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GIS-Model as a tool for program planning and management of pastoral areas

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INTRODUCTION

Sardinia (Italy) is an Island representative of Mediterranean rural areas, where agro-pastoral activities and sheep breeding for milk production in particular, have always played a major economic role; historical accounts report their presence as early as 1000 BC (Cherchi Paba, 1974). During the last century, a progressive and steady increase in sheep numbers has occurred. During the 1970s and 1980s the rise of sheep milk prices resulted in a further marked growth from 2,500,000 to 3,800,000 heads. Such increase, brought about the intensification of agro-pastoral activities in hilly and mountain areas, where agro-pastoral was the only possible economic activity (Idda, 1978), as well as their expansion to flat areas that had always been used for cultivating crops.

In order to meet the higher feeding requirements of animals, the regional government of Sardinia promoted policies aiming at increasing forage production (Regional Law 6/9/1976 n.44 Reform of the agro-pastoral zoning) while also providing subsidies. Actually, as it turns out, such policies were not accompanied by the necessary guidelines for their implementation. Some amendment actions were then carried out on several areas regardless of their specific morphological and pedological conditions, resulting in a severe impact on the land. The widespread substitution of Mediterranean shrub areas with artificial pastures, was obtained by using fire and deep tilling along the maximum gradient on steep slopes, is an example of the negative consequences of the regional regulations (D'angelo et al., 2000).

Recent political priorities in Europe aim to: rationalize agricultural production, reduce pollution, upgrade the environment, maintain rural infrastructures and meet new societal concerns such as product quality and animal welfare (Burtscher, 2004).

These radical changes seriously challenge the existing managerial approaches in agriculture and more specifically in livestock farming.

The sustainability issue, made aware to the public by the Brundtland report (WCED; 1987) and the Rio Conference in 1992, is, foremost, an expression by society to be better informed about development options, technological changes and their effects; in order to limit the potential damaging consequences for the planet's resources as well as the life of present and future human generations. The numerous definitions of sustainability produced over the last 20 years all emphasize the need to care for the ecological, economical and sociological consequences of development choices for present and futures generations (Geng et al., 1990, Musasinghe and Shearer, 1995).

Thompson and Nardone (1999) research and policy for sustainable agriculture can be grouped into two broad paradigms. The first, is one that defines sustainability in terms of *resources availability,* which *emphasizes* the accounting for the rates at which resources are produced and depleted, and frames sustainability in light of strategies for conservation, generation and substitution for increasingly scarce resources. The second, is in terms of *functional integrity* which emphasizes a dynamic system model of complex ecological and social processes of reproduction, and frames sustainability as relative, in light of system vulnerability to anthropogenic stress.

To say that agricultural systems have functional integrity, is simply to say that the system has feedback mechanisms that prevent the reproduction of crucial elements from increasing without limitations, or from disappearing from the system altogether. The idea of functional integrity can be applied to the ecological parameters of extensive livestock production, were stocking ratess, forage, non-forage plants such as bush and shrubs, and wildlife exhibit complex relationships. These elements of range systems can remain in equilibrium for extended periods of time, however, disequilibrium can appear suddenly, (or with a substantial time lag) a consequence of critical change in the reproductive capacity of any single element.

Pulina and Borlino (1998) consider grazing as a half-stable member of the ecosystem capable of further evolving itself towards a growing complexity. However, when in the presence of disturbance factors such as excessive stocking rates, it evolves towards an increasing degradation, to the point of initiating desertification processes.

In contrast, under grazing or complete elimination of grazing from rangeland and forest ecosystems, has a serious implication to the sustainability of these resources. Mediterranean rangelands and forests have evolved with the presence of herbivores, therefore, their removal or elimination could possibly lead to: shrub encroachment in grassland; dominance of unpalatable species; reduction of biodiversity and eco-diversity, increased density of shrub lands and forest; fuel accumulation, landscape homogenization, disastrous wildfires (Papanastasis 2004).

Grazing land in Mediterranean countries used mainly for extensive livestock farming, represents a significant proportion of the total land area; small ruminants livestock systems represent one the most important agricultural activity within the main tendency towards milk production. These areas have been interacting with human and livestock practices for millennia. The Mediterranean countries in total produce two-thirds of the world's sheep milk and more than one-quarter of the world's goat milk. Feed availability is identified as one the major constraints for small ruminant systems. In fact, in many areas pasture growth is limited by the irregular distribution of rainfall during and between years, coupled with high temperatures during summer and high potential rates of evapotraspiration (Nardone, 2000).

The problem of seasonality pasture production is responsible for nutritional constraints on extensive small ruminants and obviously in all grazing herbivores. In Sardinia, dairy ewes are commonly exposed to under nutrition during pregnancy, early lactation (autumn-winter) and during late lactation (end of spring) (Molle et al., 1994). In Sardinia the main livestock dairy sheep, (c.a. 3.5 million heads) graze the irrigated lowland at 10-20 ewes ha where annual forage crops and perennial forage pastures are grown, but natural pastures in the hilly inner areas are stocked at 1-3 ewes ha (Molle et al 2002).

The irrational practice of grazing is one of the main problems of the extensive breeding in the areas with an arid and semi-arid climate. The problem manifests it self on a farming business and territorial level, with the animals being wrongly led to pasture by over-grazing, following an incorrect appraisal of the stocking rates a pasture can support according to productive potentialities of the forage resources.

In both cases the wrong appraisal of the sustainable stocking rates almost always determines an overload, in the first case temporary, in the second case permanent. The animal overload shows repercussions directly on the soil by means of the trampling, which determines the compactness of the surface, the destruction of the land structure and the creation of paths in uneven lands. (Vallentine, 1990).

The compactness of the soil is the consequence of the specific pressure exercised by the foot of the animal that involves a reduction of the porosity of the soil and consequently the ability of infiltration of water rendering it in extreme cases impermeable. In such conditions the soils are susceptible to the erosive action of water and to the slipperiness of the superficial layers. This phenomenon is particularly evident and harmful in lands with argillaceous tendencies and intense precipitations. To this can be added the removal of the vegetation mantle that makes the soil bare and more vulnerable to the erosive action of water and to the superficial surface water deposits, generating in uneven areas a phenomenon of channelled erosion. The degree of compactness is also in relation to the grazing species, regarding both the specific pressure exercised by the foot on the soil, as well as the animal behaviour; surely the tendency of sheep to graze in groups is more damaging than the solitary grazing of goats and bovines (Pulina et al., 1995).

Enne et al., (1996) found that areas of pasture in which the animals gather at places such as the drinking locations, the feed boxes or the areas covered by trees where the animals can find shelter, manifest an elevated degree of sterility.

The spread of conservation techniques for forages, the availability of concentrated fodder and the necessity to possess a well equipped farming centre with the infrastructures necessary to guarantee the respect of the hygienic-sanitary characteristics of the productions, demonstrated the disappearance of the practice of moving the herbs from place to another at different altitudes . This generated the spreading out of flocks and herds within the territory, causing a strong increase in the erosive impact exercised on the soils. Infact, the removal of the animals for a few months of the year allowed the top soil coat to regenerate itself, carrying out the protection of the soil, and resuming the production of grass, which is the eventual dietary source for the successive months.

To this purpose, new concepts and evidence of sustainable rangeland management support the view that, light or moderate grazing by livestock increases rangeland productivity (Mearns, 1997). The evaluation of a sustainable carrying capacity, needs to take into consideration that, grazing by livestock, together on the same land, is a current activity that corresponds to the oldest systems of multispecies herding (Sikosana, 1996). It allows for a better utilization of the vegetation (Nolan and Connoly, 1977) and has a positive effect on plant and animal biodiversity (Steinfield et al., 1997). In particular, small ruminants are able to benefit from marginal land and crop residues, and therefore can be considered complementary to cattle (Aucamp et al., 1994).

The implementation of grazing also has an effect on the agrarian landscape, that is the emblem of an agro-pastoral civilization, and that for centuries has been able to manage complex equilibriums in an entirely compatible way. It was a wise management, finalized to the economic sustainability while at the same time conserving, strengthening and enhancing the value of the natural resources.

The rural landscape of Sardinia presents for great part of the territory, a typically pastoral connotation. This term defines the slow but constant action that man has exercised on the elements of the landscape with the activity of animal breeding and consequently grazing.

This type of landscape is widely spread in the Mediterranean, especially in the more difficult areas where sheep-rearing is still the main agricultural activity. It assumes different forms and connotations according to the nature of the areas and the breed of livestock production. In characterizing immense inner areas, it reflects a mixture of valences and functions that, beyond the mere aesthetic appearance, touch the environmental and social-economic domains (Idda et al., 2006).

With regards to the other Mediterranean pastoral landscapes, the Sardinian one is characterized by the diffused presence of herbaceous surfaces, naturally or artificially, that occupy 56% of the SAU (Eurostat 2004). These are the consequence of the livestock production activity as part of the major agricultural ones used (53% of the total economic dimension).

Considering that, the ovine breeding for milk represent the prevailing share of the livestock production farms, it can be said that the rural landscape of Sardinia is formed by the presence of sheep. However, in the last few decades it's helped itself to a gradual reduction in the consistency of the bred heads as well as to the abandonment of the more marginal and less profitable areas, in order to occupy plain areas, or to even carry out other activities.

If this trend was to be confirmed, the rural landscape of the Sardinia could show, in a relative short period of time, radical changes and could bring to an infallible loss, the greater identifiable feature of the Sardinian landscaped. Infact, grazers, both domesticated and wild, have a major impact on the vegetation composition, vegetation structure and species composition. The effect of grazing on the defoliated plants produces various structures of vegetation. Grazing induces variations in the height, density and types of vegetation that make up the landscape.

Moreover, the subtle patterning of textures and colors of the herbaceous vegetation that can be seen from a distance, shapes the landscape together with flowering plants of different colors and flowering periods. (Hadjigeorgiou et al., 2005).

The problem with the determination of the stocking rates in respect to the conservation of the territory and the safeguard of the rural landscape, are only two of the problems of the livestock production sustainability. Infact, such concept embraces many thematic ones, there has been talk about economic and social sustainability of the producers, citizens and animal well-fare (Vavra, 1996), that not always can be safeguarded at the same time and in the same context.

The strong intensification and environmental impact development models determine the risks of pollution and degradation, the scarce guarantee and quality of the food, the reduction of the genetic variability in both vegetation and animals as well as the scarce conditions of animal protection and their well-being (Nardone et al., 2000). However, contrarily to the popular opinion that, the extensive breeding farms are more respectful towards the environment, more appropriate for animal well-being and are also the producers of better food quality, we must state that this is not, or at least, automatically, the case.

Today, large breeding farms are favoured for the greater efficiency of their work, for the volume of the productions, the possibility to apply uniform treatments for homogenous groups of animals, however, with greater problems for the sanitary aspects tied to the concentration of the animals and for their waste.

The breeding farms of modest proportions and other alternative systems are often perceived more respectful towards the environment, more oriented towards a family business environment and traditions, and more suitable for the animals. However, they could actually result not having sufficient resources to put into effect the necessary practices for the well-being of the cattle, the treatment of their waste and could also supply an inadequate yield to the breeder (Pagano and Lazzaroni, 2001)

Ronchi and Nardone (2003) find that an organic farm answers to the sustainability requirements. It is largely based on a methodological approach to analyze the components of the system (biological, ecological, economic and social)and to define the appropriate model at a regional and local level. Organic livestock farming, such as defined by the basic guideline (Sundrum, 2001), involves a radical change in thinking about the production process of animal husbandry, with more attention to animal health and welfare, to environmental conservation, and to food quality and safety.

According to some authors (EQBM, 1999; Russo et al., 2000; Matassino, 2000) that evaluate the sustainability in relation to the results obtained from the conversion of forages and fodder in products of animal origin (meat, milk, eggs, wool, etc to me), the efficiency of the productions has remarkably increased and could continue to increase with the introduction of genetically modified organisms. These could allow for a greater production per head, with a consequent saving of feeding requirements and a reduction of waste, and therefore greater earnings. However, they could also lead to a reduction in genetic variability replacing the present animals, because they are less productive, and modified through a reproduction which is more or less programmed. The pre-existing genetic heritage has already partially taken place using the results of the genetic improvement.

The SEFABAR (Sustainable European Farm Animal Breeding And Production) defines common criteria to all the animals in a livestock production for a genetic improvement in relation to sustainability. Such criteria are qualities, as in the health of the products, biodiversity, ethical acceptability, animal well-being, and long term economic efficiency.

According to Pagano and Lazzaroni, (2001) the problems of livestock production sustainability appear to be of a very complex nature requiring a multidisciplinary study in order for their resolution. Infact, if up until now, in the livestock field the attention was focused on the aspects of the production processes such as those of the food production or genetic improvement, and in more recent times, on the quality of the product and the well-being of the animals, it now requires a cooperation between the scientists (Bèranger and Vissac, 1994) of the zootechnical-agrarian and veterinarian sector, but also the contribution of ecologists, economists and sociologists (Van Der Ploeg, 1996).

Today, the main approach used to study the complexity of the phenomenon is the use of simulation models. Simulation models relate inputs models and outputs of a defined live- system, through a connecting structure of inter-related processes and products. Such dynamic models contribute to a better understanding of the whole bio-technical system, but they are not sufficient for livestock farming sustainability (LFS) research purposes, since they usually lack the facilities necessary to capture the management strategies of the farmers.

Simulation models that allow the testing of scenarios for alternative management strategies, with respect to the characteristics of the farm, are developing as decision support tools for advisory purposes (see for example Herrero et al., 1996; van Alem and van Scheppingen, 1996). They rely upon the coupling of a biophysical model of farming processes and a simplified representation of farm management strategy.

Theoretical and simulation modeling is providing an increasing number of integrated models of biological processes. For example, in the regulation of nutritional functions (Baldwin and Hanigan, 1990; Danfaer, 1990; Sauvant, 1992; Tamminga, 1992) and in plant–animal interactions and in the intake at grazing (Hyer et al., 1991; Armstrong et al., 1997).

Other approaches mainly aim at deepening the conceptual understanding and the modeling of the decision systems of farmers. 'Representation models' of farm operations are often expressed as systemic diagrams relating farmers' decisions over time (strategy and tactics), to the evolution state of the operative components of the production process (Hubert et al., 1993; Halberg et al., 1994; Girard and Hubert 1996).

Such conceptual models can support the development of field methodologies for the provision of advice to farmers (Hubert et al., 1993) In many of the approaches, emphasis is given to elucidating state indicators for the components of the bio-technical system (e.g. the herd, the pasture), which farmers themselves use when making decisions. Their identification assists researchers in understanding farm management practices and helps their modeling (Dedieu and Thèriez, 1994).

The utilization of mathematical models has also been proposed by Masala et al.,(1994) for the management of extensive breeding farms of bovines for meat (Bovisoft), for ovine milk farms (Ovisoft) (Soro and Pulina 1998), for goat farms (Caprisoft) (Boe at al., 2005), and in EISR for the impact evaluation of the pastoral activities on the territory (Pulina and Zucca 1999).

Today, the application of simulation models is supported by the integration of informatics systems GIS, capable of analysing outputs of different models thus creating synthesis indices of the problem. Zhang et al.,(2006) utilizing a model to predict the productivity of a pasture and then integrating it into a GIS with their strong ability to deal with spatial factors. The integration of a decision tree approach with a GIS, offers a potential solution in meeting this challenge.

Saroinsong et al.,(2007) propose the integration of the multi-criteria analysis model with the GIS to agricultural landscape planning .The planning process consists of erosion hazard, land suitability, and economic feasibility analysis. Land resource information was developed as a GIS database from topographic maps, Landsat TM images, soil maps, and climatic data. Using this data, the universal soil loss equation was applied to erosion hazard analysis.

In this thesis i propose the implementation of GIS with the EISR mathematical model for the planning and management of the stocking rates for all the Sardinian region territory, and secondly, the use of GIS with the mathematical model for the management of marginal pasture areas of the Goceano region (SS).

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CAPTER 2

The Global Information Systems

ORIGIN OF THE GIS AND ITS EVOLUTION TO DATE

The second half of XX century was characterized, by a great technological evolution. The electronics and the computers have carried out a determining role in the transformation process of current society, changing not only the way in which we work, but also, on more general terms the actual lifestyle itself. The technological evolution of these years has assigned the passage from an industrial society to an information society (Naisbitt, 1984).

The 50's marked the start of this process with the event of telecommunications. Successively, like for many sciences, the 60's marked the beginning of the transformation process for also geographic and cartographic sciences. The now refined techniques of traditional cartographic production, the rapid development of the electronic computers and the new ideas on space analysis began in those years to gradually promote a process of innovation towards new methodologies of study and management of the territory.

In 1969 Ian McHarg published the book "Design With Nature" that formalized a mythology of spatial analysis based on the comparison of data and the production of synthesis cartography. In practice McHarg hypothesised the use of overlapping structures of geographic data of singular thematic in informative levels, realizing synthesis maps, placed within logical combinations, useful for both the planning of natural resources and for the decisional process management.

The scene where the first experimentations and applications were developed was North America.

The two main initiatives, to which the birth of the GIS (geographic information systems) science is attributed to, began simultaneously. The first was addressed to the development of commercial software (Harvard Laboratory) and the second to satisfy the requirements of a government entity. In the second half of the 60's, Howard Fischer founded the Harvard Laboratory for computer Graphics and spatial analysis, where a nucleus of programmers' planned and developed a package software, called SYMAP, that allowed given geographic data to be elaborated and to formulate simple thematic charts (Chrisman, 1988).

Successively, in the same laboratory, more specific software was evolved and developed, until in the 1970's the Harvard Laboratory produced ODYSSEY, the first true GIS commercial software that introduced the concept of a topological structure of data and "overlay mapping" (automatic overlap of informative layers). In the same period in which the Harvard Laboratory was born the Canadian government developed the first real GIS called C.G.I.S. - (Canada Geographic Information System (Tomlison, 1967).

The project had as its main objective the construction of an inventory system of the Canadian territory and in 1971 the system was definitively operating and contained a data bank of approximately 10.000 digital charts in scale 1:50.000, in various thematics. Relieved from the first positive experiences, many other American government entities set up geographic informative systems.

In 1973 the Geological Survey developed a GIS site for the analysis of natural resources; integrating information from satellite images, pre-existing charts and samples from the field, producing digital charts for the usage and cover of the soil (Mitchell, 1977).

Even in Europe, pressed by the result of the first experiences overseas, some research centres and government entities moved towards the new technologies. In the first years of the seventies, the national English cartography agency started the program for the digitalisation of cartography. Sweden, Finland, Germany, France, Italy followed. The systematic production and the availability of digital cartography both of topographical and of cadastral type, were also followed by acquisitions of informatics systems for the management of geographic data on behalf of several entities and administrations.

Informative systems were therefore born from the requirement to display powerful instruments for the collection and elaboration of information, in order to present to the people, responsible of operating decisions, all the information necessary to carry out the best possible choices. Like in Europe, the GIS in Italy in the last few years has also been experiencing a moment strong development. The majority of the government entities, of regions and provinces are elaborating informative systems. The spread amongst the local entities, the universities and the private bodies, is taking off in these last periods, thanks to the availability of contained costs of geographic data banks and GIS software and also due to the training of both government body employees and those specialised in their field.

DEFINITION OF THE TERM

The term geographical information system (GIS) is more difficult to define than one might at first imagine. Although there has been some debate about the origin of the term and the date which it commenced, it is clear that GIS is a relatively recent phenomena.

GIS and synonym geographical information system (used in North America), is frequently applied to geographically oriented computer technology, integrated systems used in substantive applications and, more recently, to a new discipline which is generating massive interest world wide.

GIS's are seen by many as special cases of information systems in general information is derived from the interpretation of data which are symbolic representations of features (Benyon, 1990).

The informative geographic systems are systems which have been computerized for the acquisition, the memorization, the control, the integration, the elaboration and the representation of data that is spatially referred to the terrestrial surface (Arnaud et al., 1993). A mixture of hardware, software and persons concerned with the acquisition, management, analysis and visualization of alphanumeric and geographic information referred to a determined territory (Cortellessa, 1995)

Many of the definitions discussed above are relatively general and cover a wide range of subjects and activities. All of the definitions, however, have a single common feature, that GIS is a system which deals with geographical information. In GIS, reality is presented as a series of geographical features defined according to two data elements. A valid initial, however reductive definition of GIS, is: “information system for the construction of thematic cartography and for the analysis of existing geographic phenomena and/or events which occur on Earth”. Today, in light of recent progress in informatics and techniques for the treatment of information, GIS is considered as utilizable technology in all those situations in which representation with overlapping layers is necessary. The definition of territorial or spatial datum provides a modern vision of territory which notably broadens the field of GIS technology application (Romani, 2001).

Other authors, however, (Densham and Goodchild, 1989; Rhind, 1988), have reservation about how well current GIS can be used in these ways.

COMPONENTS OF GIS.

GIS is comprised of four basic elements which operate in an institutional context: computer hardware, computer software, data and livewire.

The hardware element can almost be any type of computer platform, including relatively modest personal computers, high performance workstations, mini computers and mainframe computers (Franklin, 1991). In addition to the standard input, storage and output devices, specialised peripherals are required for data input (e.g. scanners, digitizers and tape drivers), data output (e.g. plotters) as well as data storage and processing. There is now a great deal of what claims to be GIS software. Although there are variations in the organization and capabilities of GIS software, three basic designs have evolved (Aronoff, 1989, Bracken and Webster, 1989).

These are called the file processing design, each dataset and function is stored as a separate file and these are linked together during analytical operations. Examples of systems using this design are IDRISI (Eastman, 1987) and MAP (Tomlin, 1986). This is the approach adopted in map processing systems. In the hybrid design, attribute data is stored in a conventional DBMS (Database Management System) and a separate bespoke software is used for geographical data. ARC/INFO (Morehouse, 1989) and Deltamap/Genamap (Reed, 1986) are examples of hybrid designs.

In situations where attribute data is stored in a relational DBMS they are sometimes referred to as geo-relational (Morehouse, 1985). In the third design type, the extended DBMS, both the geographical and the attribute data are stored in a DBMS which its extended design are SISTEM 9 (Ingram and Phillips,1987).

The third important element in a GIS is the data. In many respects data is a crucial resource. Geographical data is very expensive to collect, store and manipulate because large volumes are normally required to solve substantive geographical problems. In fact, it is not uncommon for the cost of data collection to exceed the cost of hardware and software by a factor of two. Rowley and Gilbert (1989), suggest that data collection corresponds to 70% of the total cost of implementing a GIS.

Finally, a GIS is useless without the people who design, program, maintain it, and supply it with data, and interpret its results (Fig.1).

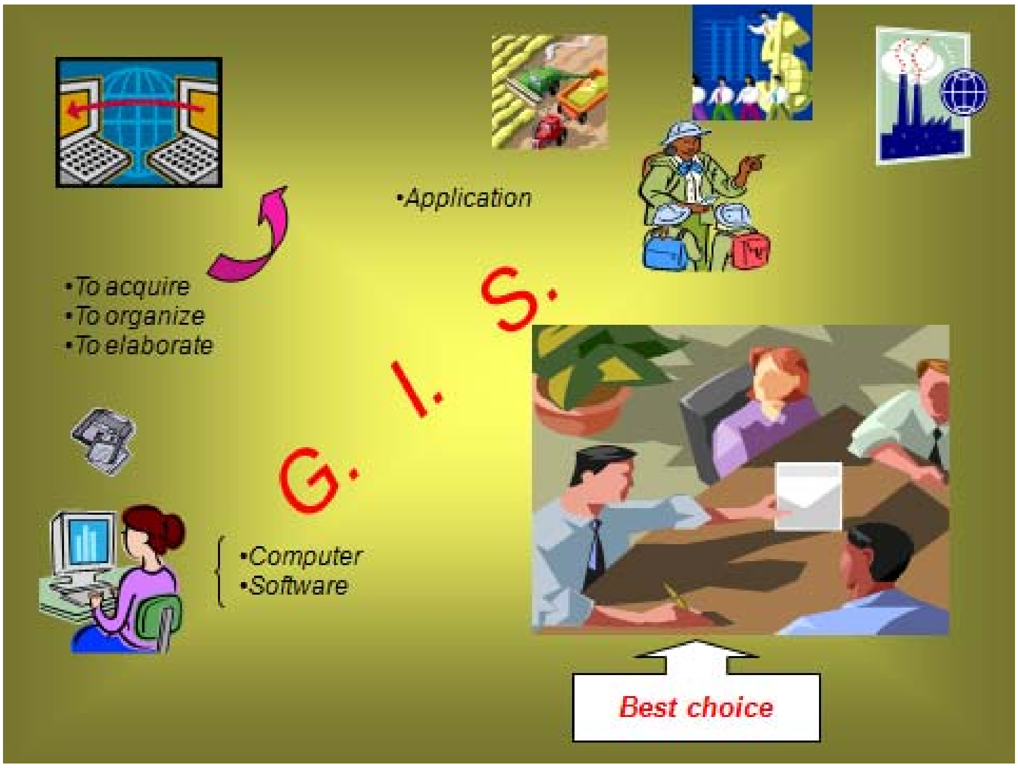


Fig.1 The component of GIS

NATURE OF THE TERRITORIAL DATA

A GIS stores two kinds of information: geographic coordinate data (spatial data) and attribute data. The GIS is a device for standardizing and storing the data, analyzing relationships in the data to create new information, and displaying the data in map or report form.

Spatial data describes graphically and spatially the position and the topology of objects through points, lines, areas and pixels, for example the border of a state, rivers, and lakes.

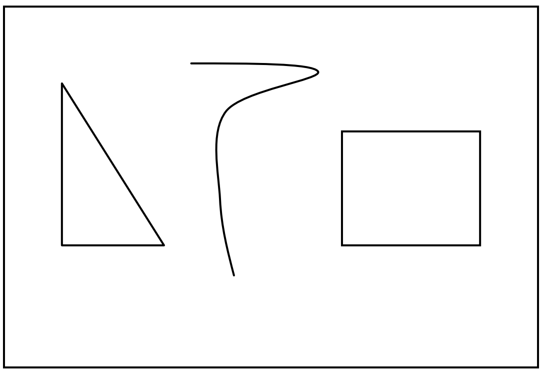
Attribute data expresses the value of a largeness and is manifested in a series of attributes (numerical values, characters) that describe the characteristics of objects.

Data layers and objects :A second requirement of a GIS is the ability to create digital data layers or objects from spatial data. “A data layer consists of a set of logically related geographic features and their attributes“(Aronoff, 1989). A paper map, such as a large-scale topographic map, contains a vast amount of information about geographic features and their relationships. The map information must be structured in a way that accurately represents the features on the earth, but that is easily handled by the computer and the GIS software. To accomplish this, the map data is separated into (and stored as) common thematic data layers. The layers may be created based on common geographic themes (e.g., roads, streams, or political boundaries) or by type of data to be stored (points, lines, or areas).

