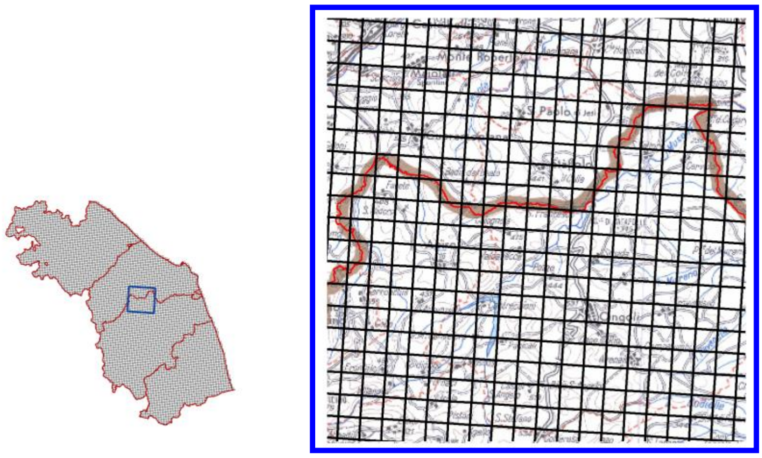


**Figure 27 – Example of reference grid on regional topographical basis**

# ANNEX 1: Description of the main features of Analogous Benchmark Environments (ABEs).

**Area 1: Mountain (AM)**

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|---|---|
| ***Area*** | Almost 25% of regional territory is found in the Mountain AO. It extends mainly to the south and centre of the Region and then is partially fragmented into small blocks towards the Apennines in Alto Metauro and Alto Marecchia in the "*massiccio*" of Monte Carpegna. |
| ***Altimetryand Geomorphology*** | Almost always above 600 m and on average around 850 m above sea level. Inland altitudes are however much higher, often over 1000 m, reaching 2480 m in the Sibillini Mountains. There are also, however, areas – Conero in particular – that in terms of altitude and bioclimatic environment do not fall into the mountain category and which are included here for a schematic reading of the regional environment. |
| ***Climate*** | Climatic features, which vary from the coast inland, bestow upon the mountain belts moderate rainfall and cool temperatures, which is clear from the average rainfall and temperatures for the month of July: P > 46-47 mm and T < 21°C. |
| ***Land use*** | Due to geological structure, morphology and climate, land use clearly identifies AO1 areas. Woods, generally broad-leaved and prevalently copses, represent 60% of surface area, with a total of the faggete in the Region and 70% of black hornbeam woods. Meadows beyond the wood boundaries and those found at altitude form almost 20% of total surface area, while agricultural areas form only around 18%. |

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|---|---|
| ***Geology and Lithology*** | The mountains include the chalky ridges of the Marche (70% of geological substrate is chalk and marl, flint chalk and chalky marl). |
| ***Soils*** | Soils in these vast mountainous areas reflect particular geomorphological and climatic conditions and are therefore often thin and stony or sit directly on chalky rock or marl. Due to the extensive coverage of woods and pasture, soils rich in organic matter are very common, particularly at medium or high altitudes – less subject to erosion – accumulated in surface horizons or mineralised in well-structured forest epipedons. In the Carpegna area and the surroundings, there are both more mature and deep soils - chalky and eutrico and poor thin soils, with a certain amount of very clayey and dynamic soil (soils at the summits). |

* **Area 2: Mid to High Hills (MAC)**

| | |
|---|---|
| ***Area*** | 29% of regional territory is included in this Environment, the largest of those defined here, which represents in a fairly all-embracing way all inland areas of the Marche that are not mountainous. |
| ***Altimetry and Geomorphology*** | Mainly from 300 to 600 m in altitude (average around 430 m above sea level). Altitudes vary widely, from 100 to above 1000 m, while average slopes (25%) clearly identify this hilly area with a discernable relief. If we look carefully, we can distinguish at least 3 sub-environments within this area 3: the inland basin of the Marche - Camerino-Fabriano - high hills to the east of the Marche ridge, including the relief of the minor ridge Cingoli-Monte Acuto,and the inland hills of Montefeltreo and the mid-high Metauro and Foglia rivers. |

| | |
|---|---|
| ***Climate*** | Almost all of the area comes under the phytoclimatic Plan "*Alto-collinare*" and is characterised by average rainfall of over 700-800 mm per year and average temperatures of less than 14 °C. |
| ***Land use*** | Overall, these are environments characterised by agriculture, still forming a part of the natural environment, where around half of agricultural land (63% in total) comprises clearly differentiated systems, with a significant amount of natural vegetation, even if there is little difference between the length of valleys and watersheds. Woods, however, still cover the significant 28% of the territory, with most of the thermophilic components being oak woods. Pasture and natural meadows are reduced here to around 3.5%, limited to higher altitudes. |
| ***Geology and Lithology*** | Chalk alcarenitic-pelitiche rocks prevail (32%) as well as marl or chalky marl (26%). However there is a significant presence of conglomerate and arenite substrate and even deposits from the Pleistocene era in the detritic cone foothills in the Appignano area. |
| ***Soils*** | Soils in this environment are very diverse and underline above all the different dynamics of slopes and soil use, whether agricultural or natural. Significant prevalence of Cambisols, moderately mature soils that develop on gentle slopes and erodible rocks, followed by less clearly differentiated soils, with horizons A on C, in particular in areas to the western edge of the Marche ridge and on hard or sandy material. Lastly there is an increase in soils with a clear redistribution of chalk in their profile (Calcisols). |

* **Area 3: Inland Alluvial Plain (PA)**

| | |
|---|---|
| ***Area*** | A limited area (4.31% of the regional total). |
| ***Altimetry and Geomorphology*** | In this environment are included all stretches of river valley floors and gullies of mappable dimensions recognised within the Marche, with an average altitude of approximately 350 m. The Marecchia valleys form a part, as do the inland stretches of all of the main rivers, in particular the Foglia, Metauro, Esino, and Chienti, but also minor valley floors, particularly in the centre and south of the Region. It is composed of fertile areas and sub-plains or gentle slopes. |
| ***Climate*** | The climate can be compared to that of moderate hills. |
| ***Land use*** | Mainly agricultural, divided among intensive crops and more differentiated and more heterogeneous management systems. There is a significant presence of tree-lined belts along watercourses. These belts cover more than 7% of the territory, also due to the length of the watercourses, demonstrated in the high ratio of linear expanses to the overall surface area of the Environment (> 0.8). On usable areas in the plains, the presence of housing and new production settlements also has a strong influence at 12%. |
| ***Geology and Lithology*** | The valleys are occupied by alluvial deposits, with a prevalence of grade III land, variable granulometry, mainly pebbly, and often with fine and colluvial coverage, from hill slopes and the nearest mountains. Around 20% of the lower areas can be attributed to the current floods (grade IV), which can often be considered to be subject to flooding and therefore subject to considerable limitations on use. |
| ***Soils*** | The soil features vary according to the granulometry of the material, but are almost always chalky and stony. They also, |

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| | sometimes, have "fluvial" features - i.e. an enrichment of organic matter in the profile, and also on the surface, when there are meadows or natural vegetation. |

* **Area 4: Low hills between the Foglia and Metauro rivers (BC_FM)**

| | |
|---|---|
| ***Area*** | Extends over almost 7% of the Marche territory (427 $km^2$) to the north of the Valle del Metauro. |
| ***Altimetry and Geomorphology*** | It has distinctive features with respect to the other hilly areas, mainly due to the diverse nature of geological substrates and consequently, a visible morphological relief. The average slope of land is around 19% and is above that of the other hill Environments, excluding the Ascolo Environment, which expresses even further the same characteristics of morphological parameters and diversity in land use. |
| ***Climate*** | The climate parameters do not have extreme values, with average temperatures of around 14°C and a regular seasonal distribution of rain with totals of around 800 mm per year. |
| ***Land use*** | Farmland covers overall around 83% of the territory in the Environment, half of which have complex typologies or a significant natural component. Woods are still widespread on the steeper chalk and chalky marl slopes of the inland ridges, mainly copses of the most common thermophilic species (oak).<br><br>This still significant presence of natural vegetation and diversified varied landscapes, even on the coastal belt, is also demonstrated in the high percentage of protected areas, around 20% of the overall surface area. |
| ***Geology and Lithology*** | The geological materials are equally divided among very clayey typologies (33.6% of clay pelite, "*Caotico*" clays) and mainly arenite types (34.5 %), which gives rise to clear contrasts in the relief and the nature of soils. There are also more consistent lithotypes, mark and chalky marl, on which |

| | |
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| | woods are still prevalent in fields and arable land. |
| ***Soils*** | In general soils with little differentiated profiles A-C, shallow on hard or arenite rocks, deeper on more erodable material. In these cases, if erosion is not accelerated, we find more mature soils, Cambisols, which are still chalky and sometimes have summit features (clayey and highly subject to cracks). Lastly, it is important to note the frequency of types with an excess of sodium in the pedological profile, mainly of natural origin. |

* **Area 5: Valleys between the Foglia and Metauro rivers (PA_FM)**

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|---|---|
| ***Area*** | The wider plains of the valleys of the Foglia and the Metauro rivers to the east of Monti della Cesana, with a total surface area of 181 $km^2$ (less than 2% of the Region), form the Analogous Environment of Valli-North, the first of the four environments surrounded by the valleys of the Marche rivers, closely correlated to the hill environments that the rivers cross. |
| ***Altimetry and Geomorphology*** | Slopes are around 2% although they can reach higher values on the edges of the valleys where material from the slopes cover alluvial land. The average altitude of the valleys is around 50 m, and, curiously, it increases regularly from more northern valley areas to the southern areas. |
| ***Climate*** | The climate of this part of the Region is considerably influenced by the sea, but maintains a notable annual thermal range, while the rainfall is quite stable, with maximums in the autumn and an annual average of around 780 mm. |
| ***Land use*** | Agricultural uses cover approximately 70% of the land and are in strong competition with expanding built-up areas and infrastructures. The latter now reach around 25% of the territory in question, occupying mainly the parts of the valleys nearest the coast and extending gradually inland.<br><br>Approximately 50% of cultivated land is involved in intensive crops, while the other half is composed of various diversified systems that give rise to a less monotonous agrarian landscape. There is a limited presence of woods, mainly in riparian belts and oak |

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|---|---|
| | copses. |
| ***Geology and Lithology*** | Geological materials are naturally composed of dissolved alluvial deposits, mainly sand-gravel, principally on grade III land (around 65%) which is thus not subject to flooding. |
| ***Soils*** | There are reasonably immature soil types in active valley floors, mainly soils A-C, stony and chalky; while on land more differentiated and deep soils can be found, sometimes saturated with lime, but not chalky. On older land there are also some deep soils, with alluvial horizons of clay and some drainage difficulties. |

* **Area 6: Low hills between the Cesano and Esino rivers (BC_CE)**

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|---|---|
| ***Area*** | The Environment of the low hills in the north and centre of the Marche extending between the Esino and Cesano rivers (675 $km^2$) characterises the typical environments of hill agriculture with little diversification in the landscape and more homogeneity in the type of crops used on the land. |
| ***Altimetry and Geomorphology*** | The morphological parameters, including the relationship between the linear lengths of watercourses and basin areas indicate little relief and average gentle slopes (13.5%). Slopes and average altitude (140 m above sea level) also characterise, with identical values, the landscapes of the agricultural Environment immediately further south, included between the valleys of the Esino and the Chienti (Area 8). |
| ***Climate*** | The bioclimatic environment is "low hills', where climatic parameters again include average temperatures (13-14.7 °C) and rainfall (750-780 mm). |
| ***Land use*** | Land use is, overall, not very diversified, since cultivated areas represent more than 92% of total area, of which only 30% is composed of relatively complex systems, environments with significant natural components or agrarian timber crops, the most extensive of which are vines.<br>Woods, pastures and bushes taken together do not exceed 3% of the territory, including the plant formations on the banks of water courses. |
| ***Geology and Lithology*** | The nature of geological material, the parent substrate agrarian soils in the area is characterised by a certain |

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| | homogeneity, mainly differentiated between pelite-calcarenite rocks (51 % of land) and pelite-clay rocks (34 % of the territory), which are highly subject to erosion and unstable, particularly the second group. Generally these are highly subject to alteration, where erosion balances a continuous development of the soil at the cost of the substrate, including at depth with the action of ploughing. |
| ***Soils*** | The soils which form on these materials are always highly and excessively chalky, above all for less mature soil types and in environments with more intense erosion. They are sometimes high in sodium? and xx (see earlier) on zones with a prevalence of pelite-clay. Calcisoils are not frequent, with secondary carbonate re-precipitated, but not always in abundance in the matrix. |

* **Area 7: Valleys between the Cesano and Esino river (BC_CE)**

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|---|---|
| ***Area*** | This area includes the valleys of the rivers from the hills to the north of Ancona, in particular the Esino, with its especially large plains in its lower course, the Misa with its affluents the Nevola and the Cesano, which marks the boundary between the provinces of Ancona and Pesaro. It covers 280 $km^2$ (2.88 % of the total) |
| ***Altimetry and Geomorphology*** | Morphologies of the sub-plains and an average altitude of around media di circa 80 m above sea level. A prevalence of fluvial land environments, grade II (33.8%) and grade III (30%), while existing and recent valley floors, mostly considered free from flooding, represent approximately a quarter of the environment's area. |
| ***Climate*** | Climatic indexes in line with averages for the Marche hills: from 700 to 800 mm annual rainfall, going from the coast inland, and average temperatures of between 13.7 and 14.7 °C. |
| ***Land use*** | Land use has features that are similar to those in the hill environment where the valleys are found, with a substantial difference as regards the considerable impact of urban areas and infrastructures in the valleys, amounting to around 15% of the total for the territory.<br>80% of the land is occupied by agrarian crops, more than 60% is composed of systems having few parcels and lacking natural elements. Naturally this leads to a reduction in the quality of the agrarian landscape, including in less built up areas. |

| | |
|---|---|
| ***Geology and Lithology*** | Lithology mainly includes alluvial deposits, sometimes gravel, which reflect the chalky basins. |
| ***Soils*** | The soils are generally deep, even when less mature and/or with a primitive profile. They are almost always chalky and may be gravelly, especially at depth. Fluvial features are rare, which indicates repeated states and reclaiming of fluvial sedimentation. On older and higher land we also find very mature soils, sometimes sub-acid and with some drainage difficulties. |

* **Area 8: Low hills between the Musone and Chienti rivers (BC_MCe)**

| | |
|---|---|
| ***Area*** | The Environment of the agricultural central and southern Low HIlls, extending over 10% of regional territory, includes hills to the east of the Cingoli ridge, bounded to the north by the Valle dell'Esino and to the south by the Valle del Chienti. |
| ***Altimetry and Geomorphology*** | It is an environment which is very similar to that of the hills to the north of the Esino described above. The average altitude and average slope is the same, but, particularly to the south of the Musone, becomes increasingly fragmented and subject to morphological variability. |
| ***Climate*** | The climate is drier with high temperatures and a lower July rainfall of approximately 40 mm. A situation which led to the Phytoclimatic mesomedilandneo Plan along the coast and the risk of a slight tendency to desertification if current climate trends continue. |
| ***Land use*** | Agricultural land use is 89.5%, of which approximately |

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| | 67% is given over to intensive crops (dry arable crops) and the rest more complex management systems. Here too, there is a slight distinction with respect to the hills to the north of Ancona, with a gradually more diversified environment and an increasingly natural component as one proceeds towards the Maceratese and Fermano and also considering the influence of the landscape surrounding the area of Conero in the Mountain Environment).<br><br>Woods still cover only a very reduced area (2,1%), but of these around half are wooded belts on the banks of water courses, conferring on the agrarian landscape further dynamics and richness. |
| ***Geology and Lithology*** | Areas with calcarenite-pelite geological substrates increase (around 60%) and there is less land on very clayey rock (23%). There is even a proportion of sandy-conglomerate rock (5%) which, together with the formation of stronger arenite banks, given more varied shapes and sometimes more stability, and to the soils a better textural balance. |
| ***Soils*** | Soils are similar to those in the central and northern hills, but with a significant increase in calcisoils; soils where the solution/re-precipitation dynamics of chalk in preferential horizons due to the strong climatic variations and thermal ranges is quite clear. Of note also soils formed by torrential transport (e.g. Valle Aspio) and large colluvial contributions on the edges of the minor valleys. |

* **Area 9: Valleys between the Musone and Chienti rivers (PA_MCe)**

| | |
|---|---|
| ***Area*** | The reference Environment includes the three large fluvial valley floors of the valleys of the Musone, the Potenza and the Chienti, naturally those parts in the hilly belt. They represent approximately 4.2% of the regional total). |
| ***Altimetry and Geomorphology*** | Average altitudes slightly above those in the valleys further north (89 m above sea level), and with the same average slopes (2-3.6 %). Recent lands are more widespread that elsewhere, corresponding to recent and current river deposits (58% of the land), while areas attributable to grade II and grade III lands, several metres higher than the valley floors correspond to less than 30%. |
| ***Climate*** | In this part of the Region there is a certain xericity of the climate and the average annual temperatures are above 14.5 -15°C. This has an influence on water availability of land for crops and is only partly compensated for by relatively widespread irrigation. |
| ***Land use*** | The portion of the territory occupied by urban areas, farming settlements, infrastructures and degraded areas of various types is considerable (around 9 %) but is also the lowest with respect to that portion in other representative Environment in valley floors in the Marche.<br><br>Agricultural use occupies around 86 % of the territory, mainly intensive crops, but the amount of woods, principally in the shape of tree-lined belts on river banks is a little higher than along the rivers of the centre and north of the Marche and is similar to the Ascolo valleys. |

| | |
|---|---|
| ***Geology and Lithology*** | Alluvial deposits. |
| ***Soils*** | Soils are very similar to those in the valleys of the centre and north, but with an increase in Calcisoils (soils with re-deposition of chalk in the profile) on stable lands and moderately mature soils, soil types A-Bw-C, chalky. |

* **Area 10: Low hills between the Tenna and Tronto rivers (BC_TT)**

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|---|---|
| ***Area*** | They represent approximately 10.11% of the regional total). |
| ***Altimetry and Geomorphology*** | The most southern hill environment was considered to extend from the Chienti to the Tronto, towards inland including areas with altitudes that are even higher than 300 m immediately north and south of the Aso valley. |
| ***Climate*** | The climate parameters indicate a certain morphological variability and the presence of areas with higher altitudes. July rain, for example, reaches 50 mm inland and the average annual temperatures are a little lower than the Maceratese area. |
| ***Land use*** | Agricultural areas are slightly reduced overall (81.6%), to the benefit of natural vegetation, including woods (10%), meadows (2.5%) and bushes and trees (around 2%). In particular among the woods, more than 40% includes tree vegetation from river-bank belts, 30% from thermophilic macchia and the rest various broad-leaved trees and coastal reforestation with conifers. Of cultivated areas, less than 30% is considered to be used for intensive crops, whilst most is more diversified agriculture with more varied agrarian landscapes and a more significant natural component. |
| ***Geology and Lithology*** | Reduction in more clayey lithotypes (15%) with more pelitie-calcarenite (47%) and arenite-conglomerate (18-19%), which are found inland or the large tabular areas in the whole coast belt south of the Chienti. |
| ***Soils*** | Soils with a primitive profile, but with various depths and always chalky, and, more often, moderately |

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| | mature soils, with a profile A-Bw-C, chalky with a slightly sodium content and sometimes with hydromorphy at depth. Soils with an accumulation of chalk in the profile are found mainly in the coastal hills. On pelite-arenite materials and stable locations mature, deep and well-structured soils can even be found. |

* **Area 11: Valleys between the Tenna and Tronto rivers (PA_TT)**

| | |
|---|---|
| ***Area*** | The benchmark Environment for the valley floors in the southern sector Fermano and Ascolano includes the plains of the Tenna, the Aso and the Tronto, as well as the minor plains of Menocchia and Tesino. The overall area is approximately 200 $km^2$ (2.1% of the Region). |
| ***Altimetry and Geomorphology*** | A morphology which presents higher average altitudes (93 m above sea level) and slopes than the other regional fluvial environments, mainly due to minor valleys and plans that are smaller than those of the principal Marche rivers, and also in view of the fact that the part of the Tronto river valley in the Abruzzo region is excluded. |
| ***Climate*** | The valleys, which belong to the mesomedilandneo and low hills phytoclimate plans have climatic parameters that are variable from the coast inland, with low rainfall (even lower than 700 mm per year) and higher average temperatures in coastal zones. |
| ***Land use*** | Agricultural areas are slightly reduced overall (81.6%), to the benefit of natural vegetation, including woods (10%), meadows (2.5%) and bushes and trees (around 2%). In particular among the woods, more than 40% includes tree vegetation from river-bank belts, 30% from thermophile macchia and the rest various broad-leaved trees and coastal reforestation with conifers. Of cultivated areas, less than 30% is considered to be intensive crops, whilst most is more diversified agriculture with more varied agrarian landscapes and a more significant natural component. |

| | |
|---|---|
| ***Geology and Lithology*** | The alluvial deposits in the valleys form approximately 50% of no longer active land, attributed, in the Quaternary period, to the Upper Pleistocene and classified as grade II land (10%) and grade III land (31%). Holocene valley floors, formed mainly of average-rough deposits and usable groundwater, represent the remaining half of the valley areas. |
| ***Soils*** | In all of these areas agricultural use exceeds 80%, a value which is higher only than the valleys in the Pesaro area. Of agricultural land, more than half hosts complex and diversified systems or agricultural areas mixed with natural environments, similar to the situation on the slopes of the Ascoli Piceno§ hills. There is a significant percentage of land used for tree crops (olives, fruit, etc.) and woods (around 5%), with belts of vines (*Vitis riparia*). |

# ANNEX 2: Identification of the farm sampling set representing "Agricultural Management Systems" in the region

## First phase: preparation of the geographical and alphanumerical data set describing the main agricultural systems adopted in the Marche

In order to define the analogous environments in the Marche we referred to the method used and trialled with the SOCO Project for the geographical delineation of the "Analogous Benchmark Environments (ABEs)", ABEs. ABEs break down the Marche territory into environments that can be defined (at a scale of 1:250 000) as analogous due to pedo-environmental features (e.g. geology, climate, morphometry, soils) and due to the Farming Systems adopted. For further information about ABEs, please refer to the monographs ASSAM *"Project So.Co. Agricolture sostenibile e conservazione del soil – Caso studio marche"* and *"Soils e paesaggi delle Marche"*.

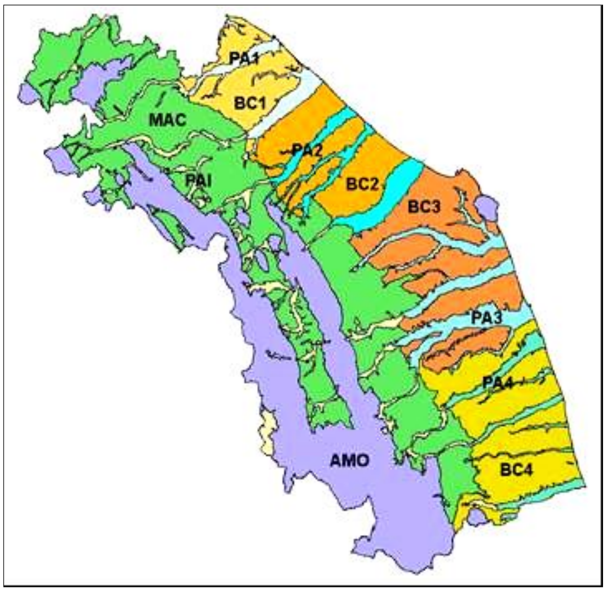



**Figure 1 - Distribution of AORs in the Marche Region**

| Map codes | Relationship with Analogous Envs. |
|---|---|
| PA1 | PA_FM |
| BC1 | BC_FM |
| PA 2 | PA_CE |
| BC2 | BC_CE |
| PA3 | PA_MCe |
| BC3 | BC_MCe |
| PA4 | PA_TT |
| BC4 | BC_TT |
| MAC | MAC |
| PAI | PAI |
| AMO | AM |

**Table 1 - List of ABEs**

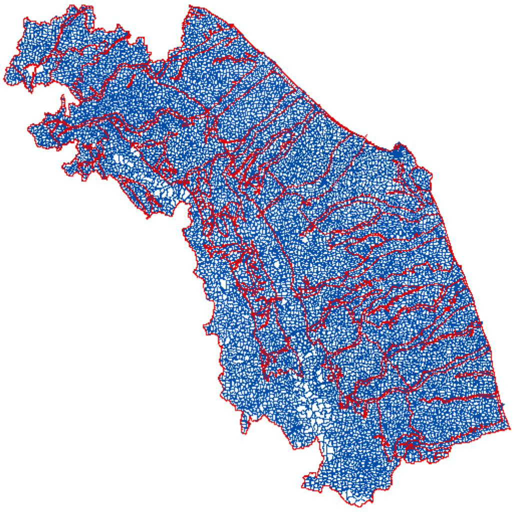
The concept of "Management System" derives from the methodological preparation resulting from the SoCo project, listed hereafter with their respective short identification FMS codes.