An emerging method for storing spatial data is *object-oriented.* In an object-oriented GIS, the geographic features and all of the information related to a feature are stored as an object. “An *object* is a structure that represents a single entity, describing both its information contents and its behavior. Every object belongs to a class, which defines a structure and a set of operations that are common to a group of objects. Individual objects of a given class are often referred to as *instances* of that class."(Clodoveu, 1994). When using an object-oriented model in a GIS "each object instance would contain all of its graphical characteristics, its geographic location, and all of the associated data". By storing information in thematic data layers or objects registered to a common geographic coordinate system, any combination of these layers or objects may be overlaid to form a new data set to be used to answer a question or analyze a problem. This ability to manipulate the separated data layers and objects provides a GIS with a vast analytical power. There are two basic formats for storing and processing geographic coordinate data in a computer: vector and raster. The vector method stores *point* locations of geographic features using an X,Y coordinate system. If the data has been projected, it's stored in a Cartesian coordinate system. In a vector data format, a point is represented by a single pair of X,Y coordinates. A line is created by a series of X, Y pairs (vertices) with the two end points identified. An area is constructed by combining a series of lines which enclose the area. Fig. 2- shows two polygons (1and 2) and the points which define the lines that form the polygon boundaries.

The raster storage method is quite different from the vector format. Raster data is stored as a matrix of pixels (short for "picture element") with each pixel's location assigned to a row and column designation. Points are represented as a single pixel, lines as a series of contiguous pixels, and areas as groups of pixels. Each data storage method has advantages and disadvantages. An obvious drawback with raster storage is the necessity to store the entire matrix of rows and columns. Storing the entire matrix may include unwanted data-for example, the pixels surrounding the polygons (fig 2b). Vector data usually requires less storage space in the computer, but it may be more difficult in a vector system to perform certain data overlays, functions-vector processing requires more sophisticated programming and processing time. Raster structure, by virtue of its matrix, has a built-in ability to perform neighborhood-type analysis easily, that is, it is easy for the computer to identify which features are adjacent to other features because of the row and column structure. In a vector system, coordinates may be stored at any desired scale, but in a raster format, the resolution is fixed by the pixel size.

a)Vector data



b) Raster data

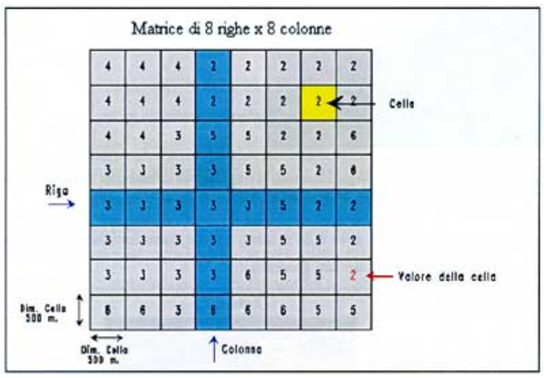


Fig.2 (a,b) Model data GIS

The geographic data can be better specified by: geographic position, attributes, spatial relations and time factor. The geographic position describes the location of an object in nominal terms (name of a town etc) or in quantitative metric terms, in which the positions are defined by x, y (geo-referenced) coordinates in a system of known coordinates. The attributes define and characterize the geographic data. The attributes are referred to as non spatial data as they do not possess an intrinsic positional connotation ; they do not vary with regards to the projection and scale of the map, because they do not have permanent location respect to other entities.

The spatial relations describe the existing logical relations between the geographical elements, and can be of various types: topological (equivalence, containment, adjacency, separation), of direction (in front, behind, over, under), of proximities (qualitative, near, far away, in proximity), quantitative (measure of the distances). The time factor, in the end allows carrying out temporal analysis through the characterization of the data relative to its position in the time so as to gain precious information on the evolution of a determined phenomenon, in order to, in the end, foresee it and intervene.

Computerized graphic Systems (for example CAD systems) can work with geo-referenced data as well, but differently from GIS, they do not have the capacity to integrate various data sources. This aspect of GIS offers advantages to the user; both in quantitative terms (large quantities of data can be manipulated and consulted rapidly) and qualitative terms (spatial data and their attributes can be integrated in a single analysis). These advantages are important, above all, in spatial and chronological research, studies such as temporal dynamics and decisional models relative to the environment and territory.

The data is fundamental for the existence and supply of the GIS as the favourable outcome depends on its availability, accuracy, and homogeneity. It is fundamental that every file of data is accompanied by information on its quality, as well as the half data, metadata, which defines the origin, reliability, precision, accuracy, and consistency of the data. Another critical element is comprised by the predisposition of a constant and adequate update of the informative base. In order for a greater number of possible customers to gain access, it's necessary for the data to correspond to a prefixed standard.

The phases for the programming of the system can be subdivided into:

Acquisition of the data: this includes all those activities that regard the collection, the predisposition and the acquisition of geographic information, for example a survey on the territory, censuses, aerial and satellite images, systems of positioning (GPS), systems of laser scanning from both the ground and sky, or acquisition of data from pre-existing data banks.

Pre-elaboration consists of the transformation of the available data in order to render it suitable for the insertion in a data bank. The main operations of pre-elaboration are: conversion between structures belonging to different data, photo interpretations, conversions between projections etc.

Management of the data happens through the informatics instruments known as Data Base Management Systems (DBMS) which allow the recall and manipulation of the data.

Data output: the data output component of GIS provides a way to see the data or information in the form of maps, tables, diagrams, and so on. The output subsystem

displays to users the results of GIS data processing, and analysis. The results may be generated in the hard- copy, soft-copy or electronic format (Aronoff, 1989).

Ability to overlay the geographic data. The ability of a GIS system is to *overlay* the separate data layers or objects. Overlaying may be defined as "the process of stacking digital representations of various spatial data on top of each other so that each position in the area covered can be analyzed in terms of this data"(Burrough, 1986).

GIS overlay is analogous to placing transparent map sheets, one over the other, on a light table. For years, geographers, landscape architects, and planners used light tables to view the intersections and relationships among various transparent map sheets. The ability of a GIS to replicate this method and overlay the geographic data is its fundamental method for conducting spatial analysis of geographic features. To overlay the data, the layers must share a common projection and coordinate system to ensure spatial registration, and the layers must have topology established. The ability to overlay spatial data is one of the capabilities that provides GIS with its analytical power: the integration and analysis of a wide variety of data.

WHY USE GIS?

Perhaps one of the most powerful benefits of GIS is its ability to integrate different databases into one environment. In effect, a GIS database may be thought of as a *database of databases.* Each layer in a GIS database may represent a complete database. All of these layers are databases which may be used for their own purposes, but whose value increases dramatically when included as a layer in a GIS: these layers (databases) may be overlaid with one another for spatial analysis.

For this ability the GIS are amply utilised in many practical fields, which demand the integration of data arriving from various sources and in various formats. One of these fields is the integration between the real world and the world of scientific research; in fact the research project of MASO-GIS (development of sustainable and multifunctional business models for the valorisation of the pastures in marginal areas by means of GIS) which the main object of this thesis tried to integrate in a common database, the data from 16 various environments which cover the entire national territory, using instruments of advanced surveying (remote sensing, dynamic modelling) and so generating sustainable business management models, which allow to take optimal advantage of the pastoral resources of marginal areas.

Actually, GIS has a wide use and acceptance in regards to natural resource management and regulatory applications. It is used for timber management, mine permitting, water quality assessment, wildlife and habitat management, and change detection and monitoring. At the local level, GIS supports land use planning, zoning, and transportation design. GIS aids emergency response by providing a tool for the prediction model of earthquakes, forest fires, and flooding, as well as helping manage and facilitate emergency response. In infrastructure management, GIS is used for utilities management, routing analysis, and facility sitting (Allan, 1994).

A second benefit of GIS is the ability to display and manage spatial data in a spatial context. Often, spatial data is managed in tabular databases that do not allow viewing or management of the data with spatial tools. Usually, the creation of a GIS database is the most costly and time-consuming activity of developing a GIS. However, once the database has been created, there are several benefits to be realized. The first is the rapid production of specialized maps and graphic products. Traditionally, maps have been created and published as general reference tools that are designed to be useful in answering a wide number of questions. A GIS database can now be seen as the general reference tool with the maps and reports, producing specific answers to specific questions. These custom maps may be generated quickly (Coppock and Rhind, 1991).

This potential of the GIS system has found a wide use with the merging of GPS systems, the integration of the two systems allows the possibility to obtain the geographic position of a vehicle in motion. The projects for traffic control systems and the optimization of delivery routes for couriers have multiplied, along with the study of herd movement etc. Putfarken et al., (2008) used collars for both sheep and cows that were equipped with a GPS in order to monitor the movement of the animals while grazing. Integrating the collected data from a GPS in a GIS it was possible to asses the eating habits of both species in regards to the latitude, the season, the characteristics of the vegetation, the distance of drinking and the enclosure points, thus determining an index of eating preferences for the two species.

Many authors have highlighted the importance of GIS as a decision support system (DSS) (Cowen, 1998, Parent and Church, 1987, Densham, 1991) and management information System (Devine and Field, 1986). Infact, Geneletti (2004) integrated the use of GIS and DSS to indentify nature conservation priorities among the remnant ecosystems within an alpine valley. Using typical functionalities of raster-based GIS, such as distance operators and spatial filters, to calculate indicators selected for the evaluation of the relevance of the forest patches for nature conservation.

Coupling GIS and DSS is becoming a common strategy to deal with problem decisions related to environmental planning and land allocation.

GIS AND REMOTE SENSING

With the term Remote Sensing, one defines the science that studies all the techniques and methodologies of acquisition, elaboration and interpretation that allow the analysis of objects or phenomena without having to enter in direct contact with them (CCRS, 1998). From this definition, it is clear that the remote sensing data can be of various nature including variations in field forces, sound waves, sources of electromagnetic power, etc. Therefore, the meaning of Remote Sensing takes us back to a wide spread disciplinary field that for intrinsic reasons has both an interdisciplinary as well as a distinctively applicable character.

Sabins, (1996) gives the following definition "*Remote Sensing may be broadly defined as the collection of information about an object without being in physical contact with the object. Aircraft and satellites are the common platforms from which remote sensing observations are made. The term remote sensing is restricted to methods that employ electromagnetic energy as the means of detecting and measuring target characteristics*".

Historically, the beginning of the Remote Sensing can be sited with the birth and development of the photographical technique that, united with the properties of various focal optics, not only extended the possibilities of perception for an observer, but also gave the possibility to record in permanent ways these observations. The principle of remote sensing is based on the ability to differentiate the greater possible number of elements or objects in the territory (ground, vegetation, water, urbanization etc), trying to describe the spectral characteristics of each one to their various wavelengths which are susceptible to a range of sensors compatible with their spatial resolution (Asrar, 1985).

Any external surface of a body, with a temperature higher than absolute zero emits its own electromagnetic radiations which in turn depend on the temperature of the body and the nature of the surface. The same surface reflects, absorbs or it allows it self to be crossed by electromagnetic radiations that come from the outside; emission, reflection, absorption and transmission of the radiations are all phenomena strictly connected between each other (Gomarasca,1997). The sensors for terrestrial resources measure the energy reflected from the surface of various bodies present on the ground; the aim of the remote sensing is to establish a correspondence

between the quantity and the quality of the reflected energy, the nature and the state of the bodies or surfaces from which it comes from, all according to the various wavelengths. Therefore a diagram can be developed for every type of surface. The diagram informs us of the reflection abilities in relation to the wavelength of the incisive radiation: this diagram, characterised by every surface, is called signature or spectral answer (Brivio et al., 1993).

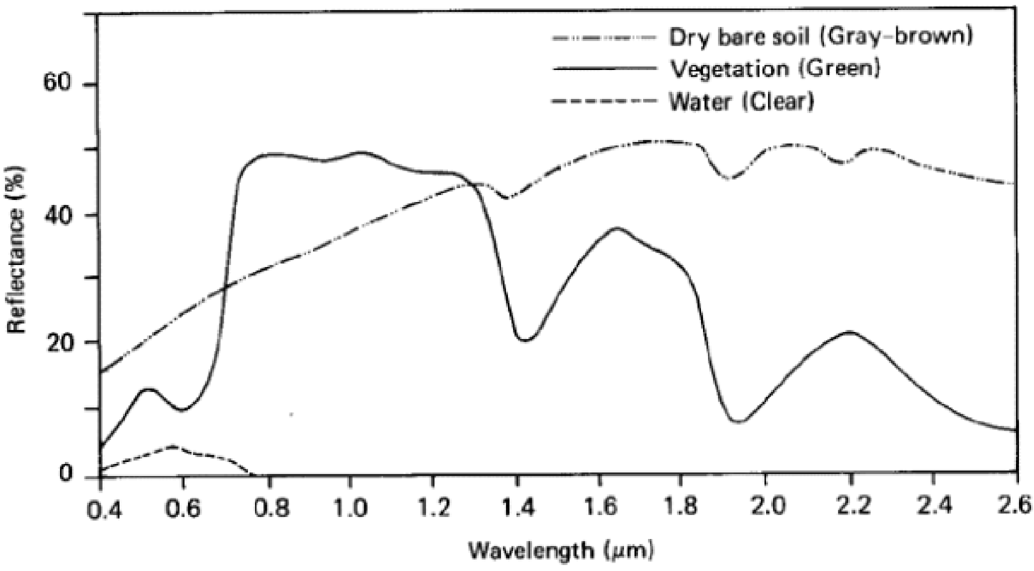


Fig 3. Reflectance of some territorial elements (soil, water, vegetation) in relation to wavelength change.

Such curves of spectral reflectance permit to recognize and identify the types, conditions and characteristics of the lands and areas covered by vegetation, bodies of water etc. The spectral signatures' however, can vary in time; this depends on the

phonologic stage of the plant, the herbaceous cultivations, their phytosanitary conditions, the degree of cover of the land etc (Philipson et al., 1988).

Therefore, becomes fundamentally important the use of multispectral and multi-temporal images with the acquisition of information at various wavelengths in characteristic stages of the phonological cycle for each cultivation to be analysed, as well as the monitoring of the ecosystems. From the analysis of the spectral behaviours it is possible to define the quantitative relations between the remote sensing data and phonology, such as the content of biomass (NDVI), by means of an algorithm that is based on the relationship of the typical spectral bands of absorption and reflection.

Rasmussen et al., (1998) used the remote sensing images in order to characterize the areas with herbaceous cover and, by later integrating them inside the GIS together with exposure data and slope of the soil, indentified new areas for the animals to graze during the winter months, resolving the problem of over grazing in Arkhangai (Mongolia). The territorial information obtained from remote sensing images needs to be organized inside a GIS in order to be integrated with other information of punctual type obtained via GPS as well as data coming from other data banks, in order to generate products of synthesis that would supply an immediate picture of the state of the territory. In fact, Kawamura et al., (2005) have determined in steppes of Mongolia the breeding intensity for sheep and cows by integrating the data collected through a GPS that was placed on the back of the animals, which monitored the routes and the elaboration of united remote sensing images to the foliage biomass index (NDVI). The authors found that the index is reduced with the increase of the breeding intensity. In the environmental studies and in the control of phenomena that are of interest to the territory, for both the surveillance and the repeated observation, the remote sensing from the satellite has become of growing importance, as it enables the evaluation of potential catastrophic events and as a result the quantification of territorial risk (Hallett et al., 1996a ,b), as well as to control extended areas of contained costs with respect to ground sampling (Giannetti and Gottero, 2003). Giannetti and Gottero (2003) used techniques of remote sensing in order to identify and delineate areas covered by fire. Taking advantage of the ability of the sensors to perceive presence of ash on the ground, the variations of signals emitted from the scars that a fire leaves behind on the vegetation, compared to the spectral signature characteristics of an undisturbed forest.

The possibility of an area being shaped by fire depends on environmental factors (topography of the territory, temperature, precipitation etc), the vegetation cover, and the anthropic activity. Brundu et al., (1995) used the remote sensing images in order to evaluate these parameters and construct a chart which outlined the risk of fire in a woodland area of Sardinia. In the monitoring field of fires, the remote sensing applications contribute to estimation of risk and the quantity and typology of the combustible fuel. Such information is also necessary for the development and the implementation of simulation models (Finney and Ryan, 1995; Chuvieco et al., 2002; Diaz-Delgado and Pons, 2001; Diaz-Delgado et al., 2003).

Another application of the remote sensing is the monitoring of the hydro geological phenomena; the frequency of landslide phenomena represents a remarkable problem for our country seen the considerable damage made to assets not to mention the loss of many human lives. In Italy the hydrogeology risk is widely and it manifests itself in different ways according to the geomorphologic order of the territory (Allegra et al., .2002). For the monitoring in time and so to foresee such events Manunta et al., (2005) within the SLAM project from the remote sensing images, obtained the precise movements of the territory, which were integrated together with morphologic and vegetation data (anomalies in the vegetation cover in regards to the contour, slopes, etc) in order to evaluate and see if in the deformation point, actually existed the vegetative and morphologic conditions for the establishment of a landslide phenomenon. The analysis aimed to delineate the area potentially interested by these movements and their geometry.

On a national level the main applications of the remote sensing applied to the problematic of agriculture, are mainly used for the MIPAF, the AGEA (agency for the distribution in agriculture) and the VI General Directory of the European Commission. It involves applications in which the remote sensing data becomes part of wider and more complex contexts that involves for starters the management of the data through GIS technology (Massari and Giovacchini, 2000).

The ITA Consortium (Italian Consortium for the remote sensing in agriculture) on behalf of the MIPAF has been one the first, on an international level, to develop a methodology, based on integration of the remote sensing data and those acquired in the field, to be able to annually produce estimates of the surfaces and the productions of the main cultivations with a high reliability, supplying data for agricultural statistics, thus overcoming the problems tied to the subjectivity of the answers given by agriculturist, the suspicion, and obsolescence of the data.

The same consortium, through the analysis of the multi-temporal satellite images, controls for every single cadastral particle, the type of cultivation and surface covered by it, allowing to carry out the objective controls needed for certification if, at the end of the PAC contribution made on the surfaces covered for cultivation, the questions presented by the agriculturists are tainted by errors. The applications of the remote sensing for agriculture in our country have found sufficient space for their development and assertion. These applications are no longer questioned because they have demonstrated a high performance in both quality of the supplied products, as well as competing on cost, with those products obtained through traditional processes not always transparent and declared (Benedetti and Ciavatella, 2006).

THE GIS AS AN INSTRUMENT FOR PLANNING

The variability of the phenomena linked to the territory and the speed with which it changes in time, imposes on the administrators and technicians the utilisation of new instruments of analysis, programming and decision making, capable of connecting and integrating different and various information. Under such light, the Territorial Informative Systems, if conceived and structured in an adequate way, represent an indispensable planning instrument of support to the technical and administrative decision makers, therefore enabling a co-ordinated and integrated plan (Cappa and Daini, 1998). At the current moment, GIS systems are widely used in both professional practices and Public Administration services of national, regional, and local scale.

In 1998 the European commission during the apex of Cardiff started the political process of integrating the environmental component in the various political sectors, with the aim of promoting the development of policies that would deal with environmental factors (European Parliament 1999). The Commission therefore presented, several communications concerning the integration of the environmental thematics in sectors like energy, transport, agriculture, internal market, development, industry, fishery and economic politics. In 2001, in occasion of the European council of Gothenburg, the European commission proposed the European strategy for sustainable development (Sustainable Europe for a Better World: To European Union Strategy For Sustainable Development) which recognises the requirement for policies of economic growth not to be different from the policies of social cohesion and protection of the environment (European Council 2001).

On European and national level, the requirement is therefore born to characterise periodic reporting mechanisms which are based on indicators and indices for monitoring the level of integration of the environmental component within the political sectors and to measure the realization of the characterized objectives in the strategies of sustainable development (Net Sinanet, 2008). Consequently, the first agencies of environmental monitoring are born; the APAT (Agency for the Protection of the environment and for Technical Services), the ARPA (Regional Environmental agency) that try to develop environmental informative systems

that are able to collect the data and information necessary to describe and understand the environmental phenomena, in the end bringing support to the government action producing with continuity products and informative services based on indicators and indices. On a national level, the SINANET (National Environmental Informative System) is the instrument of reference for all the territorial informative Systems, relative to the protection of water, the soil, waste management, climate changes etc. The current information in the SINANET can be utilised by the public and local agencies under formats of data banks, maps or digital cartography (Teti, 2004).

Other national monitoring systems implemented to control and manage the natural phenomena are the national geology system (SGN) that has the aim to implement a rational and efficient mean for the conservation, updating, elaboration and the consultation of all the available geologic data for the Italian territory, drawn from fields of remote sensing laboratory analysis, specific researches and bibliographical news (Ventura and Deligios, 2001). The National Seismic informative system has the aim to monitor the seismic events that manifest themselves on all the national territory, of each event the data gets recorded in a database of technical characteristics of the event and digital cartographies are produced. Through these elaboration a vast number of various indictors of different nature, are collected finalised to the quantifiable representation of the seismic risk and in particular of the seismic vulnerability of the national territory (Soddu et al., 1993)

The government of the territory is defined as the whole of the cognitive, evaluative, and regulative activities, of programming, localization and execution of the control implementations and valorisation (Giamo, 1999). This new conception of the government of the territory recognizes the importance of the system with geographic knowledge and the use of GIS software which are instruments that are able to guarantee a constant up to date cognitive representation (Occleppo et al., 2007).

Inside the various regional situations, some analogies in the formation and use of the informative systems emerge. Such systems lose the character of the all inclusive archives in order to assume specific and directional functions, in relation to new functions of co-planning and the giving of grants to local agencies (Teti, 2004). Currently the Sardinian region is on the a vanguard when it comes to the elaboration of regional territorial informative system (S.I.T.R.), which includes a unitary system of federated architecture, based on the sharing of topographical, environmental, urban, landscape and cultural data, geo-referenced from the entire regional territory. The system demands a co-ordinated and shared approach by all the structures of the region and by the system of the local agencies; that absolve collect and manage in a co-ordinated manner and standardized the cartographic and geographic data.

It is a shared instrument because it supplies data and digital cartography through WEB SERVICES. (Regione Autonoma della Sardegna 2008). The customers of such system are: the regional administrators, national governments, local agencies, businesses, professional sectors, and European citizens. The regional S.I.T.R was planned according to the INSPIRE (Infrastructure for Spatial Information in Europe) directive, that came to power on 15 May 2007, which intends to create a common structure that renders the territorial information of the several states compatible and usable in a cross border context, in order to overcome the problems regarding the availability, quality, organization and accessibility of the data (LABSITA, 2007). The system offers various services for the customer :

- *The cartographic Navigator:* it is the instrument that allows the customer to access the cartographic and alphanumeric information, via the typical instruments of the GIS Web; the access is gained by using an elementary series of Web services that have been opportunely assembled. The Navigator can be explored under various modalities: Simple navigator, Technical Navigator, 3D Navigator.
- *Catalogue of the metadata*: it is an instrument that allows to the management and the cataloguing of the cartographic metadata according to the standards of ISO 19115 (international standard for the description of geographic dataset). The customer is also able to perform consultation operations of the metadata.

- *Management System of the toponyms*: it's a service that is implemented on the base of available cartographic documents both current and historical; the toponyms are geo-referenced and, where possible, are also made available in Sardinian language. Operations such as research, localization and interrogation of the data will therefore be possible for customers.
- *Management procedure for the urban council Plans*: allows fundamental operations with regards to the monitoring of the PUC, of which management of the elaborated plan, management of the zoning, mosaic-like integration with other plans, calculation of fundamental the urban parameters, possibility to carry out measurements.
- *Urban and Construction control procedure*: renders possible the collection of the data relative to construction, in the end monitoring the territorial transformations on common base, through "intelligent" cartography operations.
- *Control and Monitoring Procedure of the receptive hotel structures:* illustrates both, the semantic and topologic definition of the entities that represent the receptive structures as well as their geo-reference on the regional technical map; allows spatial analysis operations, and calculation of the main parameters.

The regional government of Sardinia is also putting into effect another a vanguard project the SIT2Com, that means to extend the services and the instruments of the SITR in favour of the council and local entities, so they can be used to their full capacity giving way to a distributed and shared territorial e-governance, which will promote territorial development. The Integration of the council's SIT, with the regional informative system, would have to be the necessary instrument in order to start a procedure that sees the monitoring of the territory, for the sustainability control and verification of the projects, as the main function of the local entity

(Marescotti, 2001). The council's data bank supplies detailed information related to an increasing spectrum of information. This information can be in regards to: the general planning, the existing construction assets, the productive areas, the land registration procedures, the urban planning certifications, to the programs and plans currently in existence.

These instruments allow whomever is subject to the planning of the territory to have instruments for the individuation of the priorities within the formulation of alternative solutions and in the appraisal of the technical-economic convenience of managerial choices, and therefore to define a support system to the decisions. (Ciancarella et al., 1998). In a survey published by the Mondo Gis in (Biallo et al., 2001) nearly 60% of the 139 Italian councils with more than 50 thousand inhabitants already used the territorial informative systems. Today, councils of medium-small dimensions are also equipping themselves of such systems, persuaded by the legislative act of 27 December 2006, n. 296. for the decentralization of the councils' land registry. The more common applications are oriented towards the management of the urban plan and urban licensing.

GIS APPLICATION IN AGRICULTURE

The agriculture concept is a complex concept that exceeds the meaning of pure and simple food production. In fact, during the entire production process they launch phenomena that have repercussions on the environment and the territory. The phenomenon of soil degradation, such as desertification, erosion, the diminishing of organic matter from the soil, the contamination from heavy metals, the diminishing of biodiversity and the salinisation of the soil, are all degradation processes that can take place as a result of inadequate agricultural practices (Zalidis et al., 2002).

The environmental problems embodied a fundamental role in the Common Agricultural Policy (PAC), that steers more and more towards the risk prevention of environmental degradation, while at the same time encouraging the farmers to continue to carry out a positive role in the safeguard of the landscape and environment thanks to the development of rural measures, all contributing to the guarantee of profit from agriculture (Povellato et al., 2001). The PAC aims to

a correct equilibrium between a competitive agricultural production and the respect for nature and the environment. The multifunctionality of agriculture, seen as the valorisation of an agriculture geared towards not only to the production of general food commodities, but distributor of services to the community: management of the territory, conservation and fruition from the citizens of the landscape, food safety regulations, environmental sustainability, has been for years on a European level the key word, and is now recognised by many regulations and normative on a national and local level (Kleijn and Sutherland., 2003)

The environmental integration policy in the PAC stands within a vast process designed to face environmental problems on a local, regional, national and even global scale. Such problems regard climate change, the pollution from nitrates and pesticides, the safeguard of the soil, the management of water resources and the conservation of biodiversity. In order to face and manage such problems, the European Union underlined the importance of elaborating environmental indicators (European Council of Cardiff and Vienna 1998), able to transform the physical and economic data on the human activities and environmental conditions into useful information for the decision-makers. With the aid of the these environmental indicators, it's easier to both understand the complex agricultural and environmental thematic as well as to follow the developments in time and to obtain quantitative information. (Communication of the commission of European Communities 2000).