**Table 2 - Identifying codes for Marche Management Systems**

| | | | |
|---|---|---|---|
| SG1 | Arable crop rotation without forage | SG8 | SRF |
| SG2 | Forage and fodder crops | SG9 | Orchards for timber |
| SG3 | Pasture | SG10 | Woods |
| SG4 | Horticultural main crops | SG11 | Olive trees |
| SG5 | Fruit orchards | SG12 | Set Aside |
| SG6 | *Actinidia* (Kiwi) | SG13 | Cultivated truffle orchards |
| SG7 | Vines | SG14 | Minor management systems |

## Second phase: Preparation of GIS for the overlaying of land registry references and the geographical boundaries of ABEs

Through an *"overlay"* analysis, using *Geographic Information Systems G.I.S*. data, we extracted the lists from the relevant land registry sheets (*"Fogli catastali"*) and each individual ABE.



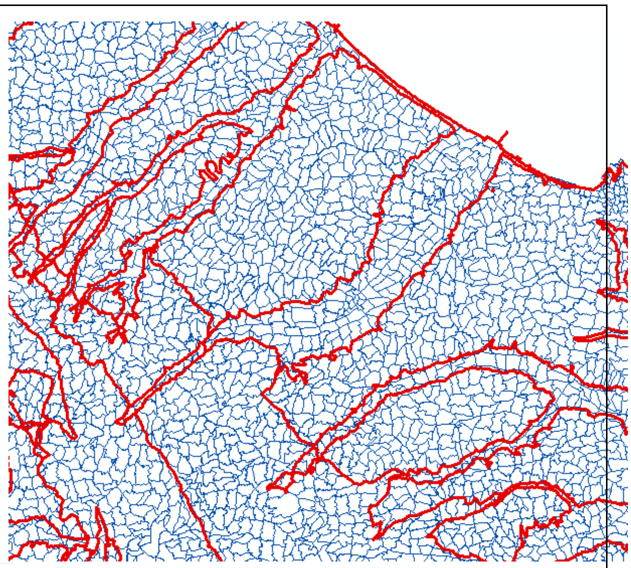


**Figure 2 - Overlay showing land registry and ABE boundaries**

Subsequently, the list of land registry sheets, distinct for each ABEs, was associated with the crop data collected from the DataBase-CAP containing farms' declarations for the purposes of receiving the bonus abbreviated to CAP. Crop data relating to the 2006 harvest was extracted from the above archive.

During that work, all farms that received CAP subsidies were identified, aggregated by Analogous Benchmark Environment.

Considering that for most farms in the Marche, CAP subsidies are an indispensable financial aid for their survival, almost all active farms apply for CAP subsidies – it can be assumed therefore that this sample of farms is a significant representation of agriculture in the Marche.

| CUAA | | Variable01 | Variable02 | Variable03 | Variable04 | Variable05 | Variable07 | Variable09 | Variable10 | Variable11 | Variable13 | Variable14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00139690432 | Case01 | 14 | 12 | 73 | | | | | | | | |
| 00388660433 | Case02 | 35 | 56 | 3 | 3 | | | | | | 2 | 2 |
| 00395750433 | Case03 | 8 | 23 | 69 | | | | | | | | |
| 00395840432 | Case04 | 21 | 54 | 0 | | | 4 | | 19 | 1 | | 1 |
| 00395920432 | Case05 | | 10 | 90 | | | | | | | | |
| 00395990435 | Case06 | 19 | 22 | 59 | 0 | | | | | | | |
| 00396090433 | Case07 | 4 | 24 | 72 | | | | | | | | |
| 00406290429 | Case08 | | 74 | 12 | | | | | 5 | | | 9 |
| 00482160447 | Case09 | 16 | 45 | 29 | | | | 8 | 2 | | | |
| 00501990428 | Case10 | | 12 | 39 | | | | | 1 | | | 47 |
| 00606180438 | Case11 | 4 | 39 | 57 | | | | | | | | |
| 00608910436 | Case12 | 18 | 21 | 61 | | | | | | | | |
| 00758850424 | Case13 | | 31 | 32 | | 0 | | | 33 | 3 | | 1 |
| 00775820442 | Case14 | 13 | 77 | 10 | | | | | | | | |
| 00863530432 | Case15 | | 18 | 82 | | | | | | | | |
| 00973030422 | Case16 | | | 40 | | | | | 60 | | | |
| 01081420422 | Case17 | | 22 | 30 | | 0 | | | 45 | | | 2 |
| 01147700437 | Case18 | | | 21 | | | | | 49 | | | 7 |
| 01158080430 | Case19 | | 31 | 68 | | | | | 1 | | | |
| 01237370414 | Case20 | | | | | 9 | | | 53 | | | 15 |
| 01241350444 | Case21 | 25 | 65 | 8 | | | 2 | | | | | |
| 01277010433 | Case22 | 0 | 30 | 68 | | | | | | | 2 | |
| 01367660410 | Case23 | | 34 | 23 | 0 | | | | 41 | | | 2 |
| 01382100418 | Case24 | | 75 | 17 | | | | | 2 | | | 7 |
| 01388160416 | Case25 | 13 | 70 | 17 | | | | | | | | |
| 01395390410 | Case26 | | 50 | 44 | | | | | 5 | | | 1 |
| 01481020418 | Case27 | | 76 | 22 | | | | | 1 | | | |
| 01517310445 | Case28 | 1 | 8 | 45 | | | | | | | | 16 |
| 01532860440 | Case29 | | 86 | 11 | | | | | | | | 3 |
| 01540890439 | Case30 | | | 100 | | | | | | | | |
| 01556760435 | Case31 | | | 100 | | | | | | | | |
| 01556770434 | Case32 | | | 100 | | | | | | | | |
| 01564200432 | Case33 | 25 | 67 | 8 | | | | | | | | |
| 01678900448 | Case34 | | | 0 | | 2 | | 1 | 65 | | 5 | 6 |
| 01692240441 | Case35 | | | 83 | | | | 16 | 0 | | | |
| 01838310447 | Case36 | | | 73 | | | | | | | | 27 |
| 01838360442 | Case37 | | | 97 | | | | | 3 | | | |
| 01838370441 | Case38 | | | 91 | | | | | 9 | | | |
| 01838400446 | Case39 | | | 92 | | | | | 8 | | | |
| 01838410445 | Case40 | | | 98 | | | | | 2 | | | |
| 01840540445 | Case41 | | | 100 | | | | | | | | |
| 01841540444 | Case42 | | | 100 | | | | | | | | |
| 01841550443 | Case43 | | | 100 | | | | | | | | |
| 01844270445 | Case44 | | | 96 | | | | | | | | 4 |

AM / BC_CE / BC_FM / BC_MCe / BC_TT / MAC / PAI / PA_CE / PA_FM / PA_MCe / PA_TT

**Figure 3 - Extract from the list of farms in the AM Alta Montagna environment: in column CUAA can be found the unique code referring to the farm, in the next column farms are renamed with an identification number preceded by "Case", the variable columns show the management systems (see Table 1), while the numbers in the matrix give the percentage of SAUs per SG.**

## Third phase: statistical data analysis to identify homogeneity among farms with regard to the management systems adopted

The structured data is prepared using "cluster analysis", aimed at defining homogenous groups of farms characterised by as similar a distribution as possible of % of SGs adopted, in order to create homogeneous groups (clusters) of farms, considering only the distribution of internal variables. The cluster algorithm *"K-Means"* was used.

K-Means is a cluster algorithm that enables groups of objects to be subdivided into K partitions on the basis of their attributes. The objective that can be met by using the algorithm is the minimising of total intra-cluster variance. Each cluster is identified using a centroid or mean point. The algorithm uses an iterative procedure. Initially it creates K partitions and assigns access points to each partition either randomly or using some heuristic information. It then calculates the

centroid for each group. Next it builds a new partition associating each access point with the cluster whose centroid is nearest to it. Then the centroids are recalculated for the new clusters and so on, until the algorithm converges.
The ultimate purpose of this algorithm is to create the best combination of farm groups which minimises variance within the group (and thus minimises differences within the farms belonging to the same group) and maximises variance between groups (and thus maximises the difference between groups).

To carry out cluster analysis on an acceptable number of farms we chose to exclude a certain number within each ABE. The criterion was to exclude farms under a certain size in terms of surface area, hereafter the selection parameters adopted.

**Table 3 Selection criteria for farms to which the cluster was applied**

| ABE | NUM. TOTAL FARMS | CRITERION | NUM. CLUSTERED FARMS |
|---|---|---|---|
| PA_FM | 1767 | > 3 ha | 230 |
| BC_FM | 6373 | > 10 ha | 382 |
| PA_CE | 4080 | > 3 ha | 524 |
| BC_CE | 13971 | > 10 ha | 885 |
| PA_MCe | 5538 | > 5 ha | 591 |
| BC_MCe | 18795 | > 25 ha | 291 |
| PA_TT | 2834 | > 3 ha | 316 |
| BC_TT | 22124 | > 25 ha | 235 |
| MAC | 28555 | > 25 ha | 844 |
| PAI | 1672 | > 3 ha | 281 |
| AM | 3871 | > 10 ha | 450 |

From a first analysis all distributions of the % of SAUs per FMS per farm were found, clustering the SG05s and SG06s together and the SG09s and SG08s together, excluding the SG12, and thus obtaining 11 variables for the analysis.

**Table 4 Definition of the variables (SGs) used in the cluster analysis**

| VARIABLES | SG | DESCRIPTION |
|---|---|---|
| Variable01 | SG01 | Arable crop rotation without forage |
| Variable02 | SG02 | Forage and fodder crops |
| Variable03 | SG03 | Pasture |
| Variable04 | SG04 | Horticultural main crops |
| Variable05 | SG05 and SG06 | Fruit and *Actinidia* (Kiwi) orchards |
| Variable07 | SG07 | Vines |
| Variable09 | SG08 and FMS09 | SRF and Orchards for timber |
| Variable10 | SG10 | Woods |
| Variable11 | SG11 | Olive trees |
| Variable13 | SG13 | Cultivated truffle orchards |
| Variable14 | SG114 | Minor management systems |

Considering the representativeness of the various SGs per ABE, we chose to perform the analysis considering only 4 variables: the most representative SGs (SG01 - Arable crop rotation without forage, SG02 - Forage and fodder crops, SG03 – Pasture, SG04 - Horticultural main crops). As regards the ABEs “BC_TT” and “ PA_TT”, in view of the specific use for vine growing and thus the significant presence of specialised wine-growing farms, we chose to perform the analysis on all variables. The algorithm was run by pre-setting the number of clusters at from 2 to 4 for all ABEs.

Hereafter two graphics showing the output of this analysis.

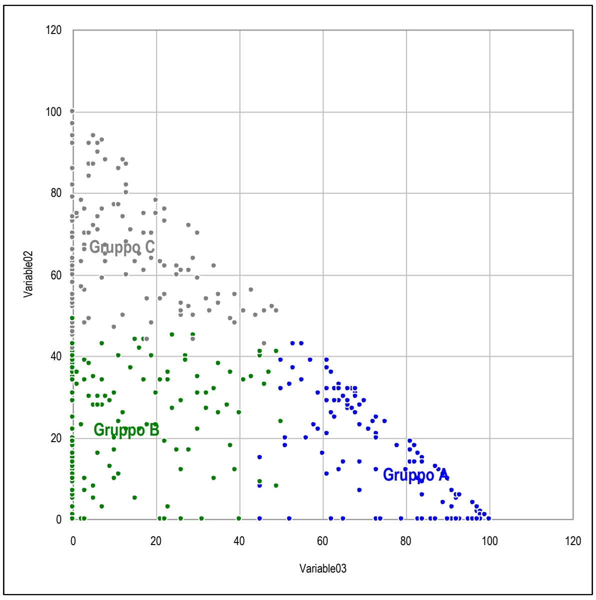
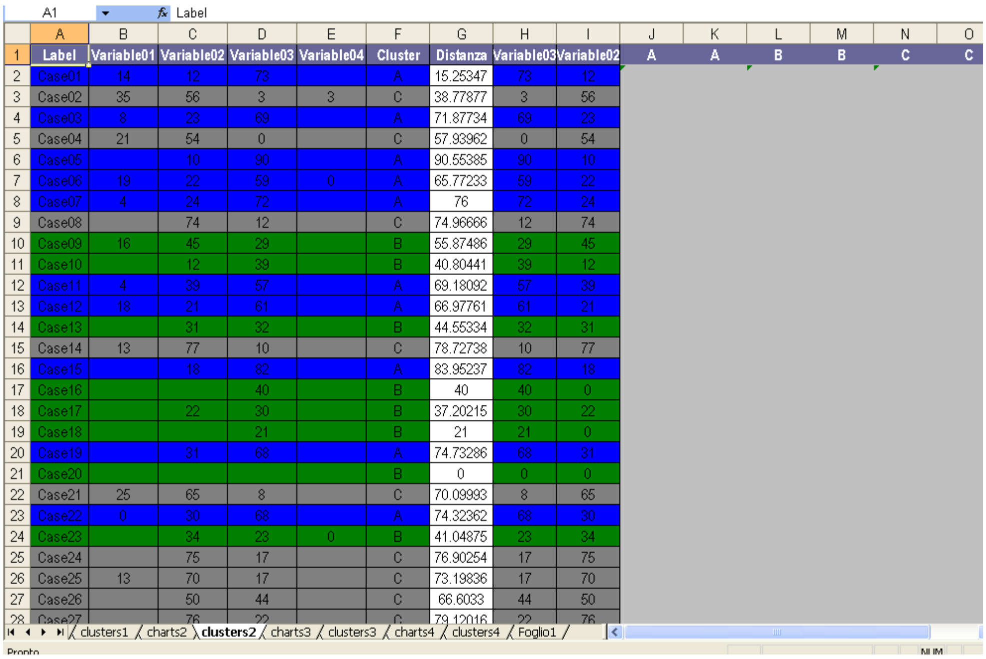



**Figure 4 - Dispersion of farms in three clusters (A, B, C) with two variables representing SG02 on the y-axis and SG03 on the x-axis-**



| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Label | Variable01 | Variable02 | Variable03 | Variable04 | Cluster | Distanza | Variable03 | Variable02 | A | A | B | B | C | C |
| 2 | Case01 | 14 | 12 | 73 | | A | 15.25347 | 73 | 12 | | | | | | |
| 3 | Case02 | 35 | 56 | 3 | 3 | C | 38.77877 | 3 | 56 | | | | | | |
| 4 | Case03 | 8 | 23 | 69 | | A | 71.87734 | 69 | 23 | | | | | | |
| 5 | Case04 | 21 | 54 | 0 | | C | 57.93962 | 0 | 54 | | | | | | |
| 6 | Case05 | | 10 | 90 | | A | 90.55385 | 90 | 10 | | | | | | |
| 7 | Case06 | 19 | 22 | 59 | 0 | A | 65.77233 | 59 | 22 | | | | | | |
| 8 | Case07 | 4 | 24 | 72 | | A | 76 | 72 | 24 | | | | | | |
| 9 | Case08 | | 74 | 12 | | C | 74.96666 | 12 | 74 | | | | | | |
| 10 | Case09 | 16 | 45 | 29 | | B | 55.87486 | 29 | 45 | | | | | | |
| 11 | Case10 | | 12 | 39 | | B | 40.80441 | 39 | 12 | | | | | | |
| 12 | Case11 | 4 | 39 | 57 | | A | 69.18092 | 57 | 39 | | | | | | |
| 13 | Case12 | 18 | 21 | 61 | | A | 66.97761 | 61 | 21 | | | | | | |
| 14 | Case13 | | 31 | 32 | | B | 44.55334 | 32 | 31 | | | | | | |
| 15 | Case14 | 13 | 77 | 10 | | C | 78.72738 | 10 | 77 | | | | | | |
| 16 | Case15 | | 18 | 82 | | A | 83.95237 | 82 | 18 | | | | | | |
| 17 | Case16 | | | 40 | | B | 40 | 40 | 0 | | | | | | |
| 18 | Case17 | | 22 | 30 | | B | 37.20215 | 30 | 22 | | | | | | |
| 19 | Case18 | | | 21 | | B | 21 | 21 | 0 | | | | | | |
| 20 | Case19 | | 31 | 68 | | A | 74.73286 | 68 | 31 | | | | | | |
| 21 | Case20 | | | | | B | 0 | 0 | 0 | | | | | | |
| 22 | Case21 | 25 | 65 | 8 | | C | 70.09993 | 8 | 65 | | | | | | |
| 23 | Case22 | 0 | 30 | 68 | | A | 74.32362 | 68 | 30 | | | | | | |
| 24 | Case23 | | 34 | 23 | 0 | B | 41.04875 | 23 | 34 | | | | | | |
| 25 | Case24 | | 75 | 17 | | C | 76.90254 | 17 | 75 | | | | | | |
| 26 | Case25 | 13 | 70 | 17 | | C | 73.19836 | 17 | 70 | | | | | | |
| 27 | Case26 | | 50 | 44 | | C | 66.6033 | 44 | 50 | | | | | | |
| 28 | Case27 | | 76 | 22 | | C | 79.12016 | 22 | 76 | | | | | | |

**Figure 5 - Attribution of "Casexx" (farms) the three clusters (A, B, C), identified respectively by the colours blue, green and grey.**

## Fourth phase: analysis of the statistical preparation and definition of selection criteria for representative farms

The results of the analysis described hereafter show for each ABE the list of groups (clusters) identified by variance trends and supported by the graphical representation of optimal dispersion in groups (Figure 4). For each ABE group the percentage distribution of SAUs is stated for the 4 SGs identified (SG01 - Arable crop rotation without forage, SG02 - Forage and fodder crops, SG03 – Pasture, SG04 - Horticultural main crops).
The field "RAPP. GRUPPO (%)" describes in percentage terms the representativeness of that group in the total of farms analysed using cluster analysis.

ABE "AM"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 1.94 | 11.03 | 82.29 | 0.01 | 37.56 |
| Group B | 19.48 | 21.96 | 12.87 | 0.39 | 32.22 |
| Group C | 9.27 | 66.72 | 11.96 | 0.23 | 30.22 |

ABE "BC_CE"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 48.88 | 12.34 | 0.34 | 8.13 | 23.64 |
| Group B | 88.86 | 1.92 | 0.14 | 0.73 | 69.23 |
| Group C | 10.29 | 72.27 | 2.60 | 0.22 | 7.13 |

ABE "BC_FM"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 16.41 | 65.73 | 1.64 | 0.73 | 17.28 |
| Group B | 83.46 | 3.54 | 0.01 | 0.54 | 50.52 |
| Group C | 38.47 | 14.54 | 0.99 | 1.28 | 32.20 |

ABE "BC_MCe"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 62.22 | 13.58 | 0.03 | 2.15 | 20.76 |
| Group B | 88.91 | 1.49 | 0.01 | 0.65 | 67.13 |
| Group C | 26.80 | 43.14 | 1.11 | 1.29 | 12.11 |

ABE "BC_TT"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | SG05 (%) | SG07 (%) | SG09 (%) | SG10 (%) | SG11 (%) | SG14 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Group A | 7.10 | 30.71 | 2.39 | 0.29 | 1.61 | 27.53 | 0.29 | 4.46 | 3.88 | 11.37 | 25.11 |
| Group B | 48.42 | 18.97 | 3.12 | 0.74 | 0.78 | 8.11 | 0.03 | 4.53 | 0.88 | 7.79 | 31.06 |
| Group C | 83.37 | 4.48 | 0.16 | 0.62 | 0.31 | 2.10 | 0.08 | 1.68 | 0.53 | 3.37 | 43.83 |

ABE "MAC"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 60.69 | 15.92 | 0.95 | 0.34 | 37.80 |
| Group B | 15.26 | 64.24 | 5.59 | 0.07 | 35.43 |
| Group C | 12.48 | 24.23 | 18.43 | 0.10 | 26.78 |

ABE "PAI"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 84.53 | 4.50 | 0.11 | 0.67 | 48.04 |
| Group B | 4.08 | 85.23 | 0.30 | 0.03 | 21.35 |
| Group C | 31.59 | 26.62 | 1.14 | 0.85 | 30.60 |

ABE "PA_CE"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 31.58 | 10.72 | 0.00 | 21.88 | 18.70 |
| Group B | 88.37 | 2.34 | 0.05 | 1.97 | 71.37 |
| Group C | 3.23 | 84.02 | 0.15 | 0.98 | 9.92 |

ABE "PA_FM"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 56.62 | 13.25 | 0.00 | 6.63 | 22.61 |
| Group B | 90.27 | 1.17 | 0.00 | 1.61 | 58.70 |
| Group C | 1.42 | 46.23 | 0.14 | 2.30 | 18.70 |

ABE "PA_MCe"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|
| Group A | 51.45 | 9.81 | 0.30 | 25.51 | 22.84 |
| Group B | 11.04 | 54.57 | 0.00 | 0.45 | 7.95 |
| Group C | 88.59 | 2.78 | 0.00 | 1.20 | 69.20 |

ABE "PA_TT"

| GROUPS | SG01 (%) | SG02 (%) | SG03 (%) | SG04 (%) | SG05 (%) | SG06 (%) | SG07 (%) | SG09 (%) | SG10 (%) | SG11 (%) | SG14 (%) | REP. GROUP (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Group A | 22.57 | 2.57 | 0.29 | 7.86 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1.29 | 47.86 | 2.22 |
| Group B | 87.29 | 2.07 | 0.06 | 2.31 | 1.56 | 0.00 | 1.56 | 0.08 | 0.51 | 0.52 | 3.04 | 56.33 |
| Group C | 18.38 | 24.05 | 0.00 | 10.84 | 11.32 | 0.43 | 8.75 | 0.45 | 1.47 | 2.15 | 4.12 | 41.46 |

The work carried out thus produces two main results that are indispensable to launching monitoring activities:

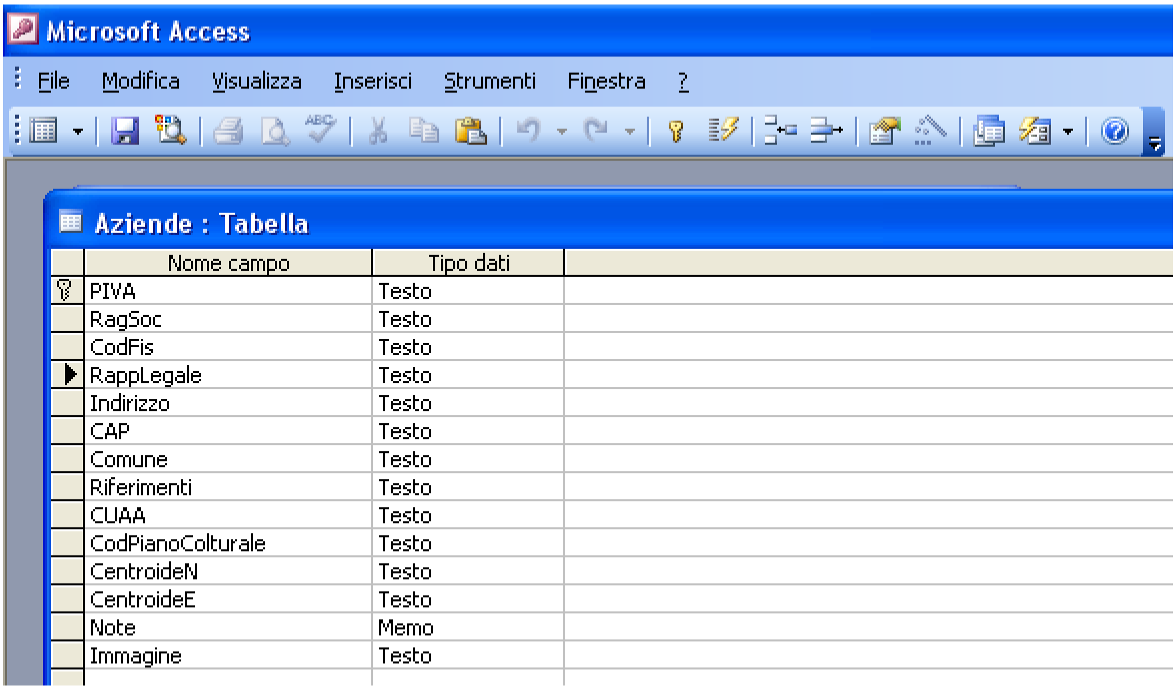
- identifying farms that are representative not of single crops but of agricultural production management systems in an integrated logic for the whole farm and related to long-term effects, particularly with regard to the conservation of the natural resources involved (soils, water, etc.- and maintaining production capacity of the farm;
- fine tuning a criterion for territorialisation of agricultural activities used as a reference to guarantee that the subsequent spatialisation of all information and considerations gathered about the monitoring farms.