The GIS instruments are a valid instrument for the management and identification of such indices; in fact, they allow combining maps and information deriving from various sources, even from a satellite, so as to simulate the interactions between

complex systems. The use of such instruments allows the union of all the information available on a territory, relating them and using the final information as precise, comparable and descriptive indices of extreme usefulness for a correct and sustainable management of the territory (Rossi, 2005). In fact Kosmass et al., (1999) in order to estimate the risk of desertification of some areas of the Mediterranean basin, put into effect the Environmental Sensitive Areas, (ESAS). Such methodology is founded on the integration of a series of indicators, relative to four triggering factors: climate, vegetation, morpho-pedologic and socio-economic, to which gets attributed and indices value, the determination of these, requires a specific informative layer so as to be able to carry out a precise overlay operation necessary for the calculation of the final ESAI index. (Environmentally Sensitive Index Area)

Another indicator of a non sustainable territory and of the carrying out of inadequate agricultural practices is the salinisation of soil index. Such phenomenon consists in the accumulation of soluble salts within the soil following irrigation with non suitable water, abuse of mineral fertilisers, excessive welling from the stratums etc. Such processes are the reason for, the reduction of biodiversity, the poor development of cultivations, the diminishing of the fertility in the soil and the decrease of crop productions (Arringhieri, 1999). Puddu et al., (2008) in order to quantify the entity of the phenomenon and the intensity of the manifestation in the more important agricultural areas, archived, in a data bank functional for the informative system, the data of 2300 samplings which were separated through geostatistic techniques thus elaborating the chart for the distribution of soils at different degrees of salinity of Sardinia.

Moreover, in order to establish the location of the areas where the phenomenon shows greater probabilities of manifesting itself, a model based on GIS was implemented. Such model is based on the construction of five indices (climatic, morphology, hydro-geology, pedology and management) which influence the salinisation phenomenon both as a predisposing factor of the accumulation processes of salts within the soil, and as an inhibition factor. Every index constitutes an informative system layer that taking advantage of the abilities of GIS software to carry out spatial calculations of multiple nature (map algebra), become factors of a multipliable algorithm that in output generates the chart derived from the theoretic risk of salinisation. The various degree of salinisation risk is subdivided in five levels of risk, very low, low, medium, high, very high, to which is combined the evaluation of the interventions which are considered priority in order to guarantee the conservation of the soils.

The use of GIS informatics systems which are suitable instruments for the recording, integration elaboration and presentation of geographically identified data (geo-referenced) is suggested by D. lgs 152/99. Such act disciplines the identification of zones at high risk of vulnerability to nitrates of agricultural origin, and regulates the agronomic use of the zoothecnical effluents, placing maximum limits to the nitrogen quantity usable in the filed. The regione Autonoma della Sardegna and others Italian Regional governments acknowledge such law putting into effect a series of interventions to monitor and manage the phenomenon.

Sacco et al., (2005) put into effect a monitoring system for the designation of vulnerable areas in Piedmont and commenced planning activities to reduce the existing pressures on the territory. The authors geo-referenced the companies, to each they attributed the use of the lands, the species bred, the relative stocking rates, surfaces proposed for expansion, and they connected the businesses' data, with the kg of nitrogen produced by livestock per hectare of surface used for the distribution in the field. They classified the companies in excess and not of nitrogen of livestock production origin with regards to the requirements of the present cultivations. The informative system thus constructed has allowed to estimate the reality of the study area and to identify the distribution possibilities of the exceeding waste between the deficit zootechnical companies, but also between the near by agricultural companies, finding a solution to the problem and valorising the use of nutrients with a livestock production origins a substitute to nitrogen filed fertilizers bought on the market.

The concept of sustainable agriculture recognizes the factors of the soil water production as entities to safeguard and assets of short consumption. In the European Union the use of water for agricultural purposes constitutes approximately 30% of the total usage, in the majority of southern European countries such percentage reaches above 60%. If on the one hand irrigation allows for improvement of productivity of the cultivations and the reduction of the associated risks with periods of drought, on the other it represents a problematic source in relation to the environment. On the exaggerated use of water we also need to add the effects that come from the utilisation of phytosanitary products, whose usage is diffused in order to fight parasites and reduce weed plants, thus improving the yield and guaranteeing the quality of the product.

In Italy the consumption of fertilizers was of approximately 5 million tons in 1950, it exceeded 20 million tons in the 70's and 80's and has currently fallen to 16 million tons (Official Journal of European communities 1999). The excessive extraction of water from the underground water-bearing stratums, the phenomenon of erosion provoked by irrigation, the salinisation of the soil, the alteration of pre-existing semi natural habitats and the pollution of the water and soil, are the direct consequence of the intensification of agricultural production rendered possible by irrigation and the use of phytosanitary products (Bragachini et al., 2000).

A change to this type of problematic has been given by the spread of precision agriculture, that consists in the agronomic management of the field according to variations, in space and time, of the pedoclimatic characteristics and in the requirements of the cultivated species (Stafford, 2000). It is many times said in literature that precision agriculture over a long period can contribute to generate a sustainable agriculture, reducing the amount of pollution on the environment, since fertilizers and pesticides are only applied where and when there is an effective necessity (Bongiovanni and Lowenberg-De Boer., 2001); with an increase in the efficiency use of the nourishing elements, a greater protection of the soil from the degradation phenomena such as erosion (Pierce et al., 1999).

The success of precision agriculture is based on the study of spatial variability of the soils, also on short distances, small relative differences in the substrate, of topography and vegetation, significantly influence the variability of the pedological cover and the properties of the soil change from one point to another (Beckett and Webster., 1971). The esteem of such variability is carried out though the use of GPS, Remote sensing imagery, software GIS, and “on-the-fly” date collection devices as well as variable-instalment implements (Robotics).

Mid-range GPS receivers can easily establish positions within a field within a meter. When connected to a data collection device, such as a yield/moisture meter, this data can be "stamped" with geographic coordinates. Several portable "feet-down digitizing" devices enable farmers to sketch conditions, such as weed infestations, on a digital map or aerial photo backdrop while standing in a field. Downloading GIS data to mobile mapping devices lets a farmer see maps that summarize complex conditions and relationships throughout a field.

These technologies can also be used to extend yield visualization and to analyze relationships among yield variability and field conditions. Once established, these relationships produce a "prescription" map of management actions required for each location in a field—often every few feet or so. The final element, variable-rate implements, automatically detects a tractor's position through GPS, and continuously displays it on the prescription map, and then varies the

application rate of field inputs, such as fertilizer blend or seed spacing, according to precise instructions for each location. Combining technologies such as GPS, GIS and intelligent devices and implements provides the mechanism to manage field variability. The maturation and commercialization of these technologies has not only made the concept possible, but increasingly practical. In early applications, most of the analysis involved visual interpretations of yield maps. By viewing a map, potential relationships between yield variability and field conditions spring to mind. These "visceral visions" and explanations can be drawn through the viewer's
knowledge of the field. More recently, data visualization is being extended through map analysis at three levels: cognitive, analysis and synthesis.

Clark and McGucken., (1996) define the GIS like the brain of a precision agricultural system.

GIS APPLICATIONS IN LIVESTOCK SYSTEM

The zootecnical sector represents one of the main agricultural activities in the towns that overlook the Mediterranean, with a consistency of approximately 2.4.million Livestock Units. A great number of the bred animals belong to the main ruminant- bovine, ovine and goat species, that mainly feed on natural forage resources that they acquire directly while grazing.

Extensive livestock systems are primarily dependent on pastoral resources and grazing farm animals, which can have a great impact on the vegetation

(Perevolotsky and Etienne, 1999) not only in terms of productivity and quality but also in terms of vegetation dynamics (Roock and Tallowin, 2003), species and community diversity (Collins et al., 1998; Sternberg et al.,2000) and landscape (Hartnett et al., 1996; Adler et al., 2001), where heterogeneous vegetation created a particularly rich mosaic landscape (Balent and Gibbon 1996).

Perez (2002); Kramer et al., (2003) have recognized the importance of the role represented by extensive grazing in the safeguard of protected natural areas, and in the prevention of fires. In many parts of Europe, extensive pastoral farming systems in semi-natural habitats are of major importance in terms of biodiversity conservation, the abandonment of the traditional grazing systems provoking the gradual disappearance of such biotopes in favour of vegetation groups which are predominated by arboreal and shrubby species.

The application of new information-based technologies may prove very useful for the appropriate management of natural resources and in improving the economic efficiency and sustainability of animals. In the last few years, computerized geographical information systems and global positioning systems have rapidly become operational tools in nature resource management, providing methods for assessing natural resources, quality–quantity, determining forage land utilization, and identifying / assessing environmental risks (Ferrer et al., 1995).

Infact, Bernués et al., (2005) took over GIS systems in order to indentify the role of grazing livestock systems in the conservation of rangelands in a protected natural park. Together with the questionnaire, farmers were asked to mark on a map the areas where livestock actually grazed. The information was digitalized into a Geographic Information System, and stocking rates were then calculated. Other digital maps were available which contained physical information (altitude, slope, geology, hydrology), pasture types and structural variables (distances to infrastructures and villages).

The GIS consisted of several layers of geo-referenced data which, once combined, allowed for the creation of new indexes. Relationships between actual stocking ratess and physical variables mentioned above allowed the deduction of a Potential Grazing Index that was used to compare actual and potential utilization of grazing resources in the Park. Finally, after combining the information of actual and potential use in the Park, a new map was obtained, where 3 intervention areas with good potential but currently not grazed, could be identified.

A similar approach in determining new areas for animal grazing in Mongolia has been used by Rasmussen et al, (1998). The method used by the authors is based on the comparison between the availability of the forage resources and the amount necessary in order to satisfy the requirements of the animals that find themselves in the area. Ronchi et al., (2002) instead used the Spatial Information System technologies in order to estimate the critical points of small ruminant livestock systems and to highlight the contribution that an organic farm can give to such systems.

The authors analysed six factors that shape the traditional breeding systems: stocking rates, percentage of annual land rented, percentage of seasonal land rented, annual hay availability and number of farm sectors from farm centre, and they correlated them with the vulnerability of forage system management. Analysis results and observations suggest some critical points on the structural characteristic of small ruminant livestock systems in the Mediterranean area: small size of farm land, high incidence of rent land, and farm fragmentation. These structural elements represent a great limiting factor for the development of organic farming.

Food availability is identified as one of the major constraints for small ruminant systems in the Mediterranean area. In many areas pasture growth is limited by irregular distribution of rainfall during and between the years, coupled with high temperatures during summer and high potential rates of evapotranspiration (Nardone, 2000).

The problem of seasonality pasture production is responsible for nutritional constraints on extensive small ruminant livestock systems and obviously in all grazing herbivores (Molle et al., 1994). A rational strategy of conservation and management of the pasture ecosystem can be based on the use productivity prediction models. Infact, Zhang et al, (2004) integrated inside GIS software a productivity prediction model of the pasture, based on the decision tree logic that accounts for topographical variables, variables of the soil and management. The decision tree models were developed for annual and seasonal pasture productivity (aboveground dry matter in kg/ha).

Using GIS in this predictive modeling approach facilitated the derivation of topographical variables and visualized model outputs for interpretation and analysis. This GIS-based predictive modeling approach can be used to investigate the response of pasture productivity to environmental changes and to improve pasture management.

GIS have been widely used in environmental modeling. Geographical information systems (GIS) have been widely used in environmental modeling (e.g., Johnston, 1990; Antoni, 1998; Wadsworth and Reweek, 1999; Dominy and Duncan, 2001), and have been increasingly used in predictive modeling of vegetation properties such as species distribution and abundance (e.g., Franklin,1995; Iverson et al., 1997; Johnston, 1998; Guisan and Zimmermann, 2000; Stocks and Wise, 2000) and community productivity (e.g., Iverson et al., 1998; Li et al., 1998; Tan and Shibasaki, 2003), showing its strong ability in analyzing spatial factors, and facilitating prediction over space. Linking a model that has a high predictive ability with a GIS, provides the ability to predict productivity for pastures with heterogeneous distribution of both environmental and management factors. The common way of using GIS in environmental modeling is to prepare input data and then visualize the model prediction (Johnston, 1998; Stocks and Wise, 2000).

The GIS which are integrated inside mathematical models are also utilised to solve the problems generated by the intensive breeding of animals.

If on the one hand, intensive breeding are concentrated production facilities that have economic advantage by managing large numbers of animals in a confined area, on the other hand it had the disadvantage of producing a high number waste materials such as waste-water, feedlot runoff, silage juices, and wasted food (Hammond, 1994).

This waste has historically been a major source of plant nutrients in traditional agricultural systems world wide. Although chemical, biological, and engineering methods of waste are available (e.g., composting, biogas generation and processing for re-feeding), application as manure to cropland remains the most common and often least expensive method of animal waste utilization (He and Shi, 1998). Fertilizing agricultural fields with animal manure recycles the nutrients (Couillard and Li, 1993), supports crop production (Hammond, 1994), and enhances the physical and chemical properties of the soil (He and Shi 1998). However, inappropriate storage, disposal, and/or use of animal waste can result in runoff of nutrients, pathogens and oxygen demanding substances that can create major environmental problems (Camberato et al.,1990). Continuous application of animal waste has been found to result in soil nutrient buildup (Liu et al.,1998), increased nutrient runoff (Davies et al., 1997), and water quality deterioration (Mostaghimi et al.,1992) due to increases in nitrogen, phosphorus and algal production (Couillard and Li, 1993).

Basnet et al., (2001) used the raster GIS based weighted linear combination (WLC) model that has been used to identify, rank, and cultivated map agricultural areas potentially suitable for animals' waste application in Queensland. In the WLC model, the input factors are selected, constrained (i.e., unsuitable areas blacked out), standardized (i.e., factor attributes classified and ranked), and weighted (i.e., assigned weights to the factor) before The use of GIS software has been indispensable in order to indentify, elaborate, digitize and to rasterise the input factors thus making it available for the elaboration of the model.

Geographic information systems and remote sensing technologies are increasingly being used to study the spatial and temporal patterns of disease (Brooker and Michael, 2000). GIS can be used to complement conventional ecological monitoring and modeling techniques, and provide a means of portraying complex relationships in the ecology of disease (Yilma and Malone, 1998).

In addition, the use of GIS and RS to identify environmental features allows determination of risk factors and delimitation of areas at risk, permitting more rational allocation of resources for cost-effective control (Beck et al., 2000).

In fact Cringoli et al., (2004) have used remote sensing and GIS to identify environmental features that influence the distribution of paramphistomosis in sheep. The environmental data obtained from GIS and RS and from data taken by the veterinarians on the field (stocking rates and presence of streams, springs and brooks on pasture) were analyzed by statistical analysis. The authors found another correlation between the farms that resulted positive to the parasite and the presence of forests, shrubs, altitude between 500-1000 asl and with a slope greater than 15%. In addition, higher values of autumn-winter and summer NDVI were correlated with “positive” farms , indicating the importance of the presence of vegetation during the whole year for the rumen fluke and its intermediate host. The same methodological approach has been utilised by other authors to identify the environmental characteristics and the evaluation of risk factors that influence the distribution of Neourospora Caninum in semi-wild bovines (Barling et al., 2000, Rinaldi et al., 2005).

FUTURE OF THE GIS

The U.S.A. Department of Labour designated Geo-technology as one of the three “mega-technologies “of the 21st century together with the nanotechnologies and the biotechnologies. This great consideration surges from the fact that the GIS concept is in continuous development and evolution, thanks to the growing availability of faster computers, less expensive software, and the new analytical functions that allow to have easy access customer interfaces. In fact, web sites that make available to customers numerous informative layers giving the possibility to manage and arrange them between each other, are growing in numerous numbers.

Data exchange and interoperability standards are taking over in extending this flexibility to multiple nodes on the web, with some data from here, analytic tools from there and display capabilities from over there. The results are high-level applications that speak in a user's idiom (not GIS-speak) and hide the complexity of data manipulation and obscure command sequences. In this new environment, the user focuses on the spatial logic of a solution and is hardly aware that GIS is even involved.

A tendency that could favour the spread also on a local level of the GIS is the development of virtual GIS (VGIS, Virtual GIS), simplified customer interfaces that allow also non qualified staff to manage the functions of analysis used in complex GIS systems. (Lin et al, 2008), Also in small technical offices in this way would become possible, not only the consultation but also the analysis of the data, leaving to specialised customers the more complex operations.

Up until now the GIS systems have been used in order to analyze and describe existing situations within the examined territory, in future the GIS systems will be used to simulate human interventions, foresee unexpected events and their impact; not only answering questions on the what and where but also when. The factor of time is in fact the fourth dimension of the geographic data. (Gomarasca 2004).

Finally, another sector in expansion is the integration of GIS with decision support systems; in this case the geographic informative system would not only be used to analyze the data and to simulate the answers of the environment to specific human intervention, but also to choose, within of a set of alternatives, the optimal solution to the problem. Some functions are already present in various GIS software and in some cases they get developed in order to satisfy the specific requirements of the customer.

The evolution of GIS in decision support systems favours the operation cycle that from an observer of the real world brings to action the planning of appropriate interventions on the territory, allowing the decisional processes to become transparent, .(Balram et al., 2008).

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Chapter 3

Designing and implementing a system with the model EISR on a regional scale.

OBJECTIVES

The contribution of this thesis aims to implement into a GIS, the environmental impact of the (EISR) stocking rates model (Pulina et. al., 1998) throughout the territory of Sardinia with detail of 1: 50000, in order to evaluate areas of Sardinia that are at risk of desertification following the activities of animal breeding. The amendments to this process for the decade 1995 - 2005, have also been assessed.

INTRODUCTION

The breeding of ruminants is the principle agricultural activity of the Mediterranean countries. Most of these are raised under a system which involves the direct use of natural or cultivated forage through grazing. The practice of animal husbandry is considered by many authors to be the most important cause of desertification in regions with dry climates (Harrigon 1981; Margaris and Grove 1993; Sheey, 1992). This is particularly evident in certain areas of the Mediterranean (e.g., Crete, North Africa), which have been overgrazed for centuries and where fire has been used to clear pastures. These two factors have resulted in great reductions of fertility levels within the soil, possibly leading to a complete sterilization in vast regions, (Novikoff, 1993., Margaris and Grove, 1993). The spread of agro pastoral activities in most Mediterranean countries and the increased grazing pressure have all been part of are also related to past European Union (Eu) policies, which have favored the uncontrolled development of modern agricultural practices.

These policies provided a system of guaranteed prices and subsidies for farmers, not to engage in the production of meat and wheat which resulted in the cultivation of marginal areas. In addition, the Common Agricultural Policy (CAP) led to a steep rise in productivity levels by encouraging mechanization. As several studies have shown, this production –orientated model, protected farmers against the economic consequences of environmental degradation and also removed their responsibility towards environmental management (Buller, 1992).

Fortunately, since the beginning of 1992, all State Members of the EU have focused their attention on a new concept for environmental sustainability, as laid out by the Treaty of Maastricht. The EU's main concerns are centered on the rural environment, land abandonment and its consequential degradation, as well as their involvement in supporting environmentally friendly practices.

Grazing as complex system, the various cognitive approaches to ecosystems involving domestic grazing are always guided by the a dominant category of complexity. Scientists dealing with agropastoralism and with quantitative analysis of grazing systems usually present it using the word "complex".The concept of complexity of grazing systems as cited in different papers: Kristensen and Sorensen, (1989) have described animal production from grassland like a complex process involving man as well as both animals and plants all interacting in a changing environment. Systems which are based on many input factors, become complex for the manager who is continuously monitoring the production and using this information to allocate inputs. Jones et al., (1995) have shown the complex nature of the grazing system which requires many integrated models; these include animal live weight change, diet selection, soil fertility, nutrient cycles, pasture growth, persistence of the same pasture, pests or diseases, pasture composition, as well as economics. may all be required to describe the system accurately. Dove, (1996) has shown that the pasture animal interface involves interactions between an animal's needs, its capacity to use nutrients, the amount of pasture available, the nutritive value of that pasture and the influence of the management system on the animals' ability to harvest the nutrients. With so many inter-reacting processes involved, an interest in modeling grazing systems is not only justified, but could also represents the only way to accommodate the complexity of the system, especially if the ultimate aim is better extension advice (Fig 1).

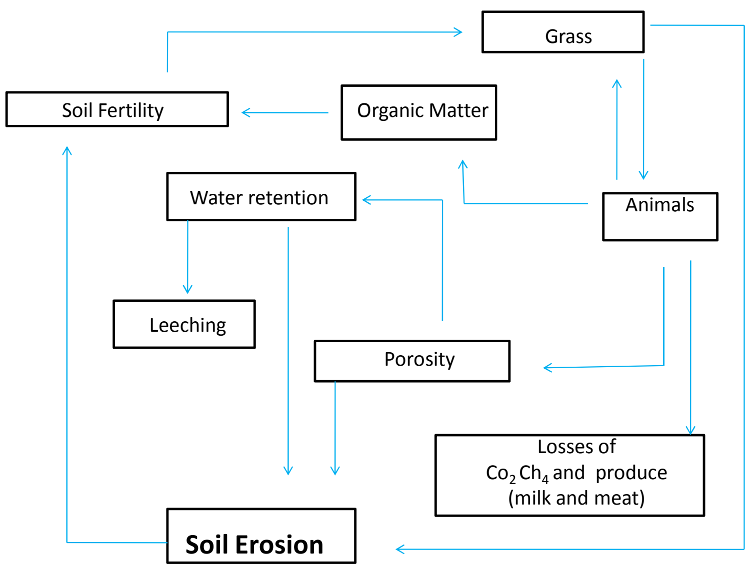


Fig 1. Grazing as a complex system (adapted by Pulina et al., 1995)

Mathematical models have been devised to aid the understanding of the complex interactions between the diverse components that make up the soil –animal-plant interaction system (Doucet and Sloep, 1992).

The common belief is that grazing is always detrimental to vegetation. This is a result of the common mistake made between grazing and overgrazing, with only the latter being destructive to plants and soil.

Rational management should encourage certain positive influences of grazing on vegetation and soil resources. Indeed, grazing delays maturation of the vegetation (Vallentine, 1990), keeping plants in a vegetative forage production state and stimulating growth by its pruning effect. This maintains the optimum Leaf Area Index thus improving the nutritive value of available forage, and reducing excessive accumulation of standing dead mulch. As a result, the vegetation biomass decreases, which if allowed to build up, would provide the undergrowth that favors fires and their propagation during hot and dry periods of summer. On the other hand, various other common agro pastoral activities can have negative effects. Soil is easily compacted due to the trampling by livestock and overgrazing or plowing could also render the soil bare (Pulina et al., 1995a). When fire is used to clear land for pasture, thus destroying vegetation, valuable organic matter is lost from the soil. Compacting depends on the behavior of the animals: their tendency to walk, run, or jump, to graze in groups and the presence of gathering points such as the shade of the trees where the sheep can rest during the summer, drinking places and so forth. It is the result of not only the stoking rate, but also of the specific pressure of the hooves per square centimeter; for instance, a calculation based on hoof area and body weight of various animals has estimated an average pressure per unit area of 0.47 kg cm^{-2} for sheep, 0.98 kg cm^{-2} for cattle, and 1.01 kg cm^{-2} for donkeys (Pulina et al., 1995a).

Compacting creates a reduction in the porosity of the soil which reduces its water filtration capacity. In sloping terrain, it increases surface erosion, while in flat terrain it increases the tendency to hydromorphis or stagnation. The destruction of the surface structure is caused by the penetration of the hooves of the animals in damp soil. Other factors that may accentuate damage to soil properties include the allowing of grazing in the wet winter months, high stocking ratess at any time, or the preponderance of cattle rather than lighter animals.

The creation of terracing on sloping terrain, and of trails on flatter terrain, is a result of the routes chosen by animals while grazing and being transferred from one pasture to another. Trails, which become areas of bare soil, are created in direct proportion to stocking rates while in an inverse proportion to the availability of forage.

At times, these trails may become a high proportion of the total pasture area, especially at waiting points near gates or high movement areas such as near drinking places.

These areas may suffer from significant wind erosion during the dry season.

Overgrazing may remove part of the vegetation cover which in turn, causes both an increase in raindrop impact and surface soil crusting, as well as a decrease in organic soil matter, aggregate stability, and water infiltration rates (Blackburn, 1983, 1984).

Organic matter in the soil is an important component of its fertility and is essential for the maintenance of good soil structure, which can counteract the erosive action of water and wind. The removal of organic matter by animals is due to an imbalance between the amount of dry matter they consume and the dry matter that returns to the soil in the form of feces and urine (Pulina et al., 1995b).

It is not easy to estimate the quantity of organic matter actually returned and incorporated into the soil by animals. Organic matter restitution is efficient only during the wet season when faeces are easily integrated back in to the soil. At this time the soil is soft due to the animals' consumption of fresh grass with a high moisture content. On the other hand, in the dry season, the faeces result much drier. This occurs for two main reasons, the first is that the animals mainly feed on dry stubble and the second is that they possess an internal body defense mechanism that prevents them from wasting any water. Dry faeces can remain on the soil surface for months and are likely to be completely oxidized.

Grazing involves biting, pulling and breaking off plant parts, which can cause defoliation or the complete extraction of the plants if they are not well rooted. Furthermore the trampling and treading of the vegetation may damage the stand. Seed dispersal either internally through the animal digestive system, or externally by temporary attachment to animal hair, fleece or hooves, is an ecological factor affecting a perennial forage stand. The impact will range from favorable to unfavorable, depending upon the plant species and the site being affected (Vallentine, 1990). The covering of some parts of the vegetation with faeces and urine is another effect of grazing. Manure spots are generally avoided by animals visiting soon after, even though the nutritive quality of the affected forage (particularly rich in nitrogen) may be better than that on the adjacent ground. Rejection is presumably on grounds of palatability based on either smell or taste, and perhaps designed to avoid recycling internal parasites (Van Soest, 1994).

Measurement of the leaf area index (LAI), is a very useful indicator of how forage responds to grazing. Under grazing allows overgrowth and shading by senescent foliage, which reduces photosynthesis and increases respiration. Optimum grazing pressure improves the effective LAI, whereas higher pressures, which result in excessive defoliation and consequently a decrease in forage yield, diminish it (Van Soest, 1994). The thinning out of grass species is a consequence of either the selective feeding action of the animals, or of the exposure of roots to the cutting edge of the hooves. This, together with the reduction in leaf area per plant caused by grazing, can have a strong impact on the final LAI and the quality of forage.

The optimum rational grazing management strategy should allow for the maximum level of defoliation which could still maintain a sustainable forage production and animal response. When using a proper stocking rates, the definition of the optimum moment for grazing, the optimum frequency and duration of grazing, as well as the intensity of defoliation, by using a proper stocking rates, are all of great importance (Brandano and Rossi, 1975).

In comparison with uncultivated areas, the breeding of livestock can maintain a high level of biodiversity (i.e., environmental fertility in a broad sense), however only if it is conducted using rational criteria and respect for the resources available in the area (Savory, 1992).

This productive system is used extensively in the Mediterranean basin, in particular for small ruminants with the occasional use for cattle. There are about 100 million grazers in livestock units (LSUs) (Pulina et al., 1997).

Sardinia is one of the Italian regions where the anthropogenic pressure for the agro-pastoral activities with widespread phenomena degradation, is more evident (Rivoira et al., 1997).

The recent data shows that, on a regional territory extended about 2.408.000 ha, 80% is comprised of agricultural areas where the zoo-technical heritage is about 762.800 LSU, 56% in particular is comprised of sheep (D’Angelo et al., 2000).

Today, about 85% of Sardinian land is used for agriculture (ISTAT 1976, 1982, 1992, 2007), livestock farming is one of the main economic activities.

There are 651506 LSU of herbivores, of which 50% are dairy sheep (table 1).

Tab 1. Grassland, livestock and stocking rates evolution (1976-2000)

Year	Agricultural land (ha)	Grassland (ha)	Livestock consistency (LSU) [a]			
			Cattle	Sheep	Goats	Total
1971	2159245	1613279	273050	215323	25070	513443
1981	2047811	1497503	287798	226714	22463	536875
1991	2050731	1539224	286840	313129	22867	622835
2000	2302066	1112921	268922	359971	22613	651506

[a] : LSU = 450 Kg live weight (1 cattle;10 sheep; 10 goats).

It's necessary to be aware of some territorial instruments in order to manage and reduce the impact of human activities on the environment, and to use it in the planning and in the management of the areas at risk of degradation (Lopez-Bermudez,1997).

Amongst the models that can be used within this context, the Land model, suitability evaluated by Fao (WFO) (1976,1984,1985,1991) for the land classification, is able to be used in both the extensive and semi-extensive breeding systems that are integrated with the Environmental Impact Stocking rates (EISR) model. The EISR is an informatics territorial system (D'Angelo et al., 2000; Zucca et al.,1998 ;Pulina et al.,1999); it seems to be the reference model more suitable for an operations plan and mitigation on a wide area, under the climate in both arid and semi-arid conditions.

The model EISR

The central problem in the assessment of the impact of pastoral activities on a territory is linked to the determination of the stocking rates either already maintained or possibly maintainable.

This parameter is usually measured in Livestock Units (LSUs) per unit area (ha, km^2). This is the standard unit of 500 kg of body weight and is roughly equivalent to 1 cow, 1 horse, 10 sheep or 10 goats. For our purposes it is not appropriate as it does not take into account the individual characteristics and behavior of the animals, nor the activities linked to agropastoralism. It does not take into account the following:

- the direct effects of the different species that constitute the LSU. Each species has its own grazing behavior with a consequently different impact on the soil (compaction) and on the vegetation (sheep prefer grass, whereas goats and cattle graze also on shrubs);
- the indirect effects. The farmers need to increase grasslands to meet feeding requirements of animals. They do this either by cultivation or by using fire to clear pastures;
- the productive level and function of animals. Mediterranean sheep and goats which are primarily used for milk, have a far higher and more

precise distributed feed requirements than sheep used for meat or wool. Thus high productivity at equal body weight, can only be obtained through high quality of forage supplements;

- farm facilities, such as the presence of roads or drinking sites, that make it possible to maintain stocking rates that exceed pasture availability.

An indicator of stocking rates, able to take into account all factors influencing the impact of grazers on soil and on the land degradation and desertification processes, is therefore needed.

This indicator which is able to meet the abovementioned requirements is the one we call Environmental Impact Stocking rates (EISR); it is expressed in Animal Units of Environmental Impact (1 AUEI = 500 kg live weight), and calculated as follows:

$$\mathbf{EISR = (b_1X_1N_{1+}\ b_2X_2N_{2+} \ldots b_n\ X_nN_n)/S * 1/500}$$

in which:

$\mathbf{b_1}$ the weighing factor of the body weight. The coefficient b is composed from b_a, b_b, b_c, b_d where:

- b_a, takes into account compaction on soil
- b_b , takes into account impact on vegetation which is greater for goats, compared to that of cattle and sheep
- b_c animal production level

- b_d farm management (grazing system, cultivation pasture etc).

These sub-coefficients estimated for extensive marginal area within Sardinia are reported in table 2:

Tab 2. Values sub-coefficient for different grazing species

Species	b_a	b_b	$b_{c\ (production\ level)}$	$b_{d(farming\ systems)}$
Cattle	0.6	0.4	0 local breeds	0 Extensive
			0.2 Crosses	0.2 Semi-extensive
Sheep	0.3	0.3	0.2 low	0.2 Extensive
			0.4 medium	0.6 Semi-extensive
			0.6 High	
Goats	0.2	0.6	0.2 low	0.2 Extensive
			0.4 medium	0.6 Semi-extensive
			0.6 High	

X_1 is the body weight of Mature Animal Unit (MAU) belonging to species n (1 MAU = adult female + part of replacement +part of the male unit).

In the Tab 3 there is the calculation of MAU

Tab.3 Shows the criterion for the calculation MAU expressed in kg.

	Sheep	Replacement	Ram	Mature Unit
Body weight	42	25	65	
Coefficient	1.00	0.20	0.025	
Value	42	5	1.6	48.6

N_1 the number of MAU over a given area with surface S (expressed in hectares).

A practical example will clarify the misuse of EISR:

On an area of 5000 ha of grazing land, 400 cattle crosses are bred on semi-extensive farms, 6000 sheep with high-level production are bred on extensive farms and 2000 goats with a medium production level are also bred on extensive farms (Tab.4).

Tab 4: Example the calculation

Species	N	X	b_a	b_b	b_c	b_d	EISR
Cattle	400	550	0.6	0.4	0.2	0.2	
Sheep	6000	45	0.3	0.3	0.6	0.2	
Goat	2000	50	0.2	0.6	0.4	0	
AUEI/ha							0.3048

The following example is very simple, but in actual practice things are more complicated as question cases must be used to calculate matrix.

The general in matrix farm equation of EISR becomes:

EISR= (X B b) /S

where:

- X is a row vector (1, k) in which the values show the number of adult units present for the different species in each piece of land.
- B is the (K, 20) incidence matrix, of 20 b- sub coefficients related to the k units of information.
- b is the (20,1) column vector of the b sub-coefficients
- S is the surface area.

The use of the EISR template on a territorial scale requires that the actual calculated load is compared with the sustainable one from the territory on which the load itself has an impact on. In General, it could be said that the sustainable load must be estimated by assessing the aptitude of soils in order to support the presence of the grazing animals.

The conceptual and methodological reference more widely accepted for this type of assessment is based, as said, on land suitability evaluation presented in the framework for land evaluation of the FAO (1976) (Tab 5).

In Sardinia this methodology has been acknowledge and applied to the specific issues of extensive grazing systems and semi - extensive (Madrau et al, 1998).

Tab.5 Land classification of Fao

Class S1 Highly Suitable:	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.
Class S2 Moderately Suitable:	Land having limitations which in aggregation are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on Class S1 land.
Class S3 Marginally Suitable:	Land having limitations which in aggregation are severe for sustained application of a given use and will therefore either reduce productivity or benefits, or increase required inputs, that this expenditure will only be marginally justified.
Class N1 Currently Not Suitable:	Land having limitations which may be surmountable in time, however cannot be corrected with existing knowledge at the currently acceptable cost; the limitations are so severe as to preclude a successful sustainable use of the land in the given manner.
Class N2 Permanently Not Suitable:	Land having limitations which appear so severe as to preclude any possibilities of a successful sustainable use of the land in the given manner.

The EISR sustainability is calculated for comparison between the classes of soil identified by FAO and the load number of AUEI/ ha(Tab.6).

Tab.6 Scheme of the sustainable stocking rates by classes of land suitability for the creation of new pastures.

Suitability class		Stocking rates (AUEI/ha)
Permanently not suitable	(N2)	0-0.1
Currently not suitable	(N1)	0.1-0.2
Marginally suitable	(S3)	0.2-0.4
Moderately suitable	(S2)	0.4-0.5
Highly suitable	(S1)	> 0.5

MATERIAL AND METHODS

The sustainability of a grazing territory is defined through the relationship between the current EISR and the sustainable EISR.

Calculation of the current EISR

The calculation of the current EISR was done by utilizing software by the same name, Microsoft Excel file 90 KB.

This calculation can be made for a dataset with numerous K (where k is the total number of information rows relative to a single species and to the information unit available, that is the farm) with the use of the following relation expressed in a matrix form:

EISR current = (X B b)/S

The input data necessary to the model in order to make the calculation of the current EISR is listed in the following table (Tab7).

Tab.7 Input necessary for the calculation of the current EISR

Data input	Encoding
Stocking of cattle, sheep, goats.	Numeric values
Corporate management for single species	Intensive, semi-extensive, copyists
Production level of livestock	Medium, high, low
Location of farm	X,Ycoordinates
Surface area of thefarm	Hectares

The main problem found with the calculation of the current EISR was the inability to find the input data required for the proper functioning of the model, that is: the geo-referencing of the farm, the consistency of the farms, the type and productive division of the different species reared.

In order to solve the problem, the AGEA database has been used with the farm code, the breeding species, the consistency and the production division.

The AGEA data, divided by farm, location and breeding species, are related to the spatial map data and the council's administrative limits. In this manner, a shapefile (SHP), has been created with information like the identification codes of the cattle farms, the direction of the production, the productivity level of the animals subdivide within the mapped area.

To avoid, multiple listings of data related to the number of animals (for example in several sheets of map in which the farm can be divided), thus generating an excessive animal burden on part of the territory concerned, it was decided to divide the total number of heads of each company for the quantity of farm plots used for grazing.

To determine the actual pasture areas within the whole region, the following classes for soil utilization have been extracted from the CORINE land cover (Tab 8).

Tab 8: Classes of CORINE land cover divided by grazing areas

243	Land principally occupied by agriculture, with significant areas of natural vegetation
244	Agro-forestry areas
2111	Arable land in non - irrigated areas
2112	Arable land in irrigated areas
2121	Intensive culture
321	Natural grassland
323	Sclerophyllous vegetation
3232	Shrubland
3231	The Maquis
31122	Forest of *Quercus pubescens*, thermophilic forest of Quercus *pubescens* with *Q. cerris Q. ilex* with brushwood rich of Mediterranean species semi-Evergreen (*Roso sempervirenti quercetum pubescentis* Biondi 1982)

The areal photogrammetric for the year 2000 of a photo interpretation of the extracted categories was then used to verify the effective activity of grazing. The photo interpretation activity was then combined with the verification in the field and the direct knowledge of the territory.

Palletizing the information layer that contains the business data, with that of classes extracted from the CORINE land cover, generated a new layer of the areas which had actually been used for grazing . In the database of the new layer, a field number (area) was added on which was reported the extension surface (ha) of the pasture areas derived by the intersection.

At this point the information layer was turned into a geo database in order to perform the calculation of the current EISR through a script of the template created on GIS software.

The result of the model was immediately converted in GRID (with 50 m step) to then correlate it with the GRID of the sustainable EISR in order to be able to reach the definition of the final EISR.

For the definition of the farming type and the production division of the various species, not having available the data of requested input from the template, bovines were chosen as resulting from mix-breeding and semi-extensive breeding. To the sheep was allocated a medium productivity level and a semi-extensive breeding type, and finally to goats was also allocated a medium productivity level as well as extensive management.

Through the adoption of these values, it was possible to furnish each species with medium standards that neither underestimate nor overestimate the over grazing.

Calculation of the sustainable EISR

The sustainable stocking rates must be seen via an assessment of the soil's aptitude that support the presence of the breeding animals, according to a parametric method based on a definition of classes and scores. The input data necessary for the calculation of the sustainable EISR was obtained from a pedology chart of

1:250000, the CORINE land cover scale 1: 25000 and from the digital land model of (Dem) with a spatial resolution of Dim / pixel of 25 m.

The following significant variables influencing land suitability for pasture improvement were identified: vegetation cover, slope, aspect, rockiness, stoniness, soil depth, as well as a soil chemical-physical characteristic index resulting from average values of texture, structure stability, base saturation and water availability. Some changes have been made, by adding, in respect to the model shown in the bibliography, characteristics related to salinity and the content made up of organic substances, that together with the weaving, drainage and the AWC allow us to define a new attribute: fertility (Tab9).

Tab.9 Soil parameters

Given input	Encoding
Rockiness	%
Stoniness	%
Depth	Cm
Weaving	%
Drainage	Qualitative Information
Awc	mms/c
Salinity	mmhos/cm
Organic substances	Qualitative Information
Dem	M

The values of these variables were then converted into suitability coefficients calculated on the basis of specific weighting functions which take into account the relative importance of each variable. A further alteration regarding the reference model, concerned the attribution of the standard values that, in some cases, were redefined during the tuning phase of the model and the relative scores.

The cumulative attitude classes of the land, to the pasture index (CASP) was then calculated as the sum of the suitability coefficients of each variable:

$$\mathbf{CASP = (R + P + Pr + F + S + A + Q + V)}$$

Where R is the rockiness, P is the stoniness, Pr is the soil depth, F is the fertility, S is the slope, A is the aspect, Q is the altitude, V is the vegetation cover.

The land suitability was then assigned to each cumulative LSI (S1- highly suitable; S2 –moderately suitable; S3- marginally suitable, N1- currently not suitable, N2-permanently not suitable) (Tab.10, 11).

Tab 10. Derivation of input from a pedological source

		S1	**S2**	**S3**	**N1**	**N2**
Rockiness	Values %	0-2	2-5	5-15	15-40	40-100
	Wight	1	8	10	25	300
Stoniness	Values %	0-2	2-5	5-15	15-40	40-100
	Wight	1	5	10	30	250

Tab 11. Derivation of input from dem source.

		S1	S2	S3	N1	N2
Slope (S)	Values %	0-2	2-6	6-15	15-55	55-100
	Wight	1	5	10	70	300
Aspet (A)	Values %	Sud	Est-Ovest		Nord	
	Wight	1	5		10	
Altitude(Q)	Values %	< 600	600-800		800-1000	>1000
	Wight	5	15		30	500

These were created through the re-classification of the various fields attributed by the pedology chart in Tab10 and through the standard values reported in the Tab13,14) later, obtaining the result.

For the production of the Fertility grid, it was necessary to produce an additional raster set: weaving, drainage, AWC, salinity, organic substances.

Tab.13 Pedological parameters

		S1	S2	S3	N1	N2
Texture	Values	F–FL-L	FSA–FLA-FA	A-AL–AS	S-SF	
	Scores	Medium	Medium-Fine	Very Fine	Coarse5	
		1	2	3		
Drainage	Values	W	M	I - S	P	E - V
	Scores	1	2	3	4	5
Awc	Values	Very high-high		Medium	Low	
	Scores	1		3	4	
Salinity	Values	Very- Low		Medium4	Very high	
	Scores	1			20	
Organic Substances	Values	Very high	high	Medium	Low	
	Scores	1	2	3	4	
Fertility	Values	5 – 7	8 – 11	12 – 15	16 - 20	>20
	weight	1	7	10	20	50

Tab.14 Input data derived from the Corine land cover 1:25000 (2003)

		S1	S2	S3	N1	N2
Vegetal	Values (%)	>40		10-40	< 10	
cover (V)	weight	5		30	50	

Tab.15 Capacity classes of soil for grazing

Suitability class	CASP	Sustainable EISR (AUEI/ha)
S1	0-40	1
S2	41-100	0.75
S3	101-174	0.5
N1	175-350	0.25
N2	>351	0.1

The output structure

The output file is a GRID file obtained from the report of the current EISR information (transformed in GRID) and the sustainable EISR. The derived output is characterized by cells with a 50 m step which conveniently re-classified defines the intensity index of grazing. (Tab.16)

Tab.16 Comparison between EISR Current and EISR Sustainable

EISR Current **/EISR** Sustainable	**Values**	**Final classification**
>1	1	Over grazed areas
1-0.75	0.75	Midium over grazed areas
0.75-0.50	0.50	Moderately over grazed areas
0.50-0.25	0.25	Weak over grazed
0.25-0	0	No over grazed areas
No data	Null	

RESULTS AND DISCUSSION

The output model found that in Sardinia on a the total area of 2408300 ha, the area intended for pasture for 1995 was equal to 1025805. 70 ha. As highlighted by the following table summary (Tab 17) 20,1% of the regional pasture territory was concerned with over breeding; this situation was mainly found in the North-Center of the Island, in particular in the old province of Nuoro where 75,432,30 ha. on a total a area of 261,355,50 ha. manifested this problem (Tab 18) (Fig.2). For the over breeding situations, to a number of elevated heads, there are almost always combined with a marginal or unsuitable capacity of soils to support the activity of grazing.

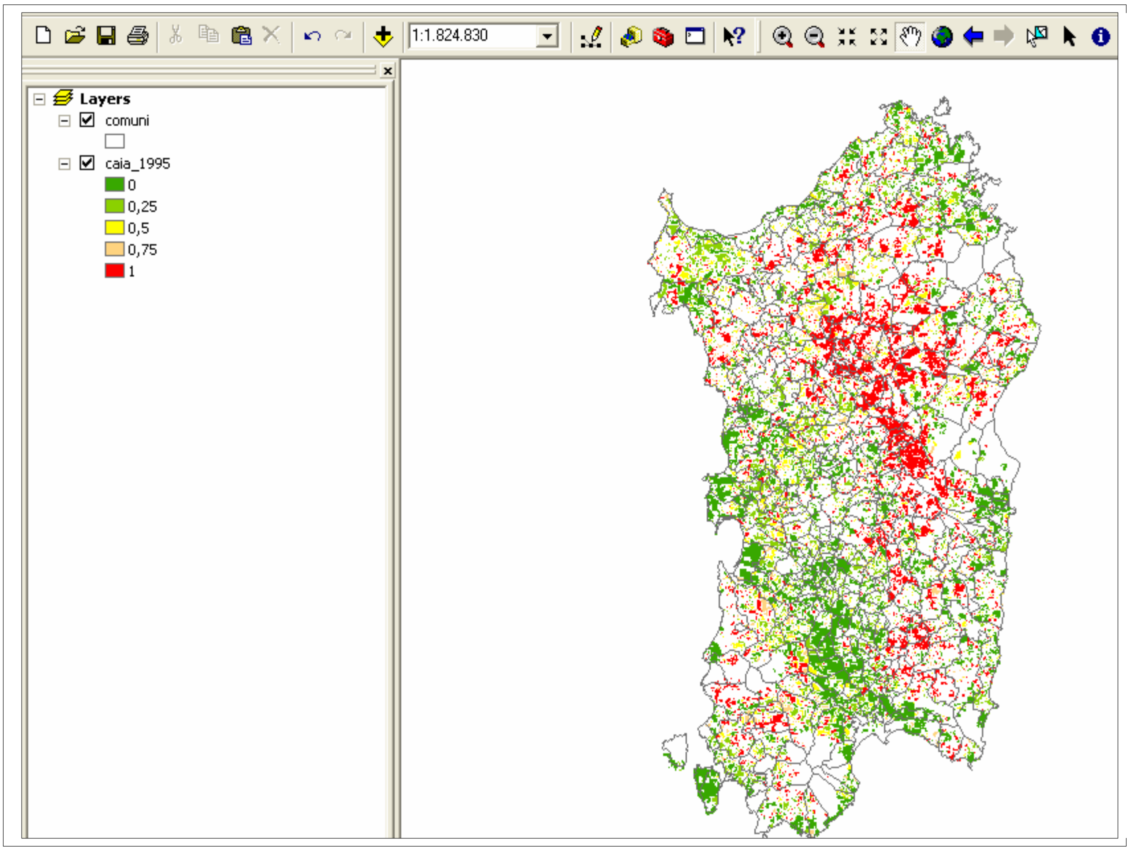


Fig.2 Output model 1995

Tab.17 Output model 1995

Output	Surface ha	Surface %
1.00	206127.60	20.10
0.75	102442.30	10.00
0.50	170477.20	16.60
0.25	253074.40	24.70
0.00	293684.20	28.60

Tab 18 Output model for province 1995

Output	SS (ha)	NU (ha)	OR (ha)	CA (ha)
1.00	83138.80	75432.30	10469.60	37076.70
0.75	41649.60	28289.40	11992.60	20506.40
0.50	68574.40	44807.00	23577.90	33503.60
0.25	94271.60	53379.10	42530.50	62867.90
0.00	60458.80	59447.70	63002.40	110702.40

The percentage of important and moderate grazing (respectively 16.6% and 24.7%) were found in the South-Center of the Island, in the Nurra and Gallura. Where the quality of the soils partly consists of zootechnics that persist in that area; while for the Gallura, more than the quality of the soil, prevails the consistency and the type of load, characterized, in this case, by a greater spread of goats and cattle.

The output model for the 2005(Fig 3) shows an increase trend for classes that express over grazing, while at the same time a decrease trend in classes were there is no or moderate grazing (Tab 20).

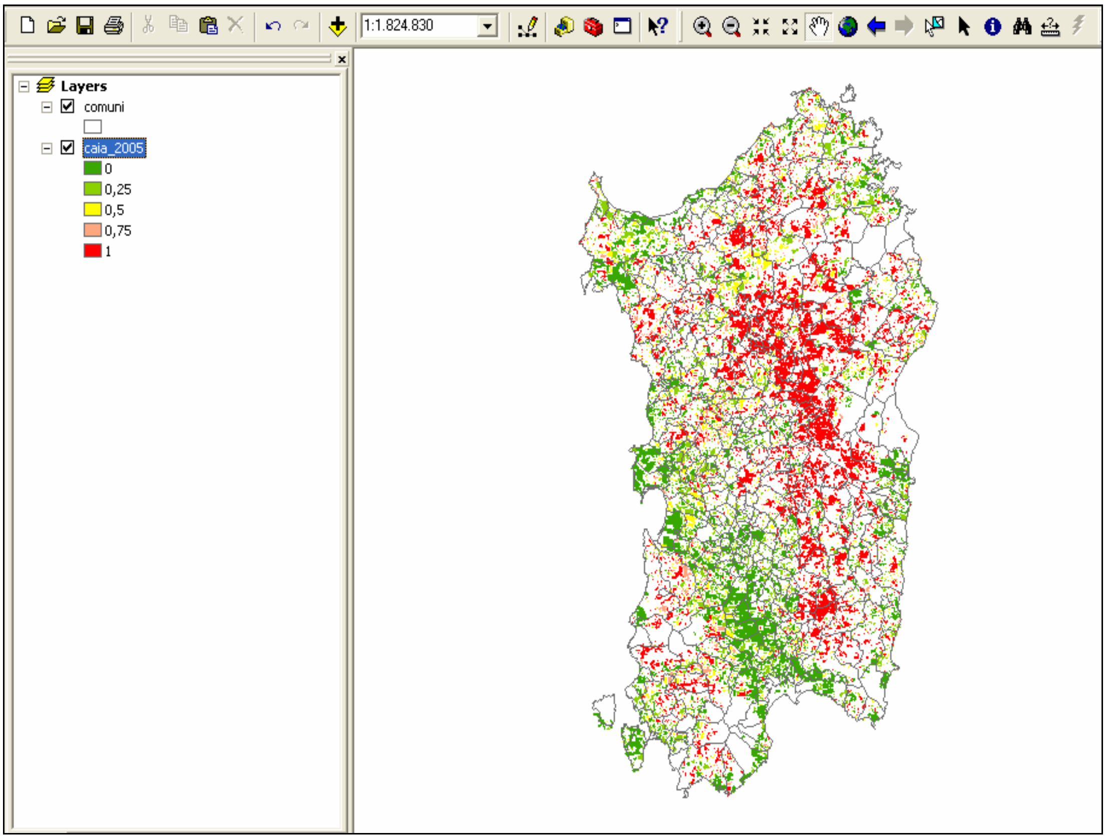


Fig.3 Output model 2005

Tab.20 Output model 2005

Output	Surface ha	Surface %
1.00	253617.00	24.70
0.75	110908.90	10.80
0.50	182250.80	17.80
0.25	240970.50	23.50
0.00	238024.40	23.20

Tab 21 Output model for province 2005

Output	SS (ha)	NU (ha)	OR (ha)	CA (ha)
1.00	92494.70	100774.50	17943.40	42395.00
0.75	43135.80	32321.70	13521.00	21923.30
0.50	75847.90	43749.40	29637.90	32998.10
0.25	85955.50	49404.90	41404.50	64168.70
0.00	50626.30	35121.30	49037.80	103174.40

	0,00	0,25	0,50	0,75	1,00
CAIA 1995	293684,20	253074,40	170477,20	102442,30	206127,60
CAIA 2005	238024,40	240970,50	182250,80	110908,90	253617,00

Fig.4 Comparison Output model 1995-2005

MODEL TUNING.

To verify the validity of the model, elaborations with a detailed scale of 1: 25000 were performed on two test areas of Sardinia. The first test area falls in the basin Rio Mannu of Mores which includes part of the communities of Uri, Ittiri, Florinas, Thiesi, Borutta, Bessude, Banari, Tissi and Ossi. The second test area is located in the towns of Orune and Oniferi. (Fig. 5).

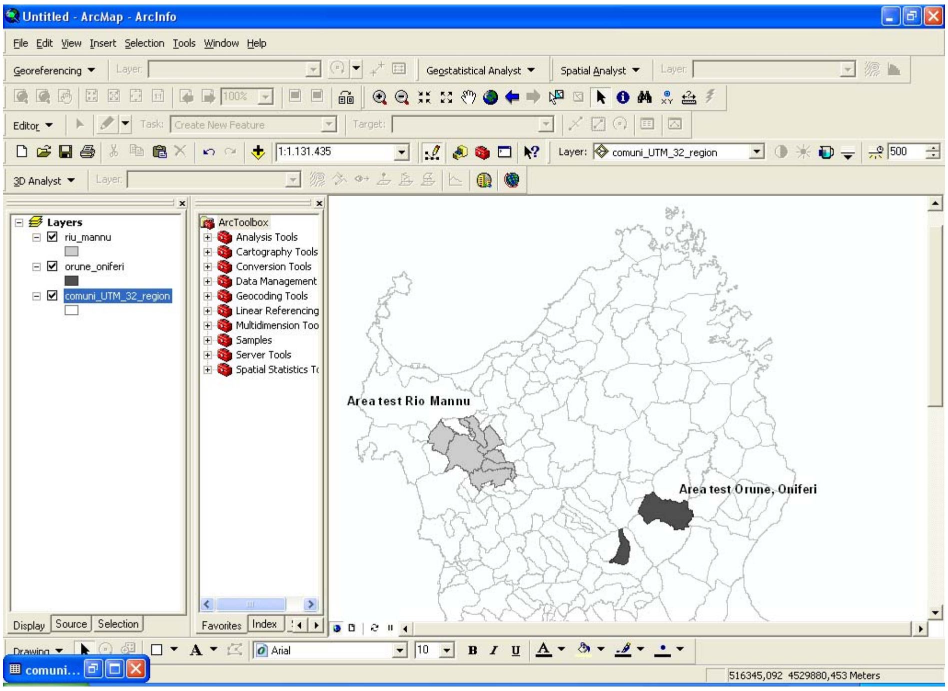


Fig 5. The areas test

To formulate the work, new data input with more detail was required such as: the soil characteristics of the' area, and the detection through aerial interpretation of the grazing areas. For the consistency level of the livestock farms the geo-referenced database of the veterinary registry office was used. The method used to make the calculation of the current EISR and the sustainable EISR was the same as that of the elaboration in scale 1: 50000. The output of the model was subsequently verified by controls that have certified the validity of the used method.