The methodological procedure adopted and experimented also meets the need to face the significant dynamics of the farmer's choice - increasingly more influenced by economic issues caused by erratic market behaviour.

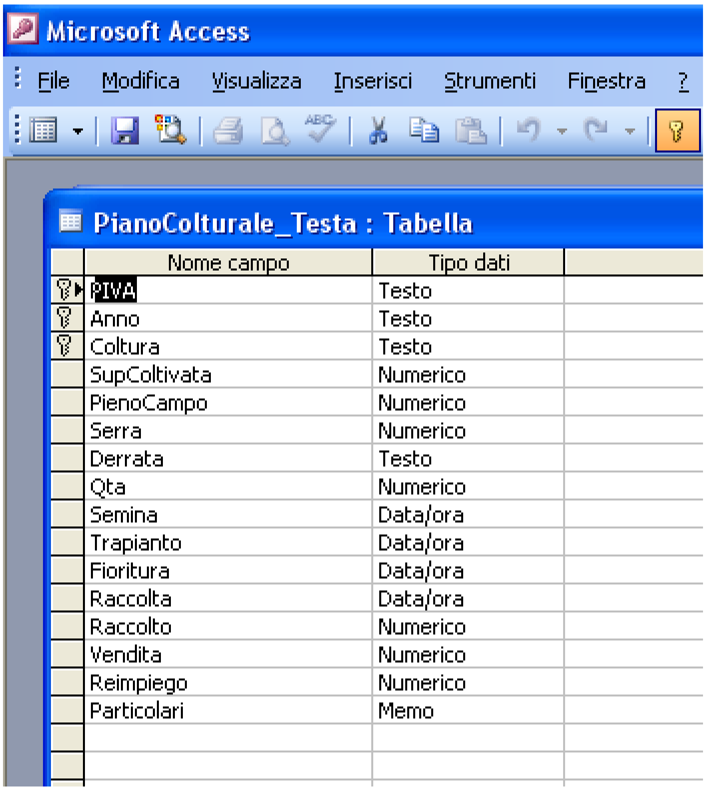
Through the method used it is possible to vary over time the monitoring farms according to variations in the management systems adopted.

# ANNEX 3: Land management monitoring system

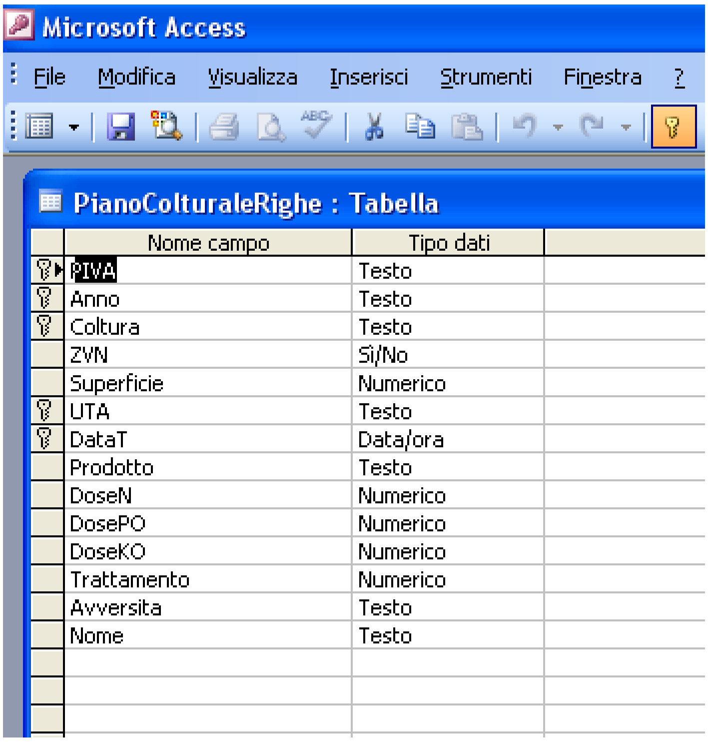
### 4.7.1. - Model for field notes




| Nome campo | Tipo dati |
|---|---|
| PIVA | Testo |
| RagSoc | Testo |
| CodFis | Testo |
| RappLegale | Testo |
| Indirizzo | Testo |
| CAP | Testo |
| Comune | Testo |
| Riferimenti | Testo |
| CUAA | Testo |
| CodPianoColturale | Testo |
| CentroideN | Testo |
| CentroideE | Testo |
| Note | Memo |
| Immagine | Testo |




| Nome campo | Tipo dati |
|---|---|
| PIVA | Testo |
| Anno | Testo |
| Coltura | Testo |
| SupColtivata | Numerico |
| PienoCampo | Numerico |
| Serra | Numerico |
| Derrata | Testo |
| Qta | Numerico |
| Semina | Data/ora |
| Trapianto | Data/ora |
| Fioritura | Data/ora |
| Raccolta | Data/ora |
| Raccolto | Numerico |
| Vendita | Numerico |
| Reimpiego | Numerico |
| Particolari | Memo |




| Nome campo | Tipo dati |
|---|---|
| PIVA | Testo |
| Anno | Testo |
| Coltura | Testo |
| ZVN | Sì/No |
| Superficie | Numerico |
| UTA | Testo |
| DataT | Data/ora |
| Prodotto | Testo |
| DoseN | Numerico |
| DosePO | Numerico |
| DoseKO | Numerico |
| Trattamento | Numerico |
| Avversita | Testo |
| Nome | Testo |

CROP PLAN database

It is divided into two sections:

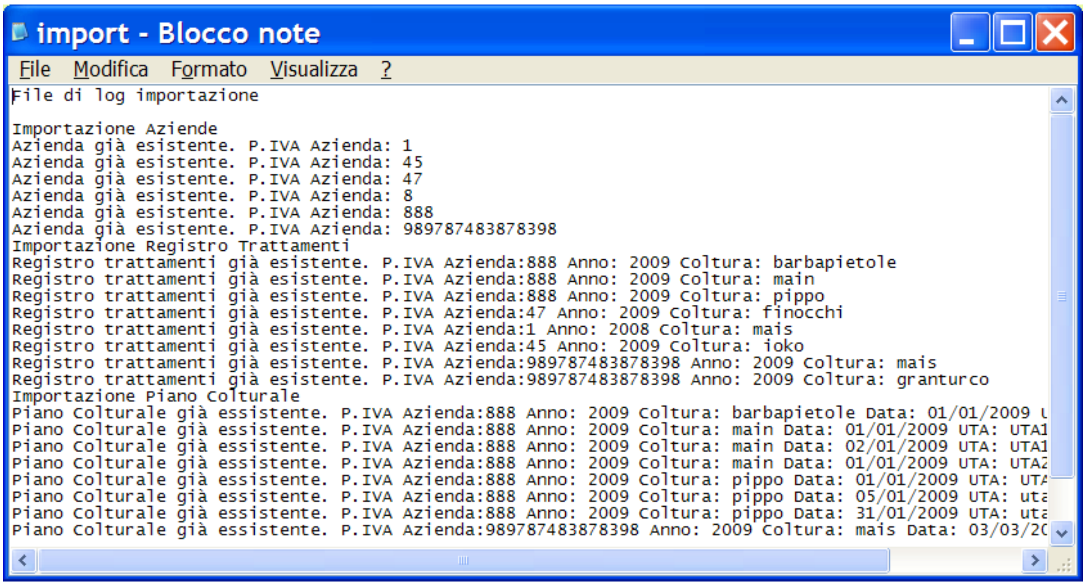
1. Import of already existing crop plans

2. Checking crop plans included


Import of already existing crop plans

Data can be imported from the Database Access FARM CROP PLAN (to be given to the farms) created on the same platform of the database (DB) in SQL described, in order to speed up data entry.

Type *"Import Farm Crop Plans"* to open the window and choice an Access DB to be imported. Once import is complete a window will appear showing a summary of the data imported.

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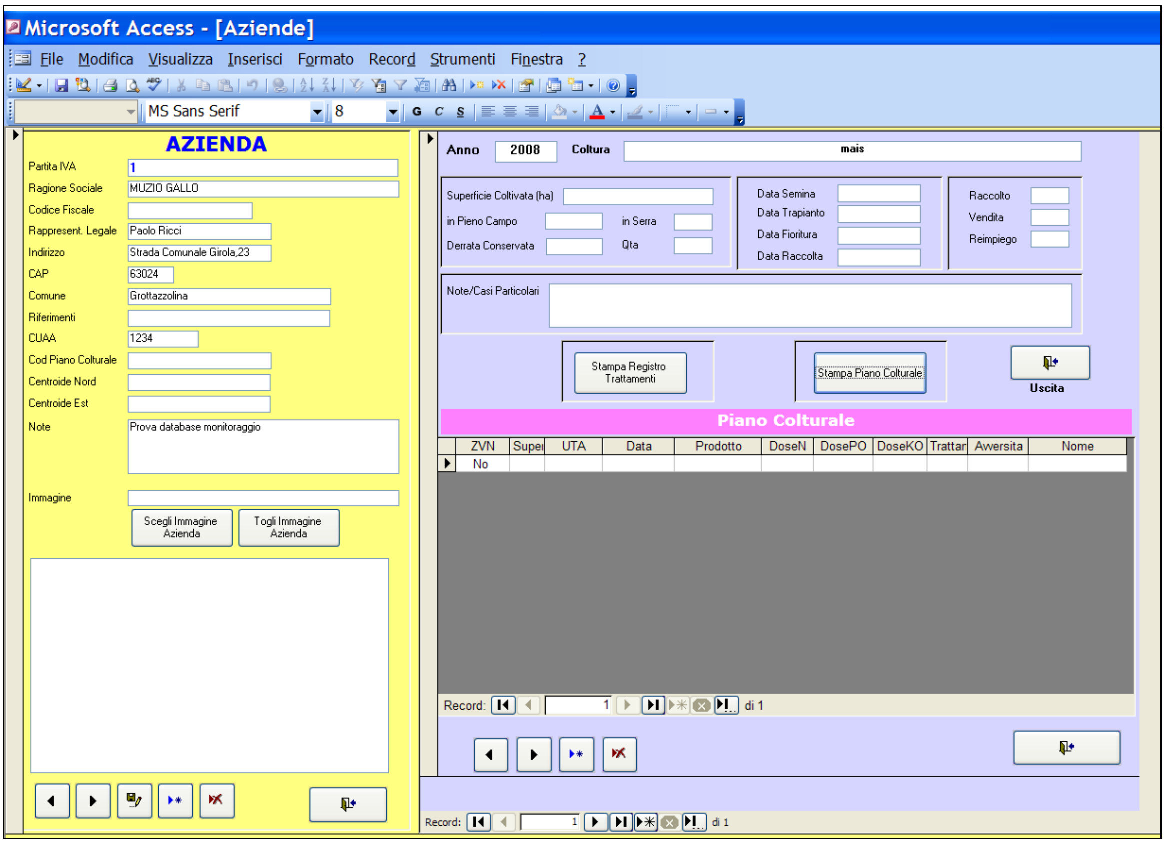
File di log importazione