Results area test: Rio Mannu.

The image below shows the output of the model where the council limits have been overlapped to facilitate the orientation within the regional territory. Represented in red are the areas that demonstrate a phenomena of overload mainly seen in the councils of Banari, Bessude and Thiesi. The different shades of Green indicate areas where these phenomena are slightly or not at all present (Fig. 6).

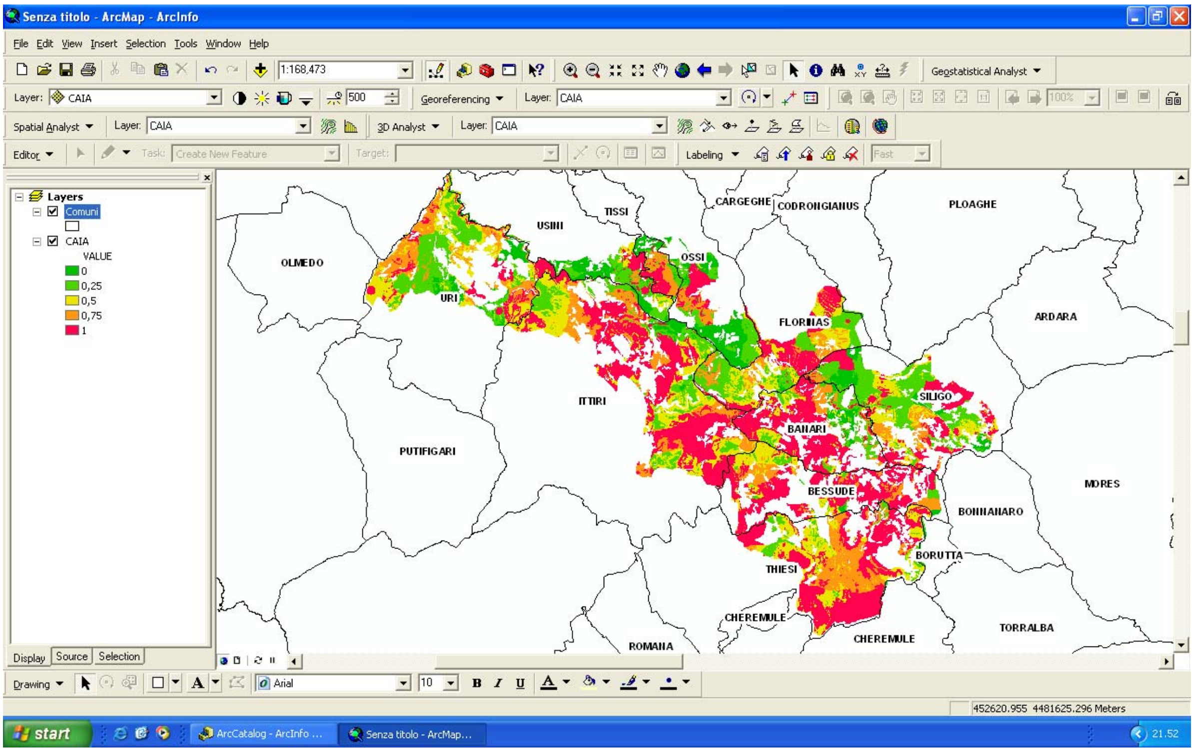


Fig.6: Output del EISR area Test Rio Mannu

In the concerned area the model has detected that about 37% of the territory is affected by over breeding, (Tab.22).

Tab.22 Output model test area Rio Mannu

Output	Surface (ha)	Surface %
1.00	6407.90	37.20
0.75	2718.70	15.80
0.50	3302.80	19.20
0.25	3554.10	20.60
0.00	1244.20	7.20

Thus it's interesting to note that more than 20% of the territory is not over grazed.

This degradation phenomena results from the continued grazing within the same soil, where all parameters of rational grazing are not respected. Grazing activities on these lands represent a marginal activity, often combined with other farm activities like horticultural crops, composed mostly of artichoke. Grazing in these soils is practiced to contain the spread of infesters.

In the South West of the analyzed areas are more frequent farms whose surface is used for zootechnical practices and forage. Farming represents one of the few forms of valorization possible in these territories, which are typically marginal because of their morphology, characterized by high slopes, high quantity of stones and rocks, scarce soil depth, rare cotic grass, and therefore difficult to be used for other purposes. Sheep or rustic cattle exploitation can be practiced on these poor pasturelands but often, because of a high animal load, these farming activities cause impoverishment of the soil and erosion. The calculated EISR for these areas shows generally a situation of maximum impact.

The considerable geomorphological heterogeneity, is noted in the territory of Siligo, in which the plain named "Campu's Lazzari", along the S.S. 131, expresses a good capacity for cultivation and grazing; the absence of canted land excludes the possibility of water erosion or loss of organic substance from the soil. The depth of the soil (> 60 cm), and the fertility, together with the absence of stone and rocks, makes these soils resistant to anthropic pressure. (The EISR detected in these areas was infact equal to 0).

Results test area: Orune-Oniferi

Output of the model in the concerned area, has detected that about 62% (Tab.23) of the pasture territory is concerned with over grazing, mainly concentrated in the council of Oniferi. These are phenomena of degradation attributable, presumably, to the incorrect management of the silvo - pastoral systems. These systems are frequently used in this area as they allow to combine the income by zootechnical practices with that of the cork extraction.

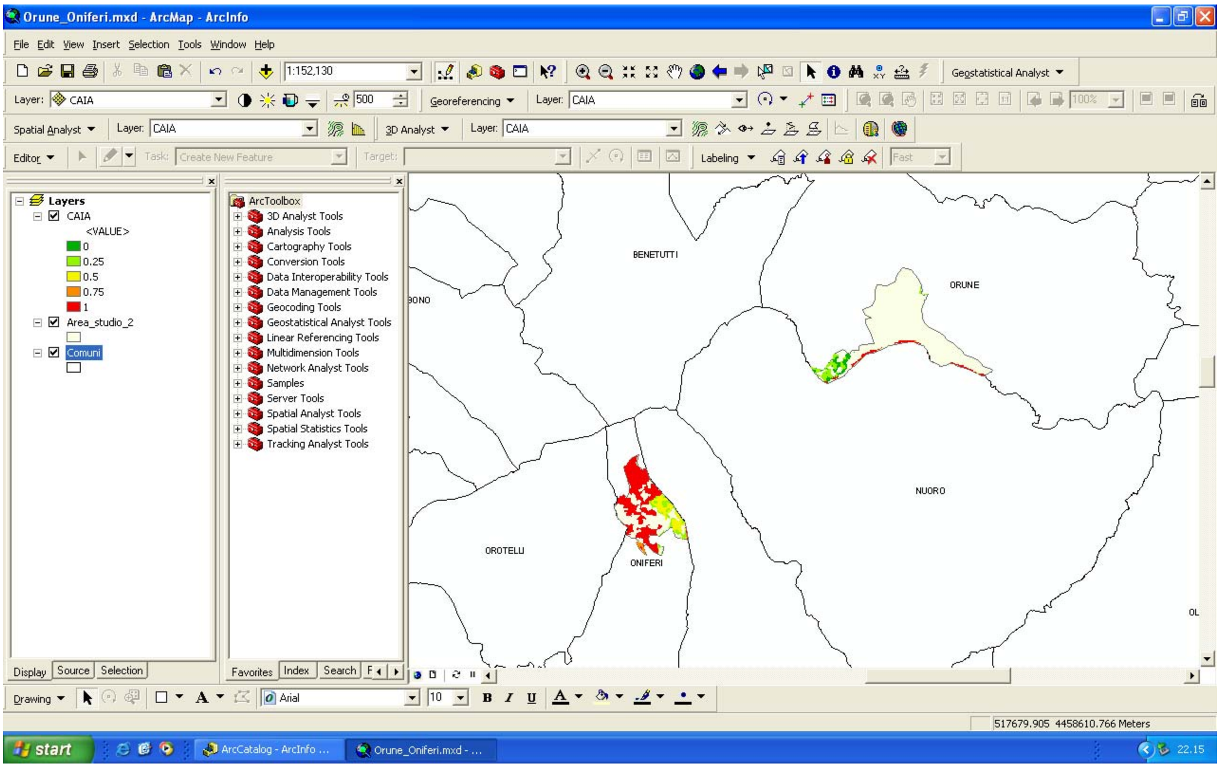


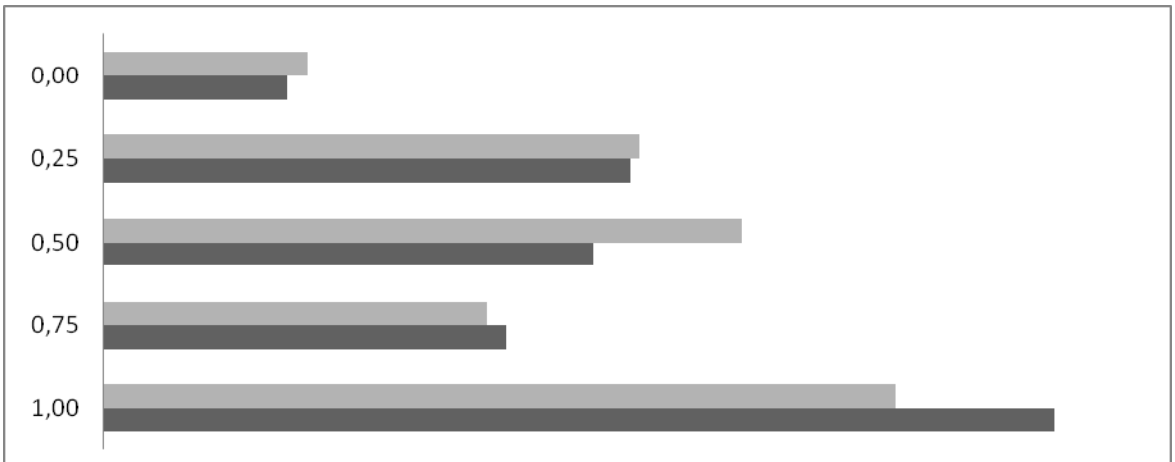
Fig.7: Output of EISR at scale of detail – Area Test 2

The cork cultivation in this land is mainly due to the plant's resistance to the effects of fire, particularly not ignorable in an area historically covered by fires, and to the capacity of the cork plant to live in poor agro-ecosystems. The soil of the analyzed areas, comprised of a franco-sandy texture, results generally, poor in organic substances and easily washed away (Soru D., 2006).

Tab.23 Output EISR areas test Orune-Oniferi

Output	Surface (ha)	Surface (%)
0	29.2	5.9
0.25	82.2	16.7
0.50	65.3	13.3
0.75	9.6	1.9
1	306.0	62.2

The comparison between the outputs of the model, obtained by the two various scales of work (1: 50000 and 1:25000) result substantially coherent (P >0.05) for both areas of study (fig.8, 9), even if some upper/under localized systems were found.



	1,00	0,75	0,50	0,25	0,00
1:50000	5340,59	2584,16	4306,93	3617,82	1378,22
1:25000	6407,90	2718,70	3302,80	3554,10	1244,20

Fig.8 Comparison between the outputs of the model in scale 1:50000, 1:25000 of the test area, in the "Rio Mannu" river.

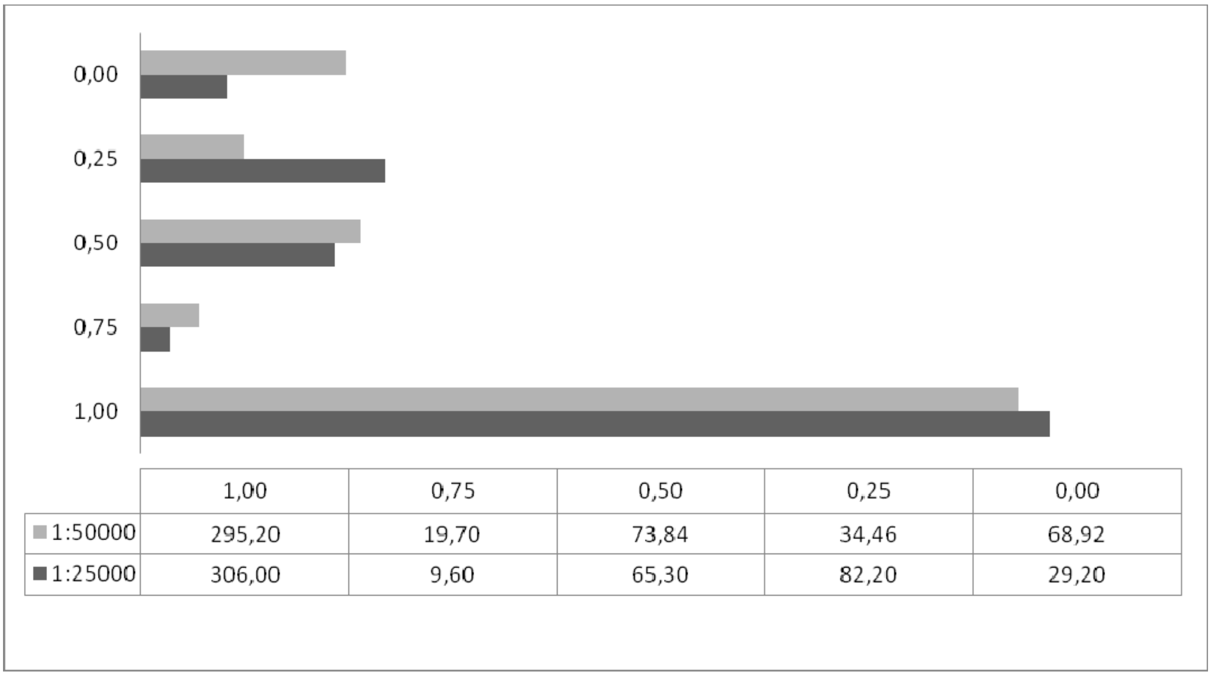


Fig.9 Comparison between the outputs of the model in scale 1:50000, 1:25000 of the test area, Orune-Oniferi

The found differences are due to the fact that working at different scales, required the use of informative input layers of much greater detail, such as a pedology chart and the map of the soil usage. The use of a pedology chart of greater detail, for the calculation of the sustainable EISR from the test areas, has determined a diversification of the classes at risk deriving from a greater heterogeneity of soils.

Furthermore, some discrepancies derive from the updating of information relative to the use of the soil. In fact, working at a greater scale of detail, it’s possible to identify destinations of use of the soil that are not cartographical in a spatial regional context.

CONCLUSIONS

The detailed elaboration in the scale 1:25000 has had the function of verifying the reliability of the model and the applicability of it on a regional scale. The identified divergences result limited, and they do not alter the total appraisal of the overgrazing phenomena.

The majority of the analyzed surface demonstrates a restitution of the coherent model for both scales of work. The differences found in the two scales of work are not significantly valid, and allow the use of the model's output as an instrument of support to the decisions in the territorial planning. The model proposed in order to determine the stocking rates of environmental impact, has been shown to be suitable for the purpose, as well as offering the advantage of being easily updated and implemented whenever new data of greater detail is available or presented.

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CHAPTER 4

Development of sustainable and multifunctional business models for the valorisation of the pastures in marginal areas by means of GIS.

OBJECTIVES

The main purpose of this work was the application of methodological approach based on the integrated use of Geographical Information Systems and decision Support Systems (DSS) in the management of the areas to pasture.

The specific objective of this research, proposes to use the systems GIS for the management of the marginal areas, to define sustainable modelling, both economic andenvironmental, and using in better manner the breeding resources of the marginal areas.

MARGINAL AREAS

On a national level, the agricultural activity and, in particular the livestock production one, is constantly being confronted and measured, both in productive and economic terms, with stronger and more competitive realities. Above all this condition places serious problems to the farms located in marginal areas, that find greater difficulty in the reduction of the production costs and in the development of economies of scale, but that similarly constitute for the Italian primary sector a distinctive and indispensable element, both in terms of the various types and quality of the produce as well as in relation to the protection of the environment and landscape. Bignal and McCracken (1996) demonstrated that almost all European grasslands of a high nature-conservation value are associated with low-intensity livestock systems. It is also maintained that marginal areas are especially (or in some extreme cases even only) suitable for agricultural systems based on extensive husbandry of locally adapted livestock breeds (Dmitriez and Ernst, 1989; Neofitidis and Tawfik, 2002)

Marginality is a complex issue that has attracted a wealth of studies, particularly in the field of human geography (Jussila et al., 1999; Leimgruber et al., 2003). Marginal areas are characteristically used for low-intensity farming systems. These have proven to be of significant importance for nature conservation. The re-launch of zootechniques in the marginal areas other than for socio-economic reasons, is more and more sought after for the protection of the territory and, on more general terms, the health of the environment. As a matter of fact, the defence of the mountain and hill ecosystems represents a priority, in the growing knowledge of the fact that the development must be sustainable.

Local livestock breeds have become endangered in many parts of the world (FAO, 1999; Hammond and Leitch,1996). In the EU 25-35% of goat and 25% of sheep autochthonous breeds are endangered. The lesser part of this loss can be attributed to the abandonment of extensive husbandry in marginal areas. There is currently a broad consensus on the importance of conserving livestock biodiversity (Joost et al., 2005), as well as maintaining an active agricultural presence in marginal areas. It is also widely held that the existence of traditional, well-adapted breeds is a necessary given for viable, sustainable land use in marginal areas (Rege and Gibson, 2003).

However the term ‘‘marginal areas’’ is used quite broadly, thus resulting in no unique, easily quantifiable or rigorous definition of this concept in the literature. here, in line with Wright (1997), marginal areas are defined as those areas where possible land uses are relatively limited because of higher altitude, shorter growing season, steeper slopes, less fertile soils, or broadly speaking because of generally lower soil productivity. Marginal areas thus defined, imply (in some severe cases) restrictions even to extensive livestock utilization. Wright (1997) has summarized these limitations as constraints on the level of nutrition of livestock, with impacts on the physiological processes of reproduction, lactation and growth. To at least, partly overcome these limitations, the choice of the species and breed is often of the uttermost importance. Infact, sheep are better able to graze selectively and more efficiently than cattle, obtaining a better quality diet where the overall quality of pasture is generally poor (Gordon and Illius, 1988). Small ruminants utilise more shrubs and less grass than larger ruminants, and goats generally utilize more shrubs and woody plants than sheep (Brand, 2000).

Goats are also versatile in harvesting forage and are able to survive under adverse foraging conditions, and this sets them apart from other species of livestock (Lu, 1988). They also have greater efficiency in chewing and prefer to consume forage of lower digestibility and higher fibre content (Hadjigeorgiou et al., 2003). Diet selection and grazing behaviours also differ between breeds, with some breeds being more selective than others (Brand, 2000). Smaller and/or less productive breeds are more adapted to harsher conditions (Wright, 1997). Identifying marginal areas by computing an index of relative marginality may prove useful for both agricultural policies focusing on livestock biodiversity conservation, as well as to provide a tool for rural development and more generally land use policies. Infact, one of the EU's main objectives aims to target disadvantaged areas with ad-hoc policies in order to promote EU's harmonious development as established in the Treaties. Current examples of these policies are Objective 1 and Objective 2 of the structural funds. In the case of Objective 1, for instance, lagging regions are identified as those which show a lower level of investments, higher unemployment rates and poor infrastructures.

Andreoli and Tellarini (1998) have reviewed the concept of marginality and its link to agricultural systems. They point to the lack of a rigorous scientific definition of marginality, claiming that is still largely valid. Citing Cannata (1989), they show how marginality can be studied at the level of integrated systems, i.e., by combining the various factors affecting marginality (environmental, productive, demographic, economic, etc.) (Fig.1).

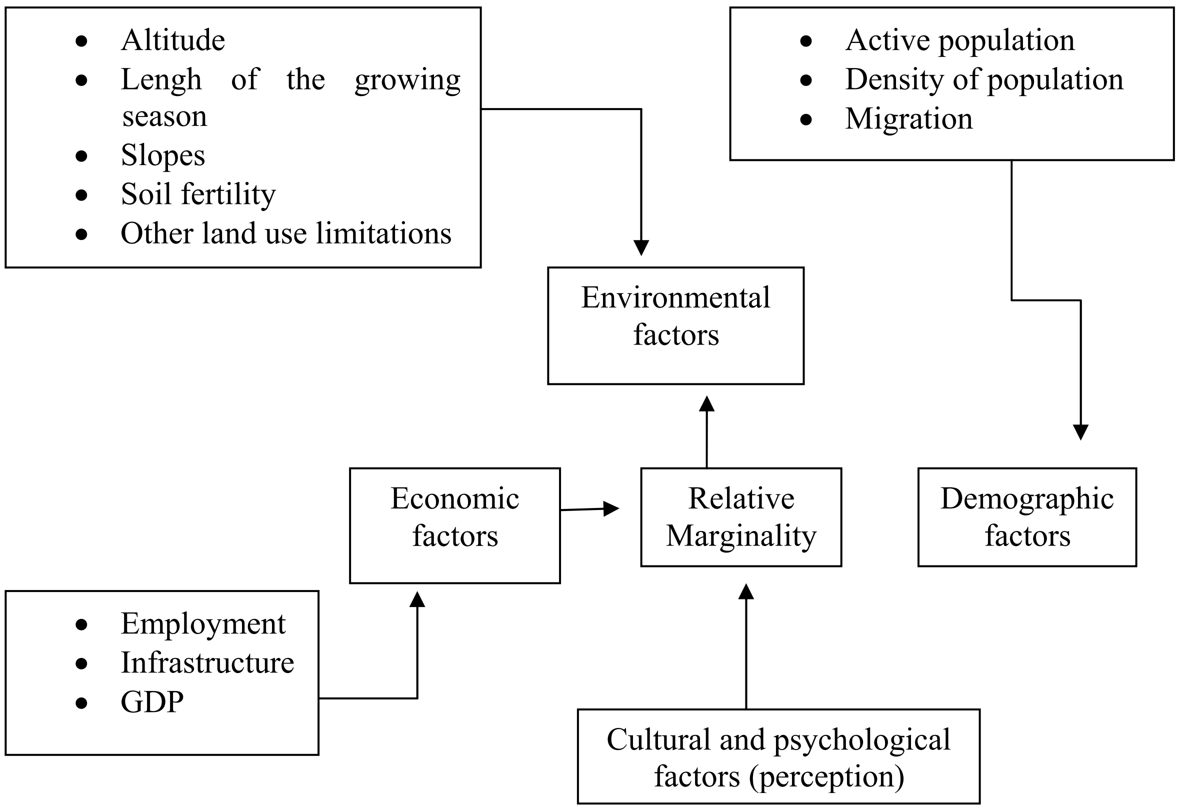


Fig.1 The concept of relative marginality (adapted by Bertaglia et al., 2007)

The constant diminishing of agricultural enterprises in marginal areas has become not only an economic and social problem, but also a problem that concerns the safeguard and management of the territory. According to the data supplied by the Ministry of Forestry Agricultural Policies, in 30 years approximately 600.000 ha of pasture land and mountainous fields have been lost, with a reduction that in some areas (like those of Liguria and Friuli Venice-Julia) reached up to 50%; a phenomenon that has gone hand in hand with the decline of the zootechnical wealth

The re-launch of zootechniques in the marginal areas other than for socio-economic reasons, is more and more sought after for the protection of the territory (Stobbelaar and Van Mansvelt, 1997).

The maintenance of agricultural activities in Italian marginal areas is possible especially initiating :

- a rationalisation of the utilisation of forage resources via an optimization of the grazing systems
- An adequate valorisation of the final products, that utilises strategies based on the recoup of the added value for the agricultural farm , derived from a local transformation of the products, both from direct sales and the commercialisation of highly typical products.

A pastoral system is a complex system in the sense that not only is it a mixture of different factors (ground, water, climate, orography, vegetation, animals, man, etc.), (Brockington 1972) but it is also the result of the existing relations between these internal factors and those ones on the outside (driving forces: Public Administration, infrastructures, market, poles of attraction, etc.). Moreover also within them, such systems are currently badly defined; for example, the fundamental interaction between grazing animals and pasture is based predominantly on the experimental empiricism poorly adapted under the explained profile and inadequate for a preview usage.

A cognitive and planed approach to the management systems mainly of territories based on grazing, involves instead, the rationalization of the components of the system and quantification of the energy flux of information and material, between such members. The study of these members is therefore translated in the development of models able to simulate the behaviour of the entire system.

THE MASO-GIS PROJECT

The research activity performer during the doctorate, contributed to reach the objectives of the inter-regional project MASO-GIS", (Development of sustainable and multifunctional farm models for the valorisation of the pastures in marginal areas by means of GIS).

The so called project initiated by the Piedmont Region commenced in 2005 and has had a triennial duration (2005-2008), which has been coordinated by Prof. Giuseppe Enne director of the Inter-departmental Center of NRD of the University of Sassari, head of the subject of the project,.

The project involved 16 study areas in as many Italian regions characterized by the typical forage and pasture systems of marginal areas. Here, the definition of sustainable farm models allowing the exploitation of pasture resources, with a view to multifunctional management and land use, constitutes a relevant support for the maintenance and development of agricultural activities in less favored areas. The peculiar feature of this project is the development of a GIS common to all areas concerned; the system will become a useful tool not only for data synthesis, analysis and elaboration, but also for the integration of conceptual and interpretation models of farms and pastures, and lastly for the definition and evaluation of environmental and economic sustainability of farms. A main distinctive feature of the project is the

collaboration and exchange network among institutions and administrations to carry out the research activity which allows the sharing of information and data.

The project tried to confront the problems which arose by a multidisciplinary approach; infact the data that is joined inside of the informative system derives from studies carried out in various fields: geopedologic-environmental, zootechnical, economic and agronomic.

The regions involved with the study are here by reported :, Val di Remhes (Valle d'Aosta), Valli del Pinerolese (Piemonte), Val Primiero (Trentino), Val Venosta (Bolzano), Val Pontebbana et Passo Premollo (Friuli Venezia Giulia), Val Polcevera (Liguria), Appennino pistoiese (Toscana), Monti Lepini e Sabina (Lazio), Gubbio e Alto Chiascio (Umbria), Montefeltro (Marche), Appennino

Monti Dauni (Puglia), Sila Grande (Calabria), Alta Irpinia (Campania), Appennino del Marmo (Basilicata), Nebrodi (Sicilia), Dorsale Marghine-Goceano (Sardegna).(fig2).

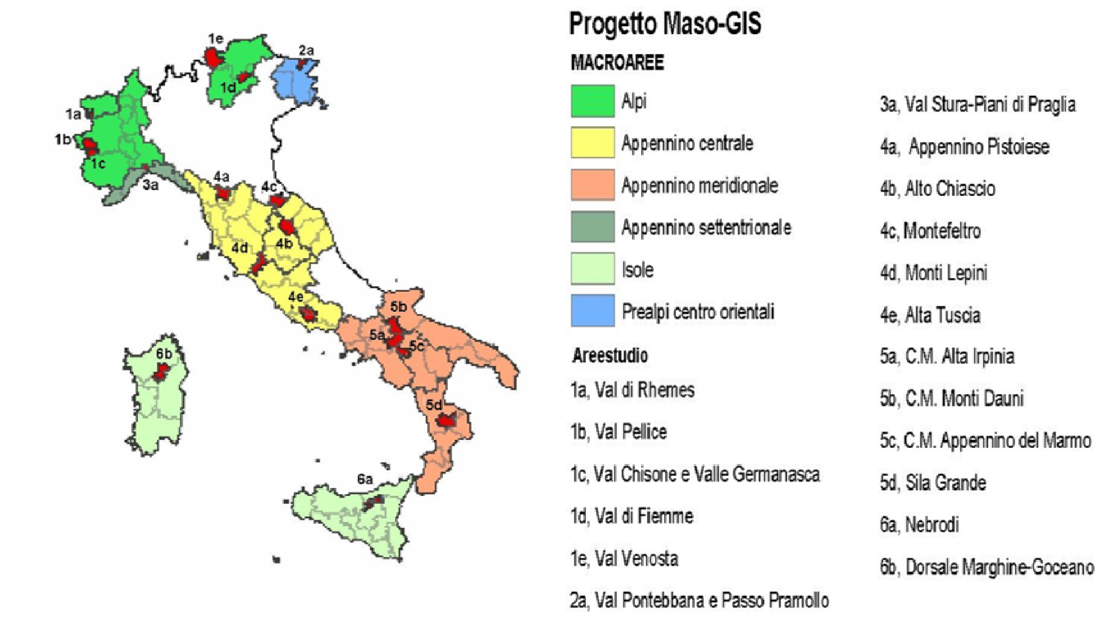


Fig.2 Areas of study of the MASO-GIS project

In such areas the mixed farms with a prevailing zootechnical address represent the overwhelming majority of the agricultural farms, as the breeding allows the maximum exploitation of resources of such territories and, especially in the past, was in a position to supply an immense range of products sufficient enough to assure a relatively self-sufficient food supply to the family (Bertaglia et al 2007). Today, surviving is not enough, it is necessary to find a modality of sustainable development that allows an agro-pastoral farm of both hills and mountains, to be profitable and in equilibrium with the social scale of the territory and with the valorisations of the environment and landscape (Andreoli and Tellarini 1999).

The project tried to find such modality by using the help of modern informatics instruments in which the conceptual and interpretative models of the pastures and the realities of the farms were studied and analyzed by means of mathematical models capable of simulating the reality and the same time to predict alternative management scenarios.

THE INTEGRATED MODELS IN GIS.

The use of mathematical models for the simulation of technical and economical scenarios is vastly spreading within the zootechnical farms, both as an instrument for corporate planning for the dimensioning of the stocking rates relative to the forage availability and the structural equipments, as well as regarding the appraisal of the economic sustainability of the farm. The informative system of the this thesis has been implemented with 3 models of simulation: Ovisoft, Pascovisoft, Bovin-latte. The first models were elaborated by the Department of Zootechnical Sciences of the University of Sassari that possess the intellectual property, Pascovisoft was elaborated by the University of Pisa, Department of Animal Productions Zoo-economic section, while Bovin-latte were elaborated by the C.R.P.A.

In particular:

Ovisoft is a simulation model of the ovine milk farms, usable for the dimensioning of projects and/or managerial programming, with reference to dry areas and the average conditions of the Mediterranean ovine breeding farms. The model supplies, on the base of the distribution of births during the year, the dynamics of the flock, the monthly feeding requirements, consumption of food, the monthly production of milk, the monthly course of the lactation curves for every sheep milked, by order of birth and the average lactation curve of the flock. This instrument allows the customer to estimate the reproductive efficiency of the flock and its influence on the total milk production.

Pascovisoft is a simulation model for milk ovine farms that on the base of structural, technical and organizational data of the functioning farm. It standardizes the economic data, that results in an evaluation of the farm characteristics in technical terms, of the environmental sustainability of the management of the pasture, and of the ability of self-sufficiency and suitability of the food plan. The model computes economic analysis for cost and revenue centers determining the economic business budget with the analysis results in terms of synthetic economic indices.

In parallel with the elaboration of the functioning farm the model simulates a scenario that optimises, based on the availability of forage and the imposed ration, the dimension of the flock, the management of both the food supply and food reserves. In order to obtain this solution the model proceeds to the economical analysis. From the comparison of the two elaborations, that were carried out simultaneously, the margins of bitterness of the technical and economical management of the real company can be observed. The standardisation allows the comparison between homogenous farms, highlighting the differences of the technical-pastoral management.

Bovin-latte is a simulation model for milk bovines that calculates the real economic budget of the farm putting it in relation to the structural, technical and organizational data. It also verifies its sustainability in regards to the management of the pasture, the capacity of self sufficiency in relation to food and the safeguard of the environment. The model allows to carry out simulations that aim to increase the business yield, in order to do this it is sufficient to introduce the technical parameter that one wishes to improve, and the model automatically re-elaborates the new economic budget.

OBJECTIVES

The purpose of this research was to locate, within the Sardinian region, an area that for geographical, social-economical, demographical and cultural purposes had characteristics of marginality, while also suggesting instruments of an objective analytical and evolutional nature, capable of managing information from various fields in an integrated and clear fashion. Such an area was found within the historic region of the Goceano, where the study was carried out on various fields.

SOCIAL-ECONOMIC AREA

The research conducted in this area had as its objective, the development of a cognitive picture of the social-economic dynamics of the area, the study of its population movement and to indentify within it the problems tied to marginality.

GEO-PEDOLOGIC AREA

The research performed within this area had the aim to characterise the studied area from a geo-pedologic environmental point of view, establishing within it, the pasture areas and their location while also studying the compatibility between their actual use and their aptitude to pasture. Since in these marginal areas, the management of the pastures is frequently combined with a poor environmental sustainability, as these maintain their productivity and landscape function on the condition that no degrading processes take place. For their evaluation, a chart of the homogeneous pasture areas was created, utilising the method proposed by Prof. Andrea Giordano for the evaluation of land.

ZOO-TECHNICAL AREA.

From a zoo-technical point of view, the research had the objective to study the reality of the farms that fall within the area, thus identifying both its strong and crucial points. The learning of the later, allowed the study of management strategies suitable for every farm reality with the support of management models (Ovisoft, Bovin-latte, Pascovisoft), while the knowledge of the strong points was used for its valorisation.

MATERIAL AND METHODS

Social-economic Area

For the assessment of the population movements, the data of the Istat Census relative to 1981,1991 and 2001 was used. The data relative to the zootechnical consistency was taken from the V General Agricultural Census. The information relating to the type of pasture management and to the breeding of animals, was taken from bibliographies.

Geo-pedologic Environmental area

For the creation of the chart of the homogeneous pasture areas, the coloured photogrammetric aerial flight of the 2000 AIMA was photo interpreted. The chart was developed in digital format (SHP) via the GIS Archiview 8.3 software. The used topography base was the IGM map in scale 1:50000, the smallest cartographical unit (u.m.c.) found, had a dimension equal to $4cm^2$.

For the creation of the chart a legend was created made up of the following:

1) Pastures in archaeological areas
2) Pastures with small lakes and rivers
3) Pastures with presence of woody plants
4) Forest with small cultivated areas
5) Pastures with rare trees
6) Pastures with small forest areas
7) Natural Pastures
8) Artificial Pastures
9) Pastures with rocks
10) Forest Grazed areas

11) Grazed Mediterranean maquis

12) Pastures by weeds

13) Pastures with signs of soil erosion or land movements

The order in which the sections were reported was hierarchical therefore, every pastoral area was classified according to the first section found on the list between those useful to its description. The hierarchical order establishes among the top places the *pastures in archaeological areas* and the *Pastures with small lakes and rivers.* This is so because the purpose of the project is the valorisation of the marginal areas, not only as areas to assign to grazing but also in the light of multifunctional development for the territory.

Surfaces, in which woody plants cover 10% of the considered area, were classified as *Pastures with presence of woody plants,* while the areas with a woody cover between 10-75% were classified as *Forest with small cultivated areas*.

The *Natural pastures* were distinguished amongst two categories: *pastures covered only by a herbaceous coat of an anthropic origin* and *Natural pastures*, in order to highlight which surfaces have been modified by the anthropic action and which have been preserved in their natural order.

For every individuated typology a database was assembled were the following sections were archived:

- Catchment area and underground area
- Code

- Local toponym
- Lithology
- Type of landscape
- Natural risks
- Anthropical risks
- Morphologic notes
- Quantifiable elements

The map of the different pasture typologies, was then superimposed on the gradient map via the elaboration of the altimetry map rasterised with steps of 10m. The map of the sample farms was also superimposed on the eco-pedologic map of Sardinia in scale 1:50.000 (Madrau et al.;2006) in order to evaluate its pedologic sub-layer and their aptitude of use.

Livestock production Area

Within this area, 13 livestock production farms were chosen as a sample representative of the postural reality of the area. Every farm was geo-referenced utilising the Garmin GPS XGETREXVS model acquiring the geographical coordinates, longitude and latitude, while utilising the reference system GCS European 1950.

Such farms were studied from a livestock production and economic point of view, through the assembling of very detailed technical-economical questionnaires. These were constructed in such a way that the information within them, would become the outputs for the farm management models.

The questionnaires were administered to the farm managers, and the gathered data was inserted in the Pascovisoft, Ovisoft, e Bovin-latte models, thus giving way to the simulations.

For the simulation of the 5GO farm the Bovine latte software finalised by the CRPA was utilised; such software was modified in the estimated section of excreted nitrogen

The value of nitrogen excreted attributed in the software, makes reference to the law of 23/12/1999 n.499 Art. 2.

The net nitrogen in the field (losses for volatilisation 28%) was taken considering the productivity levels of the animals and the type of farm breeding examined. For the cows in lactation an average productivity level was calculated to be 6000kg/ha/year of which 2000 are utilised for calf breeding and 4000 designated for transformation. Therefore, the excreted nitrogen was estimated on average, between the maximum excretion of the calf feeding cows (Tab. C2) and that of the first quartile of the milk cows (Tab. C1), resulting in a milk production of 7.263 kg/head/year. Therefore the parameter given by the estimate of the nitrogen excreted was equal to 62 kg/ head/year.

Although] the model calculated the quantity of nitrogen as kg/head/year without distinguishing between periods of lactation and non lactation, the quantity of excreted nitrogen by the different categories of animals was estimated considering the low productivity levels in a ratio of 1,5:1 respectively for lactation and non lactation according to what was reported by Van Horn (1998) in reference to NRC standard.

For the evaluation of secreted nitrogen by the breeding of sheep, the Ovisoft model was used. The equations of the models that calculate such excretions do it so keeping in mind both the PG needs of the single animal categories as well as their dietary consumption. In particular, in the Ovisoft model the daily nitrogen excretion of the different categories of sheep in the single months of the year, is estimated with a regression equation elaborated by Cannas, cited by Porcu, (2004).

$$\textbf{PG dig.} = \textbf{0,71* PG ing.} - \textbf{4,96}$$

where **PG dig**. is the digested raw protein and **PG ing**. is the ingested and also allows the calculation of the raw protein lost with faeces (difference between the ingested PG and the digested PG). The quantity of excreted protein with urine is given by the difference between the raw protein ingested, the one excreted with the faeces, and the one utilised for productions. The quantity of total nitrogen excreted is given by the sum of the PG lost with faeces and urine divided by 6,25.

From the 1GO, 2GO, 4GO, 6GO, 7GO, 10GO, 11GO farms, a economical analysis was carried out utilising the Pascovisoft model and the Net profit for Adult Bovine Unit (ABU) were inscribed. The model outputs concerning the estimation of excreted nitrogen productions, the stocking rates expressed as ABU/ha/year and the obtained Net/ABU profits, were spread out, via the GIS

Archview 8.3 Software, across the farm surface which was in turn obtained by means of geo-referencing the land registry papers supplied by the owners.

In this manner, the chart of the nitrogenised excretions of the breeding farms kg N/ha/year, the chart of the stocking rates ABU/ha/year and the chart of the Net\ABU profits, were obtained.

For the conversion of the animal number in ABU terms, reference was made to the PSR Sardinia 2007-2013.

The ABU animals were divided between the farm surfaces according to what was declared by the managers, in relation to the temporal space management of the farm surfaces. Its ABU/ha/year was also calculated.

The ABU/ha/year values were grouped in 6 classes arbitrarily chosen (Tab.1)

Tab1. The table shows the unification of the classes of the ABU/ha/year.

Classes ABU/ha/year
0-0.4
0.5-0.7
0.71-0.9
0.91-1.0
1.1-1.3
1.31-1.60
1.61-2
>2

RESULTS AND DISCUSSION

GOCEANO STUDY AREA

The research was carried out in the Goceano district (province of Sassari), whose territory has an extension of approximately 482 km². The area is represented in the tables IGM 1:25.000 480 I Mores, 480 II Forest of Burgos, 481 the Buddusò, 481 II Benetutti, 481 III Bono, 481 IV Ozieri, 498 I Bolotana, 499 I West Nuoro, 499 IV Orotelli. The territory has an altitude of which 50% is comprised between the 250 and the 500 asl (medium and high hill) and the remaining 50% goes beyond the 500 asl (mountain) (fig.3).

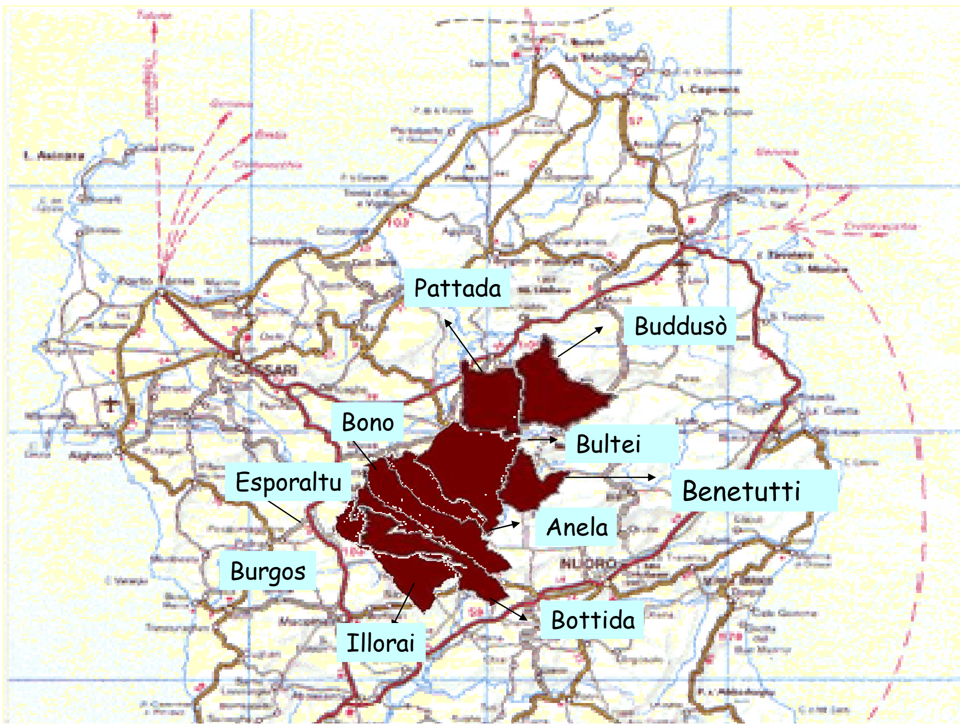


Fig.3 Goceano study area

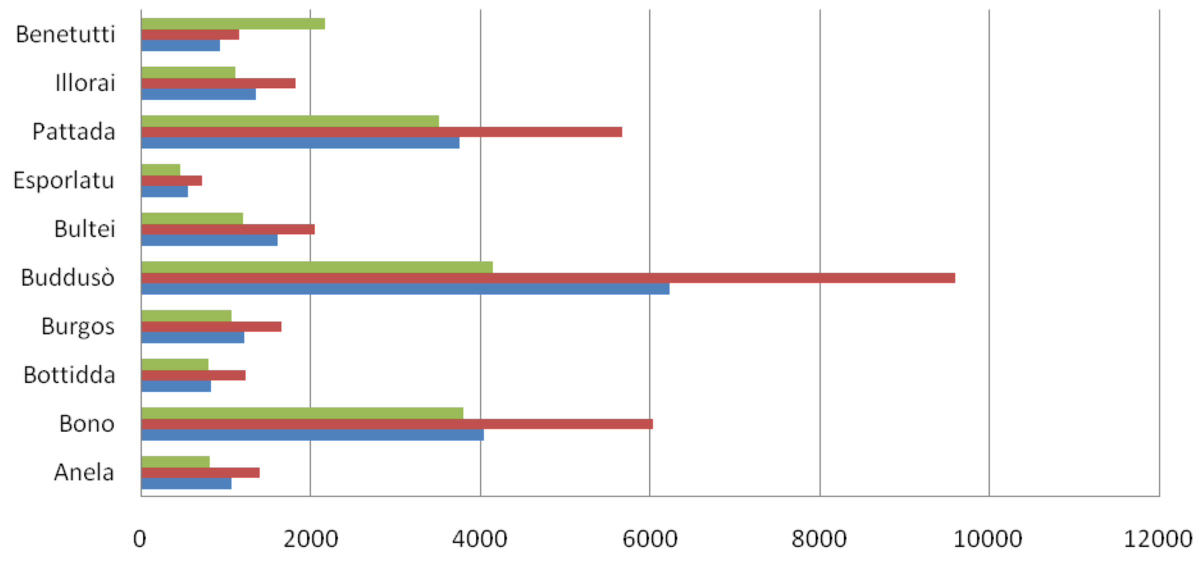
The landscape is mostly comprised of acclivity as only a quarter of the land lies within a plain-hill area, the remaining three quarters are instead strongly uneven; the soil is poorly evolved, insufficiently deep, with strong limitations of usage due to the excessive rocks and stones, the elevated slope and the insufficient depth. The climate is typically Mediterranean, classifiable bio-climatically (according to Emberger 1955) as an inferior Mediterranean humid, in the more elevated areas, and a Mediterranean sub-humid in the lower ones with some limited areas of a higher semi-arid nature. The average annual precipitations oscillate between the 700 and 1000 millimeters with a concentration of over 605 in the autumn-winter semester. The average annual temperatures fluctuate from minimums of 7° C to maximums of 18°C in zones of higher altitude, while in the lower areas they go from minimums of 9° C to maximums of 20°C. The windiness is high, the dominant wind direction is from north to the north-west.

The object area of study involved 10 councils (Gasps, Bono, Bottidda, Burgos, Buddusò Bultei, Esporlatu, Pattada and Illorai) which, in the first few years of the 2000 decade, overall were comprised of approximately 19130 inhabitants (Given census ISTAT 2001) with an demographic density inferior to 30 inhabitants per km². Table 2 shows the resident population and the relative populated density.

Tab.2 Resident population, populated density, relative to 2001.

Council	Surface km²	Populated density	Resident population
Anela	36,96	22	817
Bono	74,47	51	3800
Bottidda	33,83	24	804
Burgos	18,25	59	1068
Buddusò	217,97	19	4145
Bultei	96,61	12	1206
Esporlatu	18,31	26	475
Pattada	165,08	21	3513
Illorai	57,04	20	1121
Benetutti	94,53	23	2181

The comparison between the data of the resident population in the last thirty years (1981,1991,2001) (fig.4), highlights in nearly all councils an increase in the resident population in the 1981 - 1991 decade, and a decrease in the successive decade (1991 – 2001). The fall involved a reduction of the population that in the ten councils has been equal to approximately 2500 units relative to 1981.



	Anela	Bono	Bottidda	Burgos	Buddusò	Bultei	Esporlatu	Pattada	Illorai	Benetutti
2001	817	3800	804	1068	4145	1206	475	3513	1121	2181
1991	1406	6034	1240	1660	9607	2056	722	5669	1829	1160
1981	1065	4043	835	1218	6236	1621	561	3766	1359	931

Fig.4. Evolution of the resident population within the ten councils for the 1981–2001 period (Census data ISTAT)

This particular demographic phenomenon is probably attributed to the favourable economic trend of 80's years, during which the small and medium handicraft businesses that operated in the territory grew favourably, creating employment amongst the population. Once the phase of favourable economic conjuncture ended, the demographic presence in the area followed the decreasing trend to the par of many areas in the centre of Sardinia, following the depopulation of the inner areas to the advantage of the coastal ones.

Furthermore an important demographic tendency is the aging of the population, as marked by the index of old age - relationship between the elderly population (65 years and older) and younger population (0-14 years) – that for the study area is equal to 214 (G.A.L. Logudoro Goceano 2006). Moreso, we are looking at rather eloquent data of the existing tendency in the councils inside the Province of Sassari, that show a progressive decrease of the younger work force, capable of holding the garrison of the territory, culture and local traditions, and to generate circuits of economic growth and local development.

The economic course of this Sardinian area appears very similar to that of the other councils of the hinterland, far from the tourist areas which fell a higher percentage of employment difficulty and the deficiency of infrastructures to elevate the quality of life. The productive system of the area manifests noticeable weaknesses, introducing elements of frailty to the local economy, due to the limits of the industrial installations, a factor that is at least partially attributable to the morphology of the territory; either to the rapidity and the measure of the re-organization of the agricultural sector in the last decade; or to the limited capacity of the service sector (retailers).

The major village instead take benefit from the typical characteristics of the city, were the presence of public services and of a minimum of productive structure and private industry, still allow the presence of a secure economic vitality. A snapshot of the productive system, in particular of the secondary and tertiary sectors, is displayed in table 3.

Tab 3. Employed by economic and comunal activity section. (census source ISTAT 2001)

Councils	Agriculture	Industry	Commerce	Transport	Insurance, services	Other	Tot
Anela	42	49	43	12	10	92	248
Bono	154	241	174	25	36	369	999
Bottidda	20	42	22	14	9	109	216
Burgos	57	59	36	5	9	107	273
Buddusò	165	400	245	99	31	257	1197
Bultei	102	50	41	4	14	98	309
Esporlatu	17	35	16	4	6	43	121
Pattada	308	362	165	36	56	274	1201
Illorai	68	61	40	10	16	77	272
Benetutti	132	218	114	11	30	160	665
Tot	1065	1517	896	220	217	1586	

As seen in the table, the number of persons that find occupation in the agricultural sector and in the industry is very important. The two activities are closely linked since the industrial sector is represented by the cheese and milk industry. Infact within the area two cooperative businesses are present for the transformation of milk (Sa Concordia e Sa Costera) and a private cheese factory (Sarda Formaggi). Of remarkable economic importance is the tradition and the presence of the bakery, pastry and fresh sweets produce, which is spread uniformly over the whole area, in particular in the council of Benetutti.

The villages shown above, introduce an elevated distance with regards to the major city of the Province. Distance that signifies not only a physical barrier in regards to the weak cultural, national and international influences, but also, above all, a cultural barrier, obstacle to an active crossing into the global and local dialectic, that characterizes the contemporary society. Such distance has most weight on those who have a minor way of overcoming it and also constitutes an obstacle in the path of modernization.

The studied councils have mostly a agro-pastoral economy, were Sarda sheep are bred for the production of milk, and Sardo-Brown cattle for the beef production and the Italian Holstein and the "Brown " breeds for the production of milk. In the tougher zones, Sardinian goats are bred along with a small breeding of pigs for family consumption. The consistency of the zootechnical wealth of the study area, according to the data of V general agriculture census, is displayed in table 4.

Tab 4. Zootechnical consistency of the study area

Species	**Number Heads**	**ABU number**	**ABU (%)**
Bovine	14046	14046	43.3
Ovine	107988	16198.20	50.0
Caprine	2895	422.25	1.3
Suine	7453	1043.42	3.2
Equine	700	700	2.2
Total	133082	32409.97	100

Even in the Goceano area there is an absolute dominance of the two species (ovine and bovine) throughout the island. The territorial distribution of the zootechnical heritage varies between the various council areas according to the species. 55% of the ovine species is concentrated in the areas of Pattada, Buddusò and Benetutti, while the bovine species is concentrated in the areas of Pattada, Buddusò and Bultei. Also noticeable, is the number of swine bred, mainly for family consumption.

The territorial density (number of heads per hectare of territorial surface) is on average of 1,9 ovine, 0,19 bovine (Census ISTAT 2000). In the studied area, the semi-extensive and extensive ovine breeding co-exist.

The semi-extensive breeding requires the animals to recuperate for part of the year. Generally, this is during the giving birth period which coincides with the cold season. Even tough sheep spend the majority of their time grazing (natural pastures, improved pastures, pasture lands and annual grass crop lands) following the rules that allow the rational exploitation of resources, they spend various hours of the day within the farm area. This is where the mechanic milking takes place within modern milking halls, the administration of dry and concentrated forage, to be integrated in the daily food ration, and lastly the carrying out of veterinary controls.

The practice of grazing, on various lands for short periods of time, allowed by the discontinuity of the events practiced on dry cropped lands, determines the mobility of the herds thus guaranteeing the forage availability necessary for the entire year. Extensive breeding is typical in the lesser fertile areas generally hilly and mountainous, where the scarce productivity prevents the penetration of innovative technology and requires limited investments. Therefore, the retribution of the work and of the capital invested has to come from the extensiveness of the farm, as the production per unit surfaces, are very low. The extensive breeding is practiced in areas where permanent and semi-native pastures co-exist, as they are suitable to the biannual forage cultivations. The presence of Mediterranean vegetation is needed for the recuperation of the cattle and allows them to satisfy, with eventual integrations, their nutritional needs during the winter and summer seasons.

The extensive ovine breeding often comprises the main form of exploitation and therefore the livestock use of lands with scarce or mediocre agronomic fertility as well as unstable forage production. It is mainly practiced on lands of public or private property and on state or public lands, in the grater number of cases associated with the breeding of other species. In particular, that of the ovine in flat lands and hilly areas, and that of goats in hilly and mountainous areas. The breeding system is completely wild and if some buildings are present, they are represented by a hay barn or just a barn, were the animals go to recuperate during periods of the year.

The pastures, due to the water flow regime and to the transition of temperatures that characterise the Sardinian climate, present quantitative and qualitative profits which are irregular throughout the year. As a result, during the short time where the pasture natural availability exceeds the dietary needs of the animals are alternated by much longer periods, where the production of the pastures is amply insufficient. This situation determine a negative reflection on the profits of the animals. (Benedetto et al.,1994).

Pedologic – environmental Area

The photo-interpretation added to the creation of the map in digital form (shp) some landscape typologies of pastures (fig.5). In the map, to every polygon corresponds a category of pasture; same typologies of pastures are represented in the same colour. The photo-interpretation showed that that on every surface of 78.500 ha only a third were non grazed areas (fig.6). In this category are included both the lands of government forest lands as well as the urban centres, and this demonstrates how the studied area has had a strong agro-pastoral connotation.