Importazione Aziende
Azienda già esistente. P.IVA Azienda: 1
Azienda già esistente. P.IVA Azienda: 45
Azienda già esistente. P.IVA Azienda: 47
Azienda già esistente. P.IVA Azienda: 8
Azienda già esistente. P.IVA Azienda: 888
Azienda già esistente. P.IVA Azienda: 989787483878398
Importazione Registro Trattamenti
Registro trattamenti già esistente. P.IVA Azienda:888 Anno: 2009 Coltura: barbapietole
Registro trattamenti già esistente. P.IVA Azienda:888 Anno: 2009 Coltura: main
Registro trattamenti già esistente. P.IVA Azienda:888 Anno: 2009 Coltura: pippo
Registro trattamenti già esistente. P.IVA Azienda:47 Anno: 2009 Coltura: finocchi
Registro trattamenti già esistente. P.IVA Azienda:1 Anno: 2008 Coltura: mais
Registro trattamenti già esistente. P.IVA Azienda:45 Anno: 2009 Coltura: ioko
Registro trattamenti già esistente. P.IVA Azienda:989787483878398 Anno: 2009 Coltura: mais
Registro trattamenti già esistente. P.IVA Azienda:989787483878398 Anno: 2009 Coltura: granturco
Importazione Piano Colturale
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: barbapietole Data: 01/01/2009 U
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: main Data: 01/01/2009 UTA: UTA1
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: main Data: 02/01/2009 UTA: UTA1
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: main Data: 01/01/2009 UTA: UTA2
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: pippo Data: 01/01/2009 UTA: UTA
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: pippo Data: 05/01/2009 UTA: uta
Piano Colturale già essistente. P.IVA Azienda:888 Anno: 2009 Coltura: pippo Data: 31/01/2009 UTA: uta
Piano Colturale già essistente. P.IVA Azienda:989787483878398 Anno: 2009 Coltura: mais Data: 03/03/20
```

Checking crop plans included

Once the crop plan window opens users can check the content of the two sections: the first with farm data and the other with the compiled crop plan data.

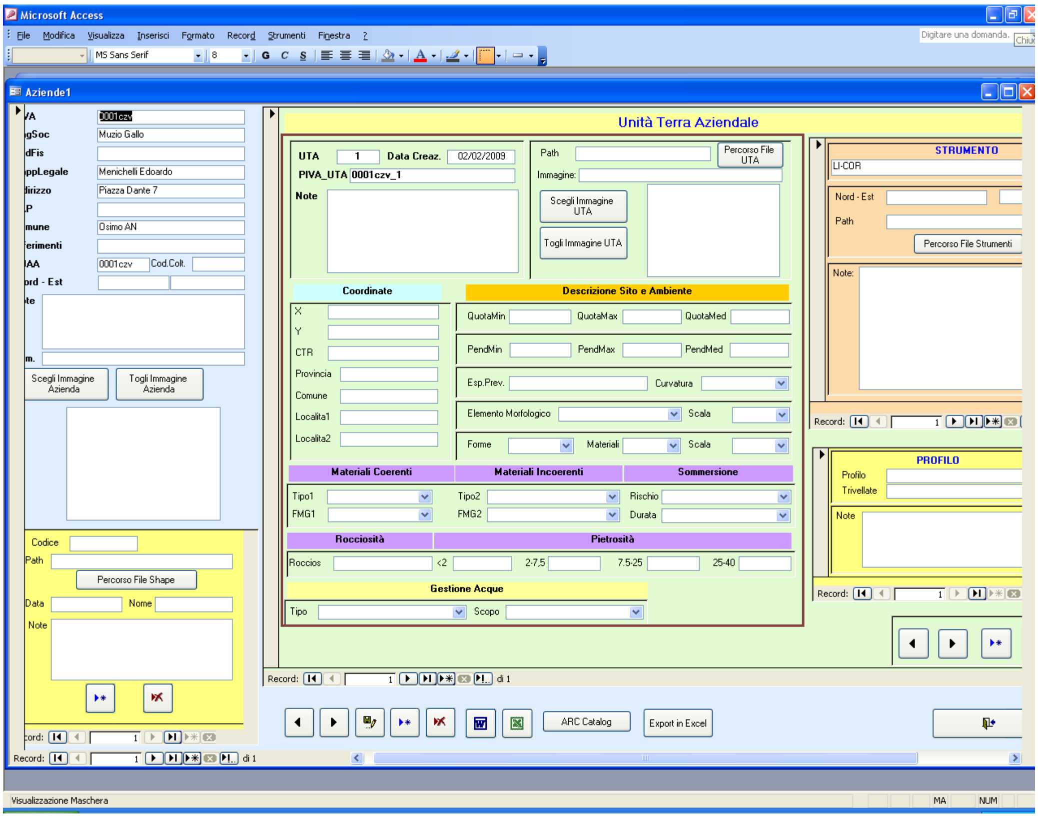



In the yellow section, farm data, users are asked to enter all farm data, as well as a picture of the farm.

The actual data from the crop plan for each crop is to be entered in the blue section.

Once data entry has been completed, users can also print the first page of the register, and the crop plan for each crop.


Storage database for data from the soil monitoring network.

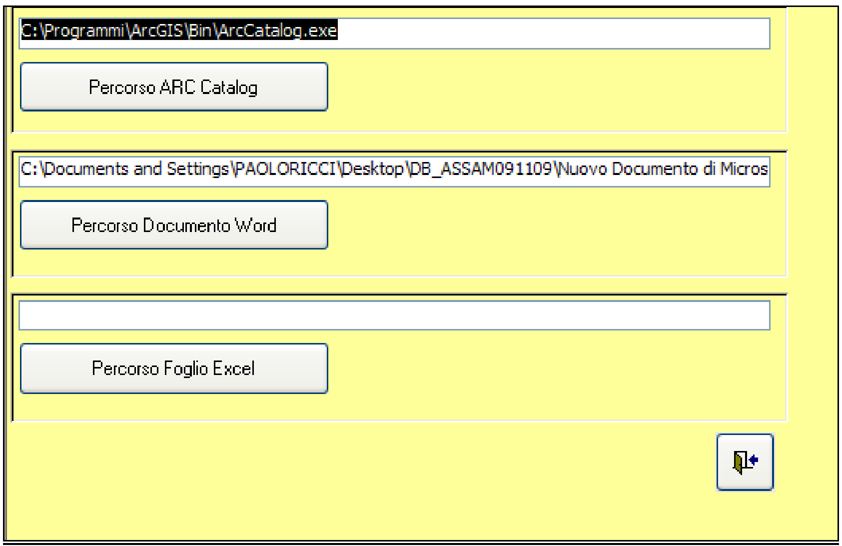


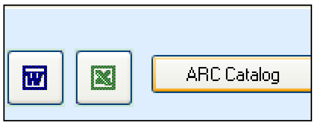

This database has been created using SQL Server and a graphical interface in Access.

The Monitoring database deals with all the management of data collected in different sites and with various tools.

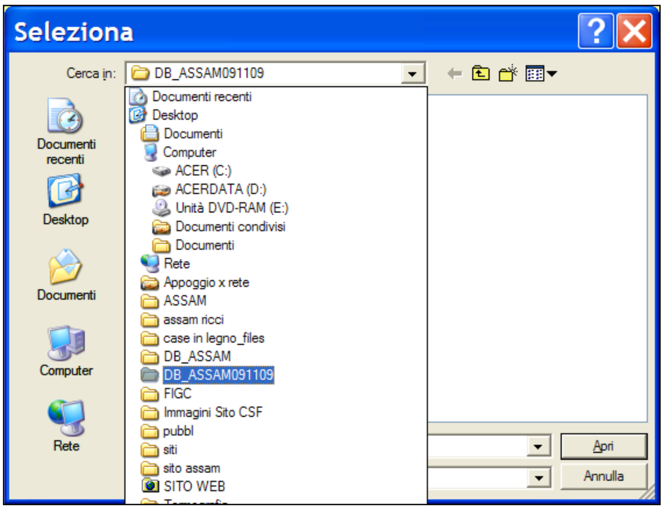
It is formed of three main windows:

<u>- Set up of File Path</u>

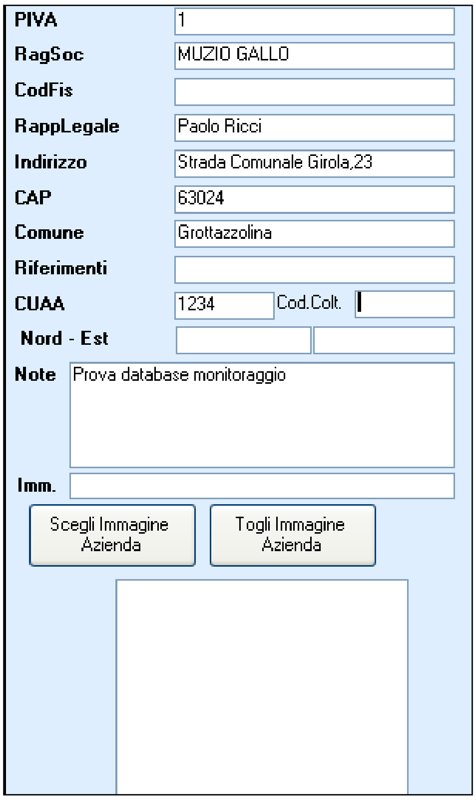





The paths of files to be opened with specific buttons in MONITORING are entered in the window.




Entering paths is performed using a traditional Windows drop-down menu.

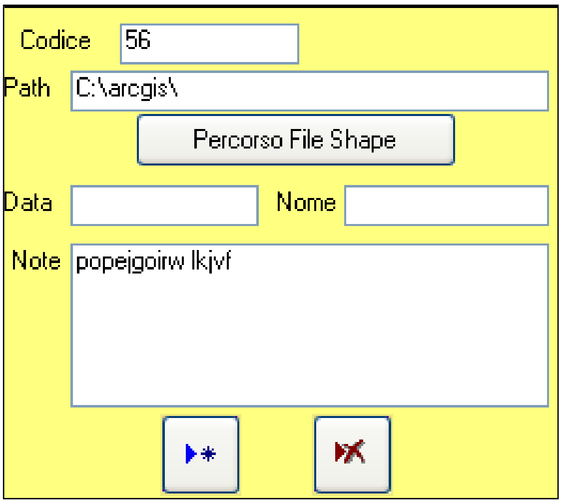



-Monitoring

All of the information needed for monitoring is collected together in sections in this window. Farm data is entered in the light blue section

It is possible to add a farm picture by browsing, using the button Choose Farm Image, to the file to be used. Users can remove any images by pressing Remove farm image. IMPORTANT!! In fact the image is substituted by a space.

In the yellow section:

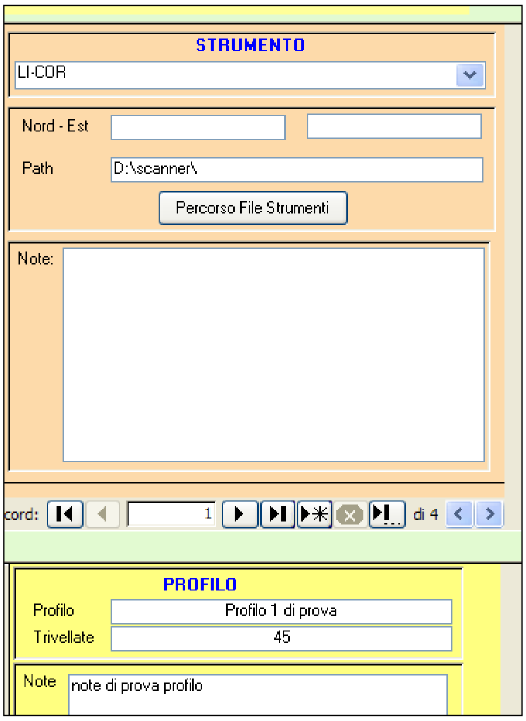



The following can be included: data relating to the paths of shape files created to identify monitoring zones within the farm, the date, the name, and notes. This can be useful to remember when and by whom data entry was performed.

In the green section data on Farmland Units (UTAs) can be included, with the file paths used to subdivide the units. Here too an image can be included for each UTA, as well as coordinates, site description, materials, rockiness, stoniness, water management.

In order to simplify data entry, in some fields there are drop-down menus with codes referring to field notes.

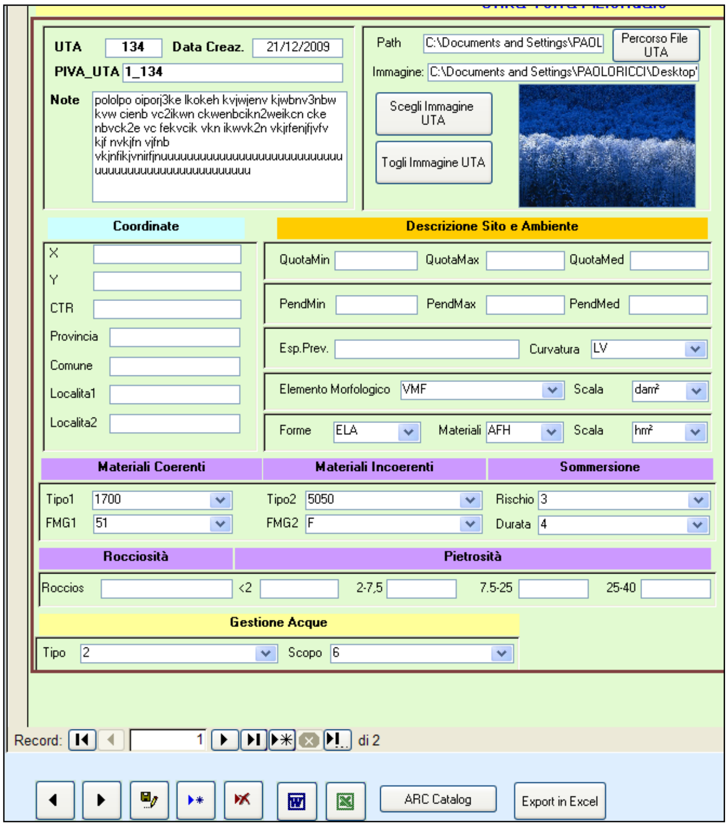
The Export in Excel function allows all UTA data for the farm selected to be exported in Excel format.




The last section on the right of the monitoring window allows all monitoring tools used in a specific UTA to be included, as well as all profiles and bores performed.

<u>- Management of Measuring Instruments</u>

All measuring instruments can be included, which can then be called up in the tools section of the Monitoring window. For each tool it is also possible to print its position, which can be in several farms.



UTA
134
Data Creaz.
21/12/2009
PIVA_UTA
1_134
Note
Path
C:\Documents and Settings\PAOL
Percorso File UTA
Immagine:
C:\Documents and Settings\PAOLORICCI\Desktop\
Scegli Immagine UTA
Togli Immagine UTA
Coordinate
X
Y
CTR
Provincia
Comune
Localita1
Localita2
Descrizione Sito e Ambiente
QuotaMin
QuotaMax
QuotaMed
PendMin
PendMax
PendMed
Esp.Prev.
Curvatura
LV
Elemento Morfologico
VMF
Scala
Forme
ELA
Materiali
AFH
Materiali Coerenti
Materiali Incoerenti
Sommersione
Tipo1
1700
FMG1
51
Tipo2
5050
FMG2
F
Rischio
3
Durata
4
Rocciosità
Pietrosità
Roccios
<2
2-7,5
7.5-25
25-40
Gestione Acque
Tipo
2
Scopo
6
Record:
1
di 2
ARC Catalog
Export in Excel


Gestione Strumenti
STRUMENTO
ANALIZZATORE DI CO2
MARCA
LI-COR
MODELLO
LI-7500
VARIABILE
CONCENTRAZIONE CO2
CAMPIONAMENTO
STAZIONE CON ACQUISITORE
Stampa Posizione Strumento

# 10 References


ANPA (2001). Atlante degli indicatori del suolo. RTI CTN_SSC 3/2001. http://ctntes.arpa.piemonte.it/pubblicazioni/RTI_CTN_SSC_3_2001_1_.pdf

ANPA (2001). Elementi di progettazione della rete nazionale di monitoraggio del suolo a fini ambientali. RTI CTN_SSC 2/2001. http://ctntes.arpa.piemonte.it/pubblicazioni/RTI_CTN_SSC_2_2001.pdf

ANPA (2000). Censimento delle reti di monitoraggio sui suoli in Europa. RTI CTN_SSC 2/2000.

ANPA (2000). Sviluppo di indicatori per il soil e i sites contaminati. Agenzia Nazionale per la Protezione dell'Ambiente. RTI CTN_SSC 1/2000. http://ctntes.arpa.piemonte.it/pubblicazioni/RTI_CTN_SSC_1_2000.pdf

APAT (2003). Elementi di progettazione della rete nazionale di monitoraggio del suolo a fini ambientali. Linee guida per un manuale di organizzazione e gestione della rete. RTI CTN_TES 1/2003. http://ctntes.arpa.piemonte.it/pubblicazioni/RTI_CTN_SSC_1_2002.pdf

Ashton, R. (2012). Zero Net Land Degradation. A Sustainable Development Goal for Rio+20. Bonn, Germany UNCCD. . http://www.unccd.int/Lists/SiteDocumentLibrary/Rio+20/UNCCD_PolicyBrief_ZeroNetLandDegradation.pdf

Assogeo-Trimble (2005). GPS. Guida all'uso del GPS per il rilevamento del territorio e l'aggiornamento cartografico. Maggioli Editore.

Ballenger A. (2005). GPS Status Update ION Plenary. Proceedings of the 18th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GNSS 2005), Long Beach, CA, September 2005.

Batjes N.H. (1996). Total carbon and nitrogen in the soils of the world. European Journal of Soil Science, 47, pp. 151-163.

Borin M., Ceccon P. (2002). I sistemi colturali nella ricerca agronomica: un problema di scala. In: Bonari E., Ceccon P. (eds.): Verso un approccio integrato allo studio dei sistemi colturali, 11-45. Franco Angeli, Milano.

CBD (2010). COP 10 Decision X/2, Strategic Plan for Biodiversity 2011-2020, Convention on biological diversity, 19 December 2010.

Cina A. (2000). GPS: principi, modalita e tecniche di rilevamento, ed. Celid, Torino.

Costantini E.A.C. (2007). Linee guida dei metodi di rilevamento e informatizzazione dei data pedologici. Ministero per le Politiche Agricole Alimentari e Forestali - CRA-ABP, Florence.

Donatelli M., M. Acutis (2006). Il modulo sistemi colturali Bologna, 14-15 dicembre 2006.

EC (2012a). Communication From The Commission To The European Parliament, The Council, The European Economic And Social Committee And The Committee Of The Regions, Accounting for land use, land use change and forestry (LULUCF) in the Union's climate change commitments. COM(2012)94final.

EC (2012b). Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, The implementation of the Soil Thematic Strategy and on going activities. COM(2012)46 final.

EC (2011a). Communication from the Commission to the European Parliament, the Council, the Economic and social Committee and the Committee of the Regions on Our life insurance, our natural capital: an EU biodiversity strategy to 2020. COM(2011) 244.

EC (2011b). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Roadmap to a resource Efficient Europe. COM (2011)571 final.

EC (2011c). Proposal for a Council Regulation establishing Rules for direct payments to farmers under support schemes within the framework of the common agricultural policy. COM(2011) 625/3.