17% of the surface belongs to the class of *Forest with small cultivated areas* and 16.5% to the class of *Grazed forest area.* This highlights how in the studied area the grazing of the forest under-layer is practiced. The presence of animals in such contexts certainly has positive effects on the ecosystem, in fact, the animals put into effect a clean up of the forest under-layer, containing the risk of fires, reducing competition between the vegetation species, as well as having with their excrement's a fertilising effect on the soil (Brandano et al., 1998).

It is important to underline how the natural pastures represent only 5%, showing how man during the centuries has modified the natural order of the territory.

Furthermore, such areas are found far away from urbanised centres and in hard to reach areas.

The *Pastures with small lakes and rivers* occupy 7.8 % of the entire surface and are mostly found in the south east of the area along the Tirso river, and in proximity of the Lerno river on the north-east.

4% represents the *Artificial Pastures* class and these are located in proximity to urbanised centres, beside roads, that allow easy access of agricultural vehicles in order to conduct the work on the field and the harvesting of the forage. In this category are also included the family farms, the vineyards and the olive groves that for coherence of the smallest cartographical unit could not have been excluded.

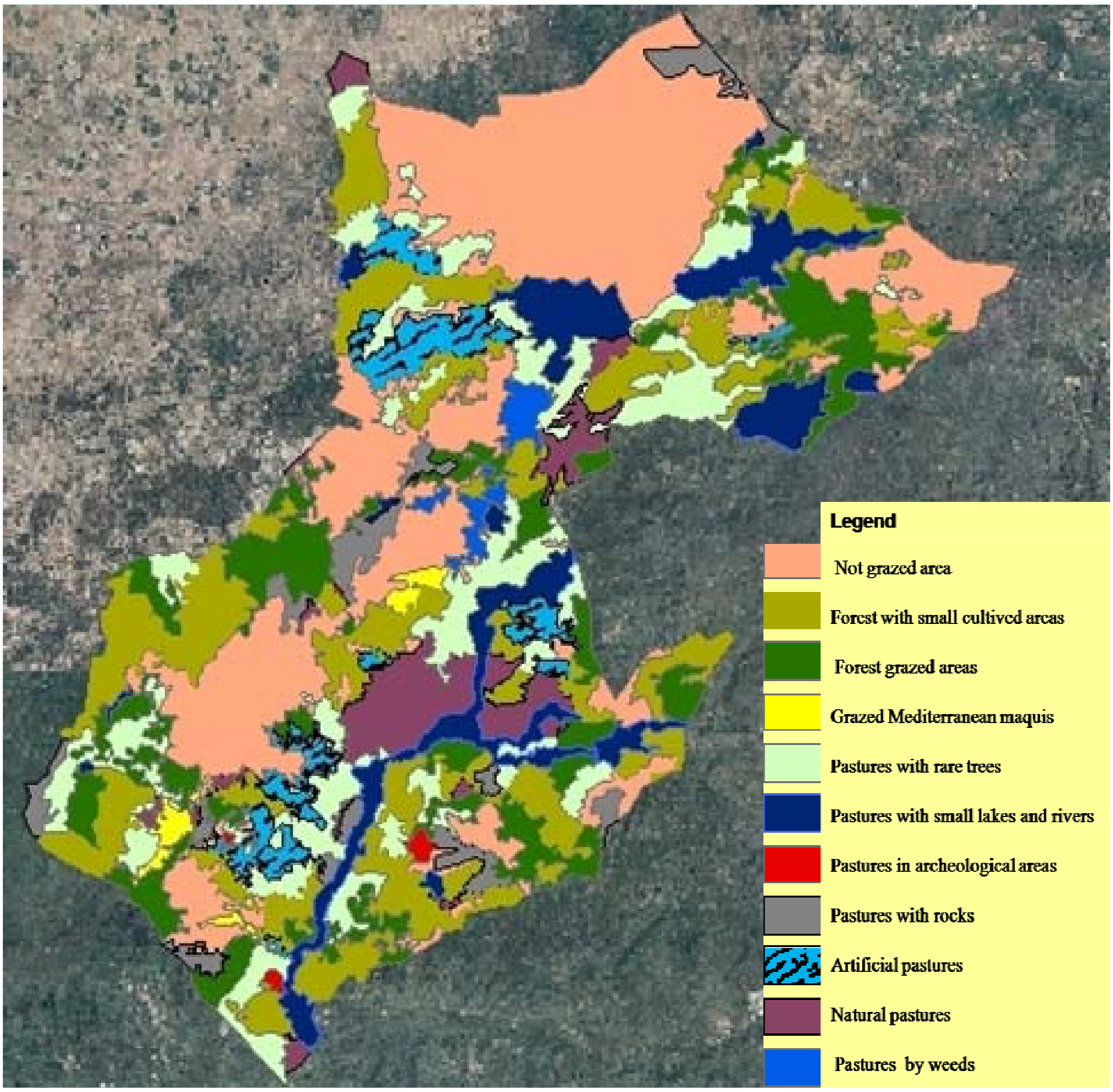


Fig.5. Map of the homogeneous areas for pasture.

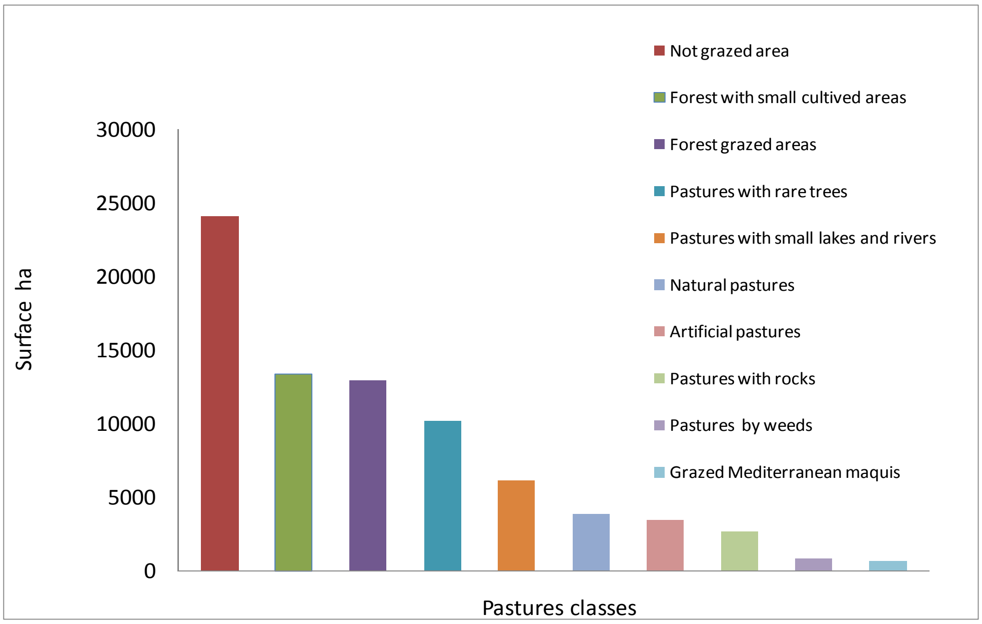


Fig 6. Classification of the different typologies of pastures

The superimposing of the map of the homogeneous areas for pasture with the gradient map showed (fig.7) that 99% of pastures are found in areas with a gradient between 0 and 22%, with regards to the agronomy limits in order to carry out the ploughing and the cultivation of the fields. Less than 1% of the areas fall within soils that have a gradient between 23% and 45%, that coincides with the non grazed areas because they fall within the areas of government forest land.

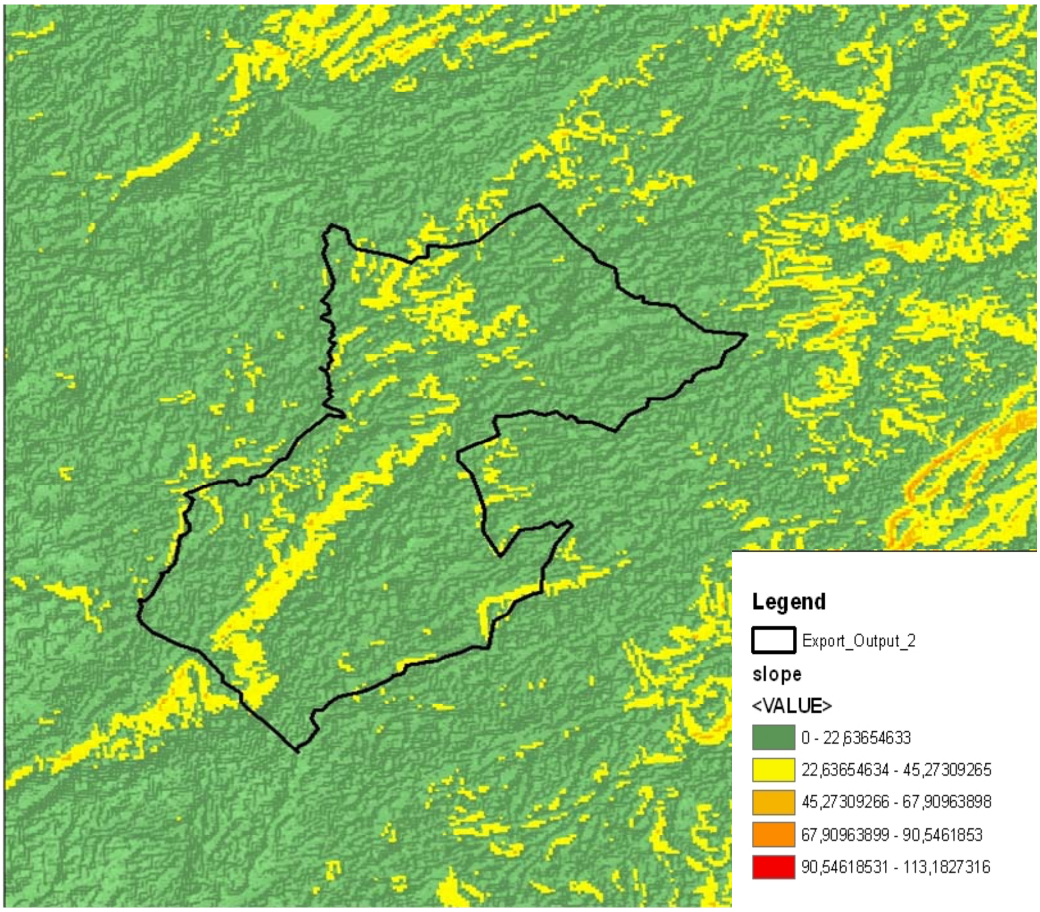


Fig. 7 Chart of the gradient pasture areas

The 1GO, 3GO, 4GO, 5GO, 6GO, 7GO, 9GO, 10GO and 11GO farms, from a pedologic point of view(fig.8), fall on landscapes made up of intrusive rocks (granite, granodiorite, leucogranite, ect) of the Palaeozoic, and relative slope deposits characterised by an acidity reaction, elevated rocks and stones, low depth, excess of skeleton and a high risk of erosion. From a morphologic point of view, they fall within harsh shaped areas and level land below 800-1000 asl, predominantly or scarcely void of any shrub or woody cover.

The 12GO, 13GO and 8GO farms are located on alluvial landscapes and on cemented Aeolian sandstones of the Pleistocene, with permeable or little permeable soils of moderate erosion, of which aptitudes of use are the cultivation of the herbaceous cultures an in the irrigated areas of woody cultures**.** From a morphologic point of view, they fall within flat to sub-flat lands void of any shrub or woody cover

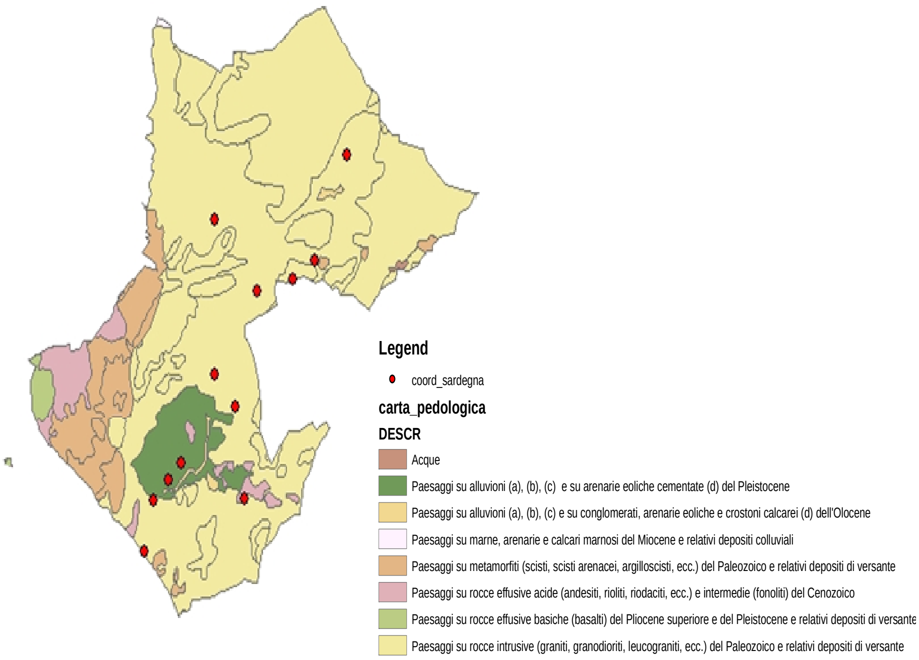


Fig.8 Pedologic chart and relative dislocation of the sample farms.

Zootechnical Area

The 13 studied farms representative of the livestock production reality of the Goceano are collocated between the different councils of the area (Tab5).

Tab. 5. Collocation of the studied farms

Councils	**N. Farms**
Anela	1
Benetutti	2
Bono	2
Buddusò	2
Bultei	2
Illorai	1
Pattada	2

The farms have a mixed livestock production address, with sheeps designated for milk production and bovines designated for meat production. The organization of the farms is characterised by a high extensiveness, mainly caused by the low intensity farm index and by the dominance of spontaneous forage productions utilised almost exclusively for grazing. Two farms produced their own cheese and one of them practices farm house activities. In the farms are bred on average 255 Sardinian ovine heads, that currently on average produce 42,000 kg of milk, with an average daily production per head of 1,025 kg and 207 days of lactation. The age at which the first birth occurs is on average in the 13th and 14ht month of life and the break between the giving births periods is very versatile between the farms. On average it's of 156 days with a standard deviation of 28 days, the mortality is on average of 5%. 60% of the births of new borns, is concentrated in the months of November-December, and for 20% in the months of February-March. The lambs exceeding the stocking rates quota, fixed around 20%, are butchered and sold for the production of meat at 25-35 days old.

The cultures present within the sample farms are the pastures, the autumn-spring grass cultivations and the grain and cereal cultures for the production of forage.

The surface annually designated for grass and/or grain amounts to an average of 27% of the farm surface. The grass cultivations are utilised with the grazing for the whole winter up until March, after which it is suspended in order to allow the re-growth of the grass designated for the production of hay.

The practiced rotation is based on the grazing rest, spaced out to every 3 – 4 years from the cultivation of the essential vegetation.

The natural pastures make up on average 60% of the farm surface and the grazing-lawns make about 16%, of which the average production is reported in (Tab.6)

Tab.6. Forage Productions

	Prod. t/ha		UF/kg SS	Prod. UF/ha		Prod. Average UF/ha
	Min.	**Max**		**Min.**	**Max**	
Natural Pasture	1.5	5	0.7	1050	3500	2275
Cultivation of oat grass or mixed	3	6	0.75	2250	4500	3375
Hay	2.5	5	0.65	1625	3250	2437.5
Cereals	1	2.5	1.1	1100	2750	1925
Hay cereals	1	2.5	0.4	400	1000	700
Woody and shrub pasture	0.975	3.25	0.7	682.5	2275	1478.75

Farm 1GO: The farm is located in the council of Bono (SS) at 287 asl at 40° 23'N of longitude and 9°04' E of latitude, on lands of harsh and sub-flat nature, characterised by a sandy texture, not very deep as well as by rocks that limit its usability. It is a farm that breeds exclusively Sardinian sheep for the production of milk that is completely given to the " Sa concordia" cooperative society. The lands on which the grazing takes place is in part owned property and in part rented, a part of the farm surface is utilised for the autumn-winter grass cultivation that are in part grazed and in part cut for the production of forage.

Farm 2GO the farm falls, in part, within the council of Bono and in part in the council of Anela (SS). The farm is sited at 265 asl at 40° 24' N attitude and 9° 04' E of longitude. The farm is located about 3km from the build up area of Bono on flat lands with a scarce woody and shrub cover. The farm breeds around 300 Sardinian sheep whose milk is entirely transformed by the cooperative society. The farm surfaces are in part designated to the grazing of animals and about 20 ha are designated to the sowing of the grass cultivations The manager autonomously runs all the farm practices including the management of the breeding and of the cultures as he possesses the machinery necessary to carry out the agronomy practices.

Farm 3GO is situated in the council of Buddusò at about 610 asl and 40° 34' N of latitude and 9°7' E in longitude, it is very close to the council of Osidda(SS), on lands with a harsh nature and elevated gradients, characterised by an high erosion factor. In the farm the breeding is mainly of sheep however, there is the occasional bovine and swine head. Within the farms a small creamery is present were the ovine milk is transformed in Pecorino while from the bovine milk the "Perette" cheese are produced. Connected to the farm is the farm house where the farm products are utilised for the preparation of the dishes. Four people work within the farm; the manager, that deals with the agro-zootechnical management, and three sisters that manage the transformation of both milk and meat as well as managing the farm house. Such productive system is the only one of the studied area and is an example of a multifunctional farm.

Farm 4GO the farm is located in the council of Buddusò at about 620 asl and 40° 60' N in latitude and 9° 25' E in longitude. The farm breeds Sardinian sheep on an owned property of extensive pastures and for three months of the year on lands of council property. Around 80% of the farm surface is characterised by woody pastures of Quercus Suber, in fact, together with the activity of cork extraction, the grazing of the forest under-layer is also carried out. Around 20 hectares of surface area are selected for the sowing of autumn-winter grass cultivations that are in part grazed and in part for the production of provision supplies. The farm is run by two owners that manage both the breeding and the carrying out of agricultural practices by means of equipped machinery and a recently bought tractor.

Farm 5GO farm is situated in the Pattada (SS) district at 40° 33' in latitude N and 9° 13' in longitude E at around 600 asl. The farm is located around 2Km from the built up area to which its connected via an asphalted road in the proximity of lake Lerno. Within the farm are bred "Sardo-Bruna" bovines for the production of milk. The milk is transformed directly in the creamery adjacent to the farm, into Perette cheese for the local market. The farm is run by the manager that mainly deals with the direction of the farm as he is employed the association of Sardinian Breeders (ARA) as a technician. For the care of the animals and for the execution of agricultural practices the farm turns to a fixed employee and for about 200 hours a year on a casual employee. The transformation of milk is done and managed by the family itself.

Farm 6GO the farm is located in the district of Buddusò at 40° 33' in latitude N and 9° 13' in longitude E at about 670 asl along the provincial road that connects Buddusò and Osidda. The area is one with a scarce woody and shrub cover, not very deep acid soils, elevated number of rocks and high risk of erosion. The farm breeds Sardinian sheep and transforms it's own milk in cheese and out of this, part is for self consumption and in part for the local market.

The farm is run by the owner who manages both the breeding and the transformation of milk. As the farm is not equipped with the necessary machinery and tractor needed for the agricultural practices it turns to a third party that as a matter of fact, represents an important cost section of the farm balance. Even though the farm doesn't exploit the full capacity of all the factors of the production, as it transforms its own milk and succeeds in the selling of the cheese, it results in an earning that is double in respect to the sales of the milk made in the creamery, thus allowing the farm to be economically sustainable.

Farm 7GO the farm is located in the council of Pattada at 40° 53' in latitude N and 9° 17' in longitude E at 560 asl. Within the farm are bred 360 ovine heads and 6 bovines of mixed breed "Sardo-Bruna" -. The farm, made up of a single farm body is run by the lessee that manages the animals and the execution of the agronomy practices tied to the cultivation of the autumn-winter grass cultivations.

Farm 8GO the farm is found within the council of Bultei at 40° 43' in latitude N and 9°13'in longitude E at around 310 asl, on not very deep lands characterised by a high number of rocks and acid and sub-acid reactions that strongly limit its utilisation. The land on which the farm is located is not particularly suitable for the agro-zootechnical activity, in fact, at short distance from the farm you can find an open mine were the extraction of granite takes place. Within the farm sheeps are bred, around 190 sheep on a total surface of 64 ha equal to 34 UAA.

Farm 9GO the farm is located in the council of Benetutti at 40° 46' in latitude N and 9°15'in longitude at 320 asl, on a flat area a few kilometres from the centre. Within the farm are bred 170 sheep heads and 35 Brown and Italian Holstein bovines on a surface of 37 ha. The produced milk is given to the "Sa Concordia" cooperative society.

Farm 10GO the farm is situated in the council of Bultei and is comprised of two separate farm bodies. The firts is found in the area of Molimentos and is of 40 ha, and the second is found in the area of Trunzu and has an extension of 30 ha. Within the farms are bred 60 bovines of Sardo Bruna- breed, and 300 Sardinian sheep that produce 30,000 litres of milk that are given to the cooperative society, as well as 5 horses of anglo-araibian breed. The farm has a good structural equipment, in fact, there is a multifunctional sample of 240 m^2 of recent construction, a hay barn of 300m^2 and the milking hall of 24 places.

Farm 11GO the farm is within the council of Benetutti 330 asl and at 40° 41' in latitude N and 9° 16' in longitude E; it extends it self on a surface of 50 ha that are mainly woody. Within the farm are bred 10 local native breeds of bovines and 260 Sardinian sheep.

Farm 12GO the farm is located in the council of Illorai at 40°43'in latitude N and 9°11' in longitude E and at 260 asl, on a flat area characterised by deep soils particularly suitable for the agro-zootechnical activity. Around 30% of the farm surface is designated to the sowing of legume and oat grass cultivations of which product is utilised for the dietary integration of the animals. However, part of it is also sold. The farm breeds Sardinian sheep of whose milk is given to the “Sa Concordia” cooperative society.

Farm 13GO Located at 40° 42’ in latitude N, 9° 08’ in longitude E and 620 asl in the council of Anela, on flat lands void of woody vegetation. The farm is made up of two farm bodies for a total surface of 60 ha in which are bred 40 bovines of Brown breed, and 370 Sardinian sheep. The dietary base of the animals is natural grazing, with integrations of hay that is in part produced by the farm and in part bought with additional integrated fodder. The work is carried out exclusively by the manager.

Chart of the stocking rates

The images show in detail the result of the spreading out of the stocking rates expressed as ABU/ha of grazable surface.

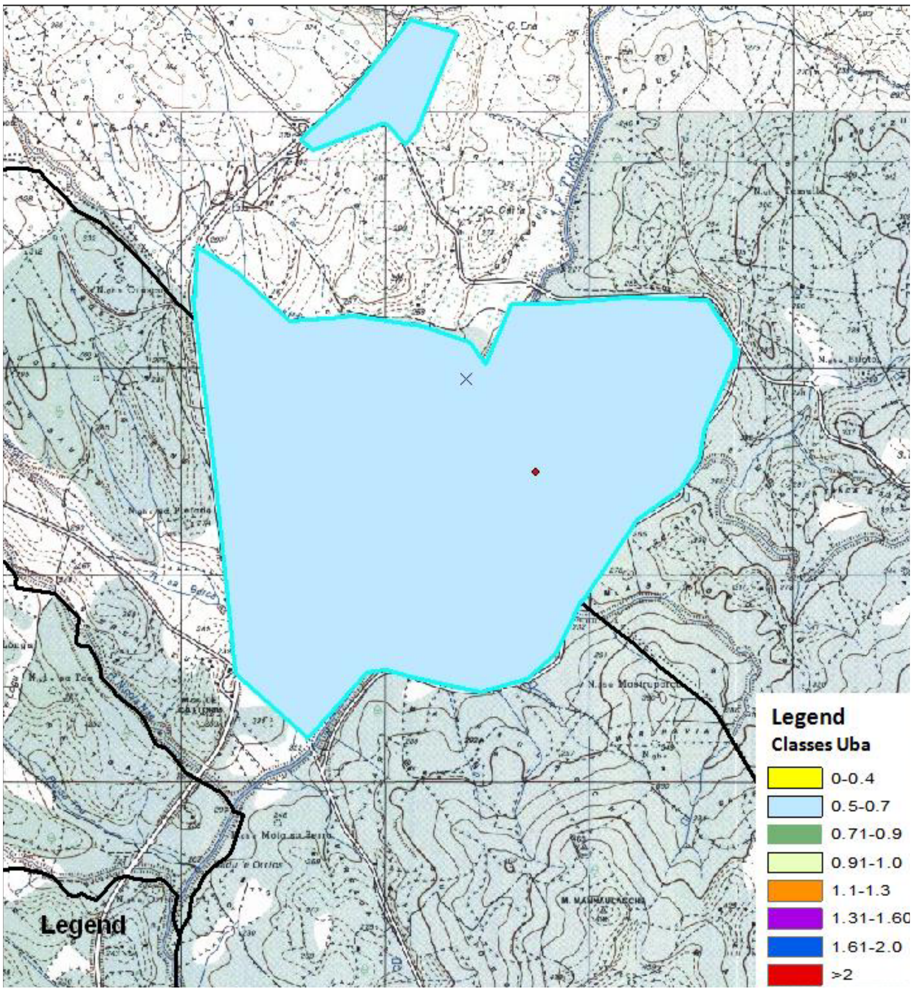


Fig 9. Chart of the stocking rates ABU/ha Grazed relative to the 1GO farm in scale 1:25000.

The 1GO farm is comprised by two farm bodies which have a 0,67 ABU/ha/year relative to the sheep breeding.