EC (2011d). Proposal for a Council Regulation EC/1698/2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD). COM(2011) 627/3.

EC (2010a), Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. The CAP towards 2020: Meeting the food, natural resources and territorial challenges of the future, COM(2010) 672/5.

EC (2010b). European Atlas of Soil Biodiversity . Office for Official Publications of the European Communities, Luxembourg.

EC (2010c), Report from the Commission to the Council and the European Parliament: the 2010 assessment of implementation of the EU biodiversity action plan. COM (2010) 548. European Commission, Brussels.

EC (2009a). White Paper. Adapting to climate change: towards a European framework for action. Brussels: European Commission. COM(2009) 147 final.

EC (2009b). Commission staff working document accompanying the White Paper. Adapting to climate change: towards a European framework for action. Adapting to climate change: the challenge for European agriculture and rural areas. Brussels: European Commission. SEC(2009) 417.

EC (2006a). Communication of 22 September 2006 from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions: Thematic Strategy for Soil Protection. COM (2006) 231final.

EC (2006b). Proposal for a Directive of the European Parliament and of the Council establishing a framework for the protection of soil and amending Directive 2004/35/EC. COM(2006) 232 final.

EC (2006c), Rural Development 2007-2013, Handbook on Common Monitoring and Evaluation Framework (CMEF), Guidance document. Directorate-General for Agriculture and Rural Development, Brussels, September 2006.

EC (2006d), Rural Development 2007-2013, Handbook on Common Monitoring and Evaluation Framework (CMEF), Guidance note G – Baseline Indicator Fiches. Directorate-General for Agriculture and Rural Development, Brussels, September 2006.

EC (2006e), Rural Development 2007-2013, Handbook on Common Monitoring and Evaluation Framework (CMEF), Guidance note I – Result Indicator Fiches. Directorate-General for Agriculture and Rural Development, Brussels, September 2006.

EC (2005). Soil Atlas of Europe. Office for Official Publications of the European Communities, Luxembourg.

EC (2003). European Soil Database (distribution version v2.0). European Commission, Joint Research Centre, Italy.

EC, 2003. The Lucas survey - European statisticians monitor territory. ISBN 92-894-4984-5, ISSN 1725- 0714

EC (2002). Communication of 16 April 2002 from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions: Towards a Thematic Strategy for Soil Protection. COM (2002) 179final.

EEA (2011). CORINE land cover dataset from 1990-2000-2006. Web address: http:/www.eea.europa.eu/

EEA (2005). CORINE land cover updating for the year 2000: image 2000 and CLC2000. In: Lima, V. (Ed.), Products and Methods. Report EUR 21757 EN. Joint Research Centre, Ispra, Italy.

EEA (2001). Proposal for a European soil monitoring and assessment framework, Technical Report n° 61.

ESB (1999). Soil Geographical Database of Europe, Version 3.21. European Soil Bureau, Ispra, Italy.

EU (2009). Council Regulation (EC) No 73/2009 of 19 January 2009 establishing common rules for direct support schemes for farmers under the common agricultural policy and establishing certain support schemes for farmers, amending Regulations (EC) No 1290/2005, (EC) No 247/2006, (EC) No 378/2007 and repealing Regulation (EC) No 1782/2003. EC/73/2009. Official Journal of the European Union, Brussels.

EU (2007) Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). Official Journal of the European Communities, Brussels.

EU (2006). Council Decision of 20 February 2006, on Community strategic guidelines for rural development (programming period 2007-2013). 2006/144/EC, L 55/20, Official Journal of the European Union, Brussels.

EU (2005a). Council Regulation of 20 September 2005 on support for rural development by the European Agricultural Fund for Rural Development (EAFRD), EC/1698/2005, Official Journal of the European Union, Brussels.

EU (2005b). Council Regulation of 21 June 2005 on the financing of the common agricultural policy. EC/1290/2005E. Official Journal of the European Union, Brussels.

EU (2002). Decision Of The European Parliament And Of The Council Of 22 July 2002 laying down the Sixth Community Environment Action Programme. 1600/2002/EC. Official Journal of the European Communities, Brussels.

EU (1992). Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union, Brussels.

European Evaluation Network for Rural Development (2009), Guidance Document - The Application of the High Nature Value Impact Indicator 2007-2013.

European Evaluation Network for Rural Development (2010), Working Paper on Approaches for assessing the impacts of the Rural Development Programmes in the context of multiple intervening factors.

Eurostat 2012. LUCAS — a multi-purpose land use survey. Web address: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/LUCAS_%E2%80%94_a_multipurpose_land_ use_survey

Eurostat 2009a. LUCAS 2009 (Land Use / Cover Area Frame Survey). Technical reference document C-4: Quality Control procedures. Version of 03 March 2009. Eurostat, European Commission, Luxembourg.

Eurostat 2009b. LUCAS 2009 (Land Use / Cover Area Frame Survey). Quality Assurance. Eurostat, European Commission, Luxembourg.

Eurostat (2003). LUCAS (Land Use / Cover Area Frame Survey). Technical Document n°. 1: Sampling plan. Eurostat, European Commission, Luxembourg.

FAO (2006). World reference base for soil resources 2006 - A framework for international classification, correlation and communication. 2nd edition. World Soil Resources Reports 103. Food and Agriculture Organization of the United Nations, Rome, 128pp. [IUSS Working Group WRB.]

Giordano, A (2002) "Pedologia forestale e conservazione del soil" UTET.

Gobin P. Campling, L. Janssen, N. Desmet, H. van Delden, J. Hurkens, P. Lavelle and S. Berman, A. (2011). Soil organic matter management across the EU – best practices, constraints and trade-offs. Final Report for the European Commission's DG Environment, 140pp. Web: http://www.riks.nl/resources/papers/full_report_som.pdf

Grimm, M., Jones, R.J.A., Montanarella, L. (2003). Soil Erosion Risk in Italy: a Revised USLE Approach. European Soil Bureau Research Report No. 11, EUR 20677 EN, Office for Official Publications of the European Communities, Luxembourg, 28 pp.

Hiederer, R., Michéli, E., & Durrant, T. (2011). Evaluation of BioSoil Demonstration Project Soil Data Analysis. EUR 24729/EN, European Commission, Luxembourg, 428pp.

Hofmann-Wellenhof B., Lichtenegger B., Collins J. (2001). Soil Database for Europe. Manual of procedures, version 1.0. EUR 18092 EN. Office of the Official Publications of the European Communities, Luxembourg.

Huber, S., Prokop, G., Arrouays, D., Banko, G., Bispo, A., Jones, R.J.A., Kibblewhite, M.G., Lexer, W., Möller, A., Rickson, R.J., Shishkov, T., Stephens, M., Toth, G. Van den Akker, J.J.H., Varallyay, G., Verheijen, F.G.A., Jones, A.R. (eds) (2008). Environmental Assessment of Soil for Monitoring: Volume I Indicators & Criteria. EUR 23490 EN/1, Office for the Official Publications of the European Communities, Luxembourg, 339pp.

Huber S., Syed B., Freudenschus A., Ernstsen V., Loveland P., (2001). GPS - theory and practice, 5th ed., Springer.

INEA (2011a). Giarè, F., Povellato, A., Vanni, F., Longhitano, D., Trisorio, A., Scardera, A., Maso, D., Coderoni, S., Zezza, A., Agricoltura, ambiente e società. Monografia,Pubblicazioni Agrisole, INEA, Rome. http://dspace.inea.it/bitstream/inea/234/1/SE5-1157.pdf

INEA (2011b), Libro Bianco. Sfide ed opportunità dello sviluppo rurale per la mitigazione e l'adattamento ai cambiamenti climatici, MIPAAF, INEA, RRN, Roma. http://www.reterurale.it/flex/cm/pages/ServeAttachment.php/L/IT/D/3%252F4%252F6%252FD.3eedaaafed4e1eefa95e/P/BLOB%3AID%3D5799

INEA (2009). Il sistema agricolo e alimentare nelle Marche. Osservatorio agroalimentare delle Marche.

Jolivet C., Boulonne L., Ratie C. (2006). Manuel du Reseau de Mesures de la Qualite des Sols. Unite InfoSol, INRA, Orleans, France.

Karlen, D.L., M.J. Mausbach, J.W. Doran, R.G. Cline, R.F. Harris, G.E. Schuman. (1997). Soil quality: a concept, definition and framework for evaluation. Soil Sci. Soc. Am. J. 61: 4–10

Kayadjanian M., Deumlich D., Eiden G. (2004). LUCAS as a potential soil monitoring system data provider. EUROSTAT, European Commission, Luxembourg.

Kibblewhite, M.G., Jones, R.J.A., Montanarella, L., Baritz, R., Huber, S., Arrouays, D., Micheli, E. and Stephens, M. (eds) (2008). Environmental Assessment of Soil for Monitoring Volume VI: Soil Monitoring System for Europe. EUR 23490 EN/6, Office for the Official Publications of the European Communities Luxembourg, 72pp.

Louwagie, G., S. H., Gay and A., Burrell (2009). Addressing soil degradation in EU agriculture: relevant processes, practices and policies. Report on the project Sustainable Agriculture and Soil Conservation (SoCo), Office for Official Publications of the European Communities, Luxembourg, 329pp. Retrieved from http://eusoils.jrc.ec.europa.eu/esdb_archive/eusoils_docs/other/EUR23767.pdf

Louwagie, G., S. H., Gay and A., Burrell (2009). Final Report on the project Sustainable Agriculture and Soil Conservation (SoCo). Office for Official Publications of the European Communities, Luxembourg, 169pp. Retrieved from http://eusoils.jrc.ec.europa.eu/esdb_archive/eusoils_docs/other/EUR23767.pdf

LUCAS (2009). Land Use and Cover Area frame Survey. Web address: http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/methodology.

Marino, M. (2011), Biodiversità in agricoltura. Scenari internazionali e misure nazionali, RRNMagazine La rivista della Rete Rurale Nazionale n. 1 .

Martino, L. and Fritz, M. (2008). New insight into land cover and land use in Europe, Statistics in Focus, 33, Eurostat, , European Commission ,Luxembourg.

Ministero dell'Ambiente, della Tutela del Territorio e del Mare (2010) La Strategia Nazionale per la Biodiversità.

Ministero delle Politiche Agricole e Forestali Mipaaf (2007) Piano Strategico Nazionale per lo Sviluppo Rurale.

Ministero per le Politiche Agricole (1997). Metodi di analisi fisica del suolo. Franco Angeli Editore, Milan.

Ministero per le Politiche Agricole (2000). Metodi di analisi chimica del suolo. Franco Angeli Editore, Milan.

Ministero per le Politiche Agricole, Alimentari e Forestali (2008) Piano Nazionale sulla Biodiversità di interesse agricolo. Rome.

Ministero per le Politiche Agricole, Alimentari e Forestali (2010) Piano Strategico Nazionale per lo Sviluppo Rurale.

Montanarella, L. and R. Vargas (2012). "Global governance of soil resources as a necessary condition for sustainable development." Current Opinion in Environmental Sustainability 4(5): 559-564.

OECD (2001). Environmental Indicators for Agriculture. Volume 3. Methods and results. OECD, Paris ed. pp. 409.

Paracchini M. L., Jan-Erik Petersen, Ybele Hoogeveen, Catharina Bamps, Ian Burfield, Chris van Swaay (2008), High Nature Value Farmland in Europe - An Estimate of the Distribution Patterns on the Basis of Land Cover and Biodiversity Data. EUR 23480 EN, Office for Official Publications of the European Communities, Luxembourg, 102pp.

Penman, J., Gytarsky, M., Krug, T., Kruger, D., Pipatti, R., Buendia, L., Miwa, K., Ngara, T., Tanabe, K. and Wagner F. (2003). Good practice guidance for land use, land use change and forestry (GPG-LULUCF). IPCC-IGES, Kanagawa.

Rasio R. (2001). I suoli. Cappelli Editore

RRN (2009) - Task Force Ambiente e Condizionalità, Aree forestali ad alto valore naturale. Linee metodologiche per la stima delle aree forestali ad alto valore naturale a livello nazionale e regionale.

Rusco, E., B., Maréchal, M. Tiberi, C. Bernacconi, G. Ciabocco, P. Ricci, E. Spurio (2008). Case study-Italy, Sustainable Agriculture and soil conservation (SOCO project). EUR 24131 EN/1, Office of the Official Publications of the European Communities, Luxembourg, 138pp.

Rusco E., L. Montanarella, M. Tiberi, L. Rossini, P. Ricci, G. Ciabocco, A. Budini, C. Bernacconi (2007). Implementazione a livello regionale della proposta di Direttiva quadro sui suoli in Europa.

Rutgers, M., C., Mulder, A.J., Schouten (eds) (2008). Soil ecosystem profiling in the Netherlands with ten references for biological soil quality, Report 607604009/2008, RIVM 2008.

Sequi. P., Benedetti A., Dell'Abate MT. ( 2003). ATLAS. Atlante di Indicatori della Qualita del Soil. CRA - Istituto Sperimentale per la Nutrizione delleplants. Reprinted 2006

Servizio Suoli Assam (2005). Suoli e paesaggi delle Marche. (Disclosure monograph). Web: http://suoli.regione.marche.it/ServiziInformativi/Divulgazioneonline.aspx

Smeets E., Weterings R. (1999). Environmental indicators. Typology and overview. EEA-European Environment Agency, Technical Report n°. 25.

SOILQUALIMON (2010). Quaderni della Ricerca n. 110.

Soil Survey Staff (1999). Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. Handbook n°. 18 2nd ed.

Stolbovoy, V., Filippi N., Montanarella L., Piazzi M., Petrella F., Gallego J., Selvaradjou S-K. (2006). Validation of the EU soil sampling protocol to verify the changes of organic carbon stock in mineral soil (Piedmont region, Italy). EUR 22339. Office for Official Publications of the European Communities, Luxembourg.

Stolbovoy, V., Montanarella L., Filippi N., Selvaradjou S., Panagos P., Gallego J. (2005). Soil Sampling Protocol to Certify the Changes of Organic Carbon Stock in Mineral Soils of European Union. EUR 21576 EN, Office for Official Publications of the European Communities, Luxembourg.

Tóth, G., Jones, A., and Montanarella, L. (eds) (2013). LUCAS topsoil survey methodology, data and results. EUR 26102 EN, Office of the European Union, Luxembourg, 154pp.

Tóth, G., Jones, A. and Montanarella, L. (2013). The LUCAS topsoil database and derived information on the regional variability of cropland topsoil properties in the European Union. Environmental Monitoring and Assessment 185 (9), 7409-7425.

Trisorio A., Povellato A. Borlizzi A. (2010), High Nature Value Farming Systems in Italy: a Policy Perspective, paper presented at the OECD Workshop on Agri-environmental Indicators: Lessons Learned and Future Directions, 23-26 March, 2010, Leysin, Switzerland.

U.S. Forest Service (2003). GPS Data Accuracy Standard (draft). U.S. Forest Service, March 14, 2003.

UNCEC (2003). Kyiv Resolution on biodiversity. ECE/CEP/108. United Nations, Economic Commission for Europe.

UNCTAD-WTO (2007), Organic farming and climate change. United Nations.

UNFCCC (1992). United Nations General Assembly. United Nations Framework Convention on Climate Change. United Nations, New York. Web: http:// www.unfccc.int/resources

USDA (1993). Soil survey manual. Soil Survey Division Staff Soil Conservation Service.

USDA-NRCS Agriculture Handbook n°. 436. United States Department of Agriculture.

USDA-NRCS, 2008. Soil Quality Physical Indicators: Selecting Dynamic Soil Properties to Assess Soil Function. United States Department of Agriculture, Soil Quality Technical Note n°. 10, September 2008.

USDA-NRCS, 2006. Keys to Soil Taxonomy. United States Department of Agriculture, Tenth Edition.

USDA-NRCS, 1996. Indicators for Soil Quality Evaluation. United States Department of Agriculture, Soil Quality Information Sheet.

Van Rompaey, A.J.J., Bazzoffi, P., Jones, R.J.A., Montanarella, L., Govers, G. (2003). Validation of Soil Erosion Risk Assessments in Italy. European Soil Bureau Research Report No. 12, EUR 20676 EN, Office for Official Publications of the European Communities, Luxembourg, 25 pp.

Van-Camp, L., Bujarrabal, B., Gentile, A-R., Jones, R.J.A., Montanarella, L., Olazabal, C. And Selvaradjou, S-K., (2004). Reports of the Technical Working Groups Established under the Thematic Strategy for Soil Protection. Volume 5 - Monitoring. EUR 21319 EN/5. Office for Official Publications of the European Communities, Luxembourg, 872pp.

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Abstract

MOSYSS is a project launched in June 2010 by the Agriculture, Forest and Fisheries Department [Servizio Agricoltura Forestazione e Pesca] of the Marche Region in Italy. It has been coordinated by the Regional Soil Observatory [Osservatorio Regionale Suoli] as part of the assessment activities of the Rural Development Plan (RDP) Marche 2007-2013 [Piano di Sviluppo Rurale - PSR] as described in the Common Monitoring and Assessment Framework [Quadro Comune di Monitoraggio e valutazione – QCMV].

Among the objectives is the creation of a permanent soil monitoring system for the whole Marche territory, combining technical and scientific requirements (e.g. rigour and representativeness) while at the same time optimising financial and organisational resources. The information obtainable from the monitoring system could potentially be upscaled, on a functional basis, to other existing soil and biodiversity monitoring networks at national and EU level.

The main function of the project is to investigate soils starting from their intrinsic properties (e.g. chemical, physical or biological) in order to obtain a detailed evaluation of their current "quality" status, and to monitor, over time, changes in these parameters by repeating the monitoring campaign at pre-established time intervals.

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