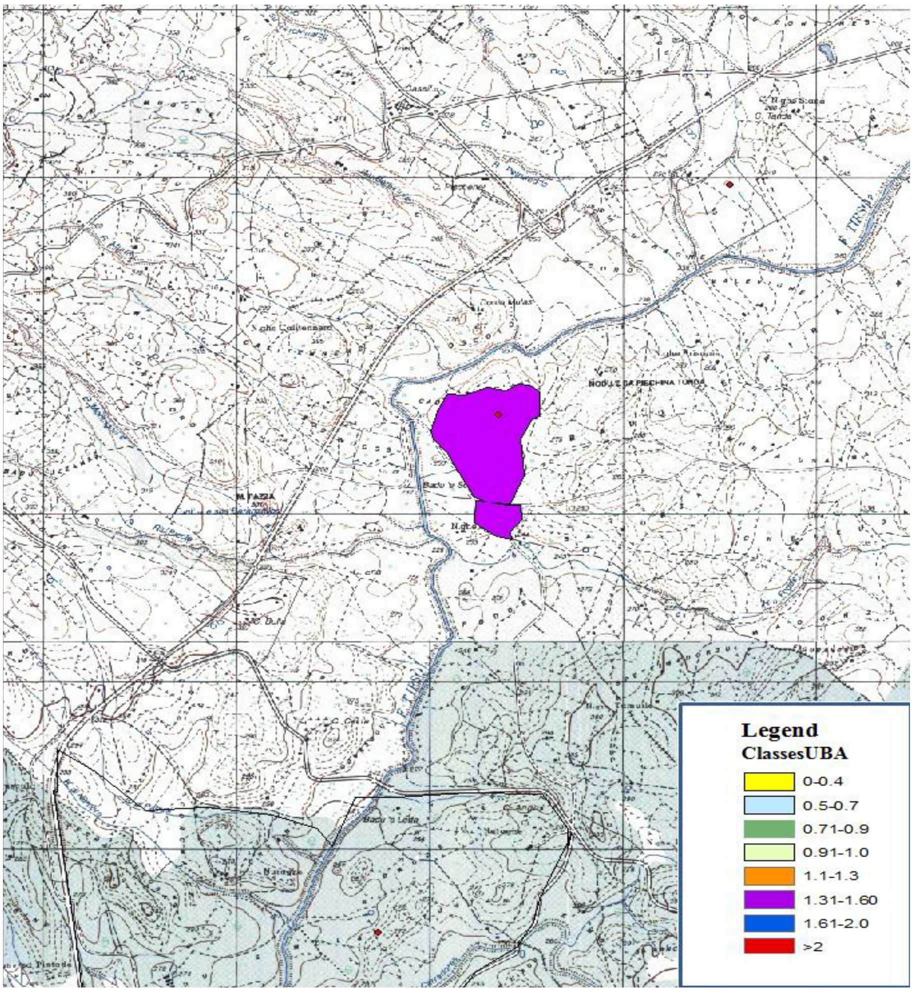


Fig. 10 Chart of the stocking rates ABU/ha Grazed, relative to the 2GO farm in scale 1:25000.

The 2GO farm is comprised of only one farm body of 30 ha which have a 1.43 ABU/ha/year.

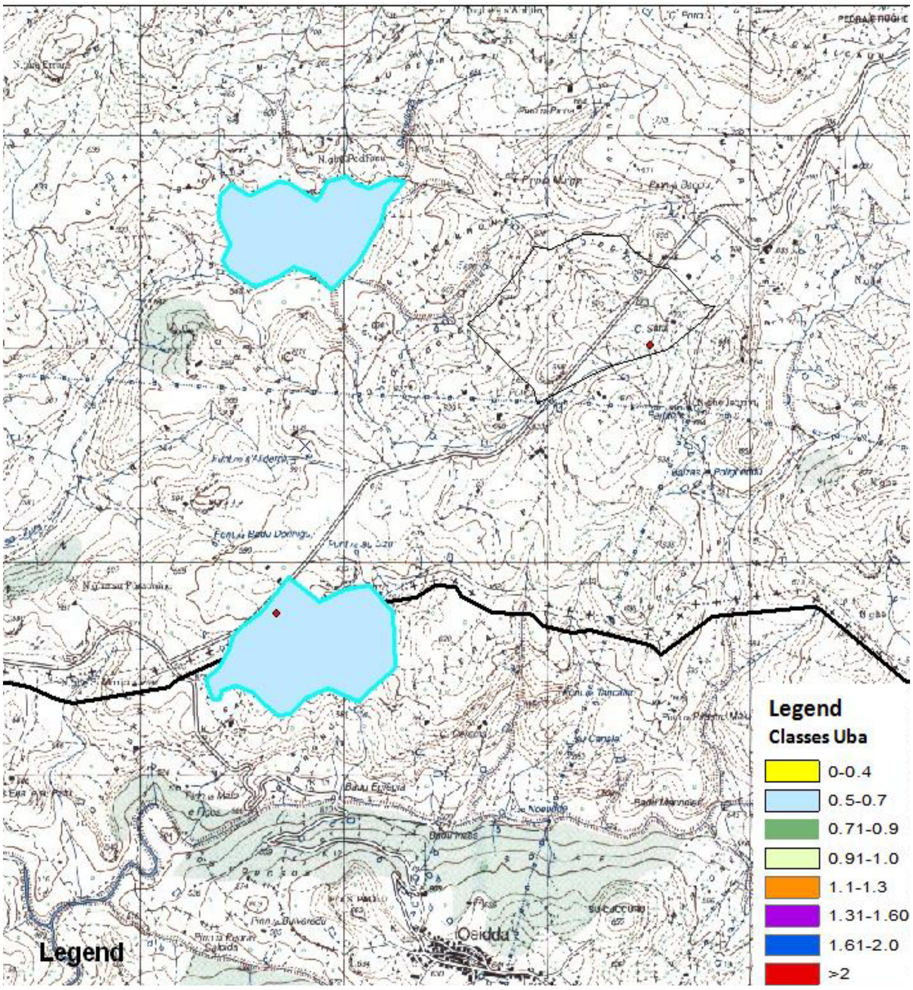


Fig.11 Chart of the stocking rates ABU/ha Grazed, relative to the 3GO farm in scale 1:25000.

The 3GO is comprised of two farm bodies for a total of 68 ha of grazed surface which have a 0,57 ABU/ha/year relative to sheep.

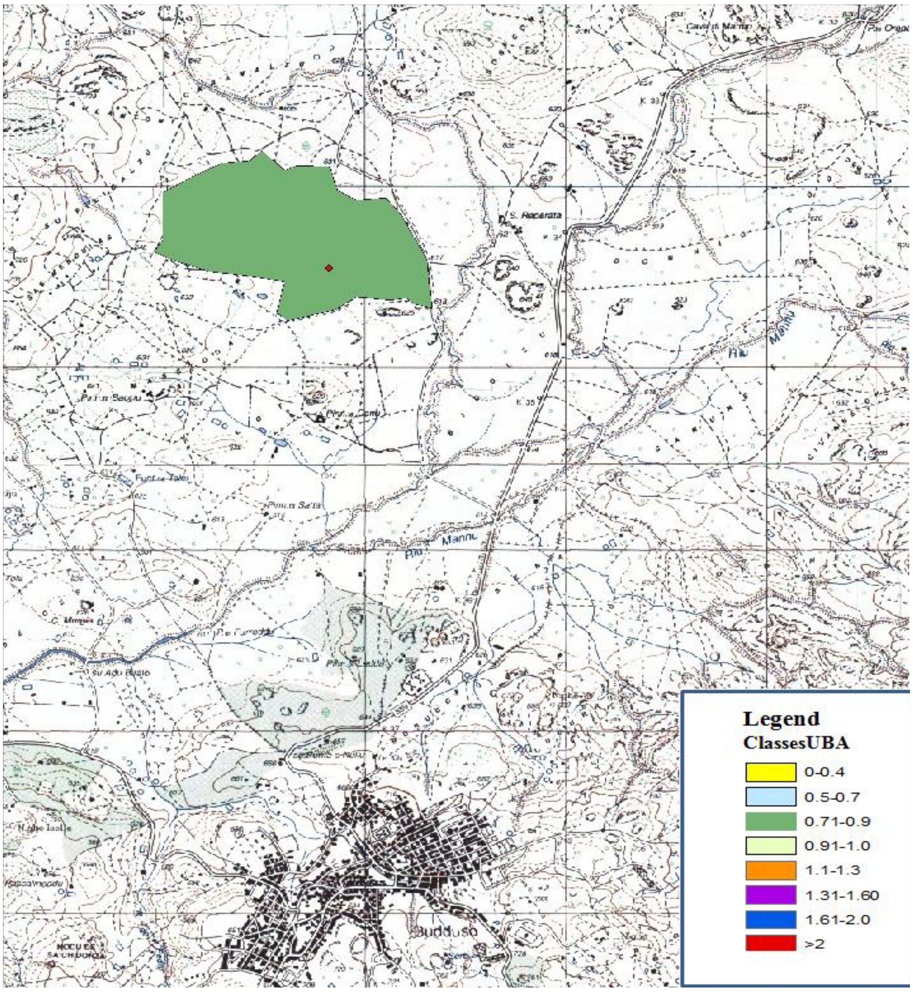


Fig.12 Chart of the stocking rates ABU/ha Grazed, relative to the 4GO farm in scale 1:25000 .

The 4GO farm is comprised on only one farm body of which grazable surface is 78 ha which has a 0,83 ABU/ha/year.

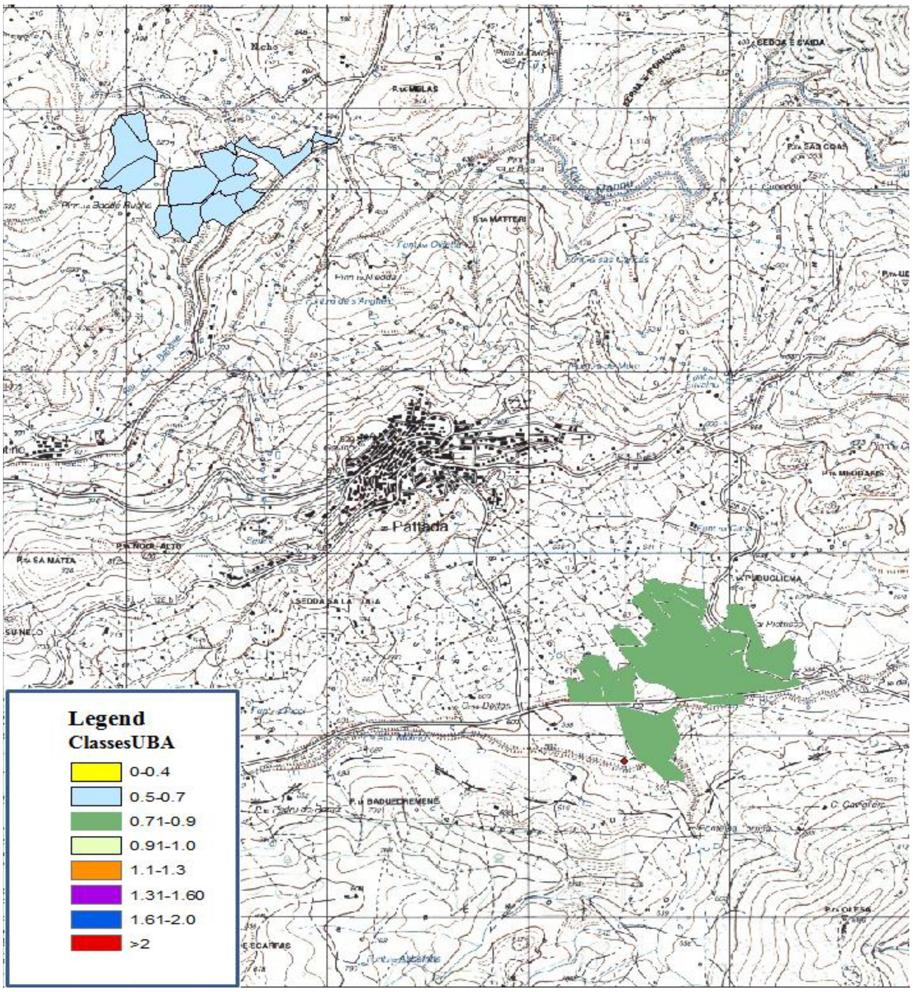


Fig.13 Chart of the stocking rates ABU/ha Grazed, relative to the 5GO farm in scale 1:25000.

The 5GO farm is comprised of two farm bodies of which one has a surface of 40 ha which has a 0,66 ABU/ha and the other has a surface of 30 ha which has a 0,75 ABU/ ha. Within the farm are only bred bovines heads that are divided between the two farm bodies in regards to the lactation stages.

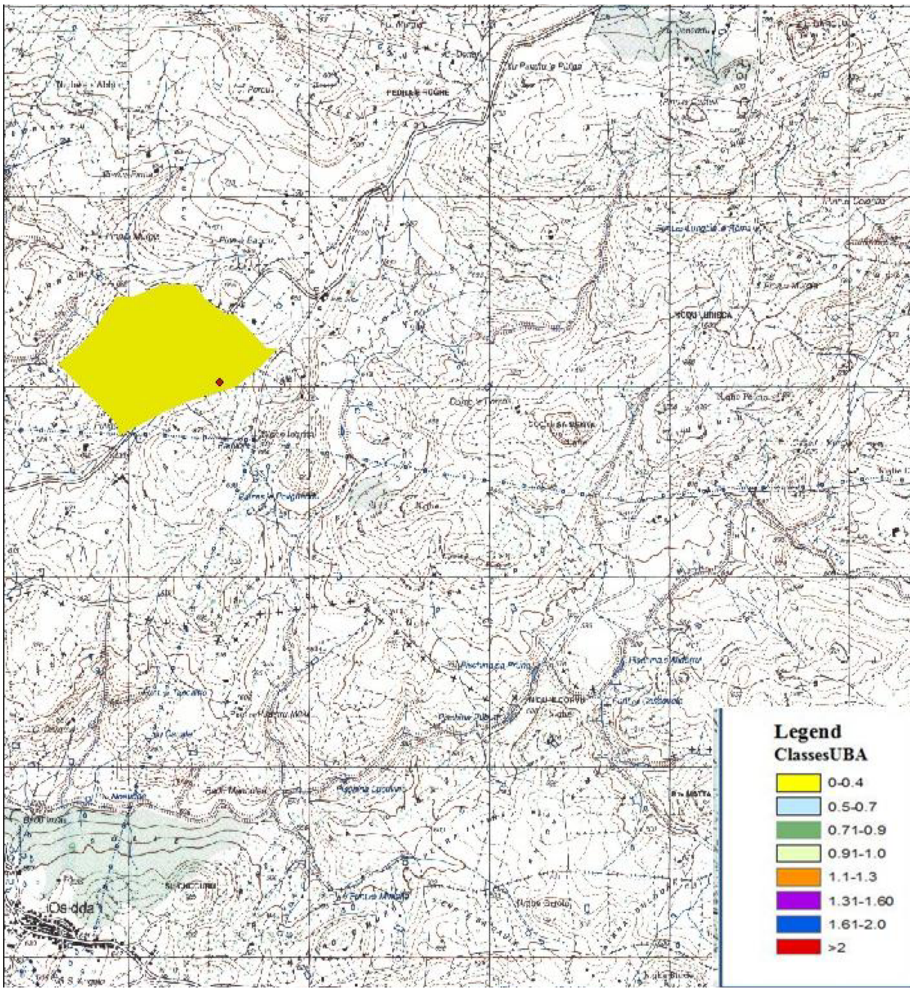


Fig.14 Chart of the stocking rates ABU/ha Grazed, relative to the 6GO farm in scale 1:25000.

The 6GO farm is comprised of a single farm body of which grazable surface is of 48 ha which has a 0,4 ABU/ha all relative to the ovine specie.

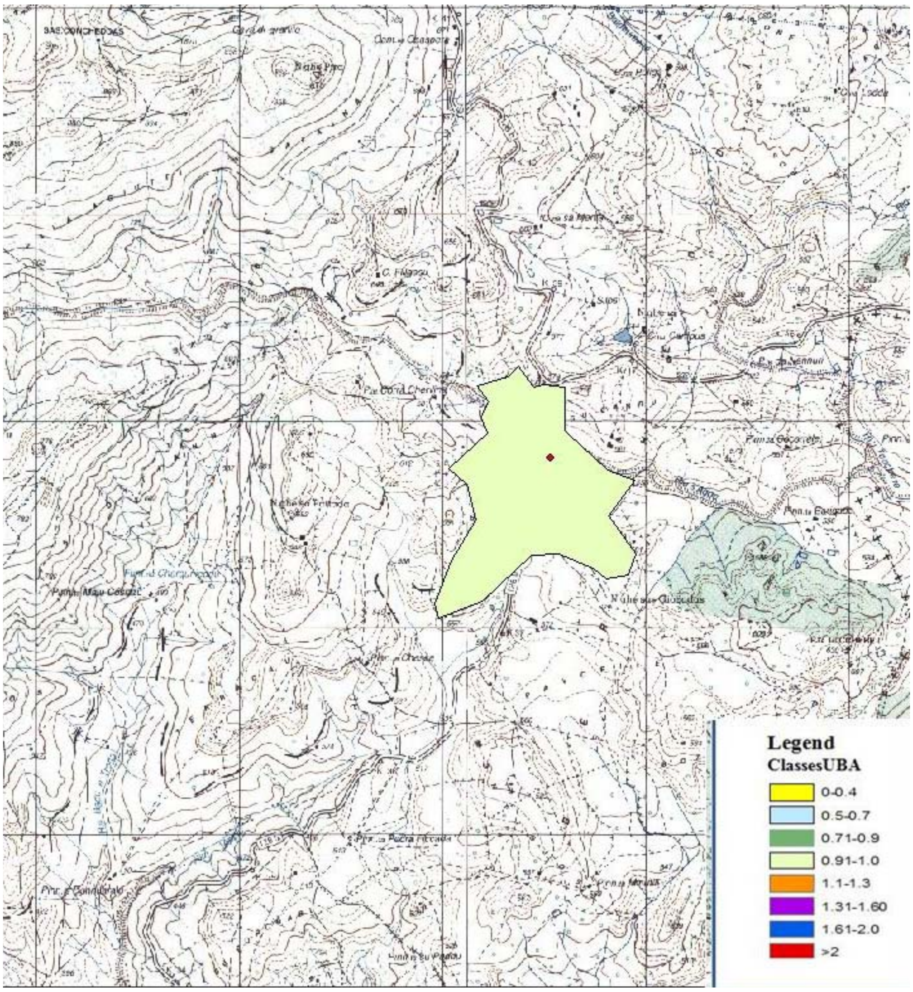


Fig.15 Chart of the stocking rates ABU/ha Grazed, relative to the 7GO farm in scale 1:25000.

The 7GO farm is comprised of only one farm body of 62 ha which has a 0,93 ABU/ha.

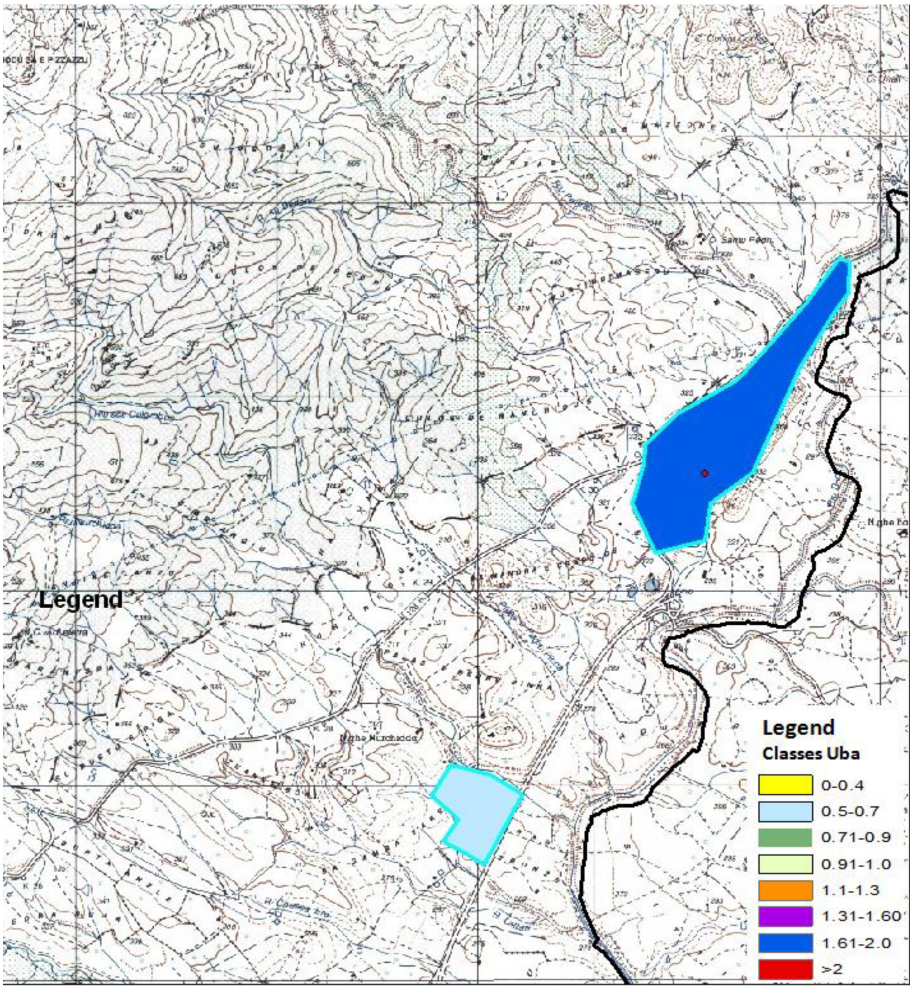


Fig.16 Chart of the stocking rates ABU/ha Grazed, relative to the 8GO farm in scale 1:25000.

The 8GO farm is comprised of two farm bodies of which one is of 12 ha which has a 0,55 ABU/ha/year and the other is of 50 ha which has a 1,66 ABU/ha relative to the breeding of sheep.

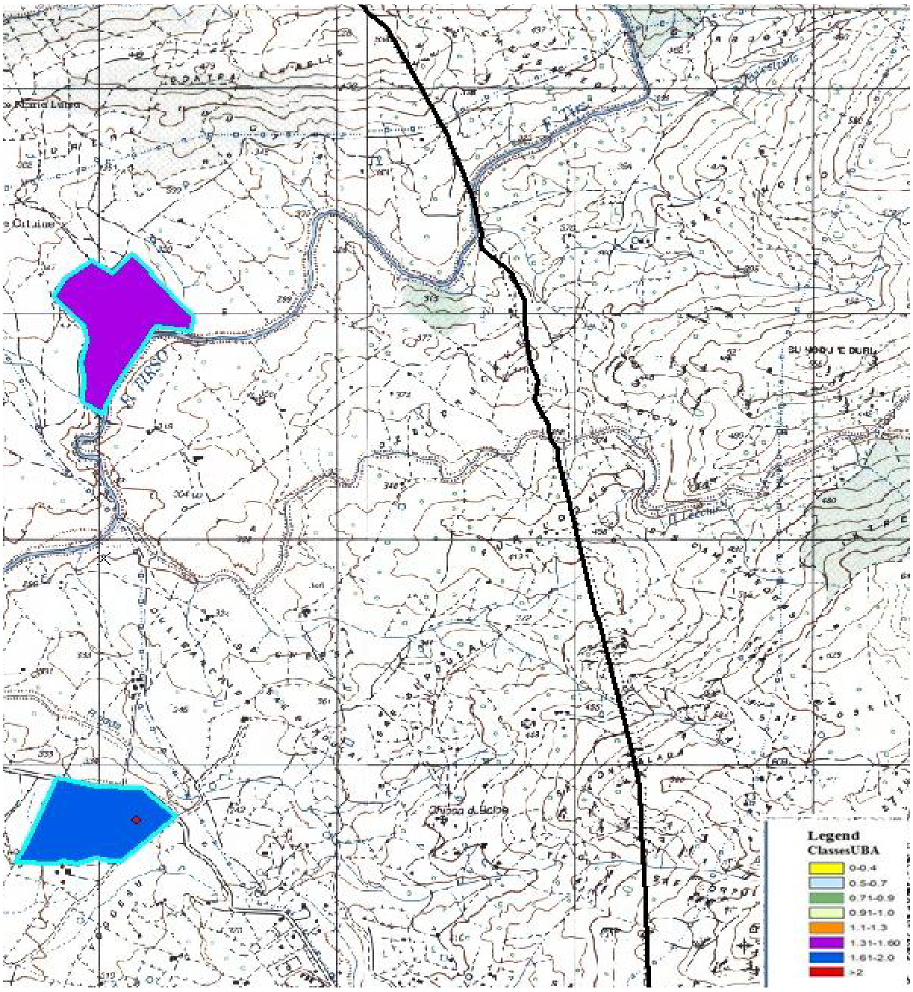


Fig.17Chart of the stocking rates ABU/ha Grazed, relative to the 9GO farm in scale 1:25000.

The 9GO farm is comprised of two farm bodies, one of 15 ha and the other of 20 ha. In the first the ABU/ha is 1,5 relative to the ovine breeding and in the second it's of 1,7 relative to the bovine species.

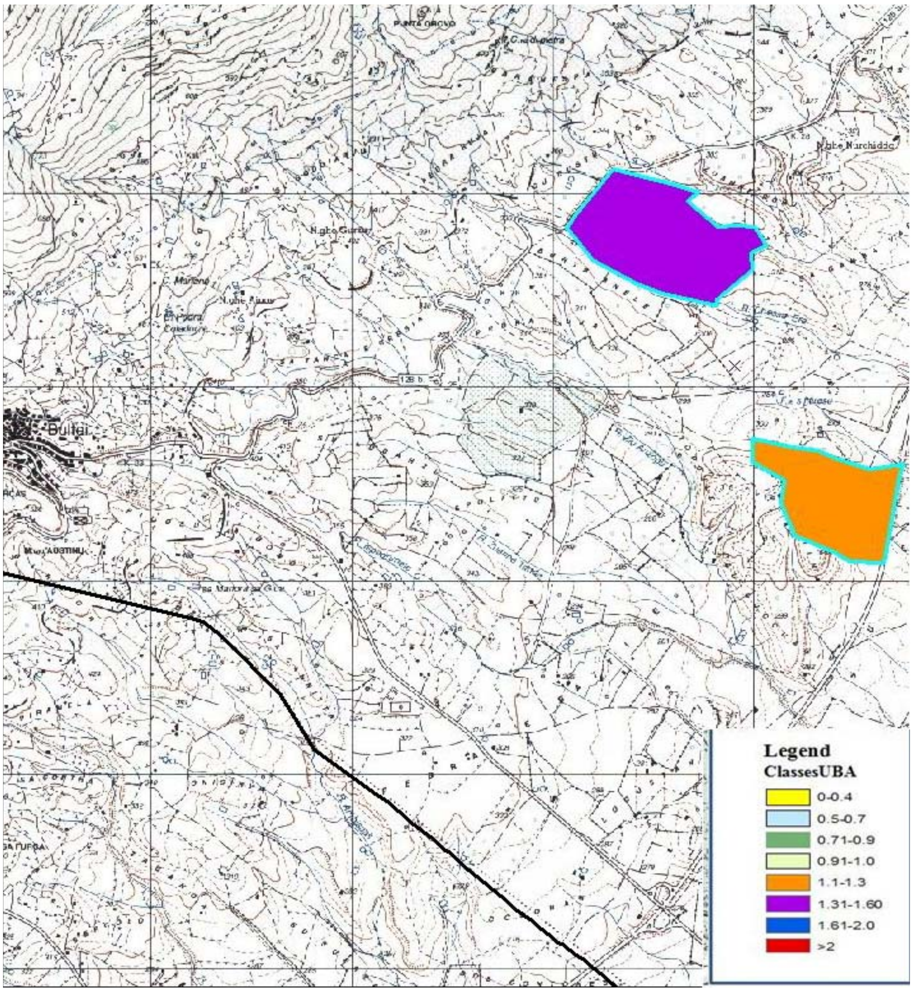


Fig.18 Chart of the stocking rates ABU/ha Grazed, relative to the 10GO farm in scale 1:25000 .

The 10GO farm is comprised of two farm bodies one of 30 ha and the other of 40 ha. In the first body there is a 1,5 ABU/ha relative to the ovine breeding and in the second there is a 1,2 ABU/ha relative to the bovine species.

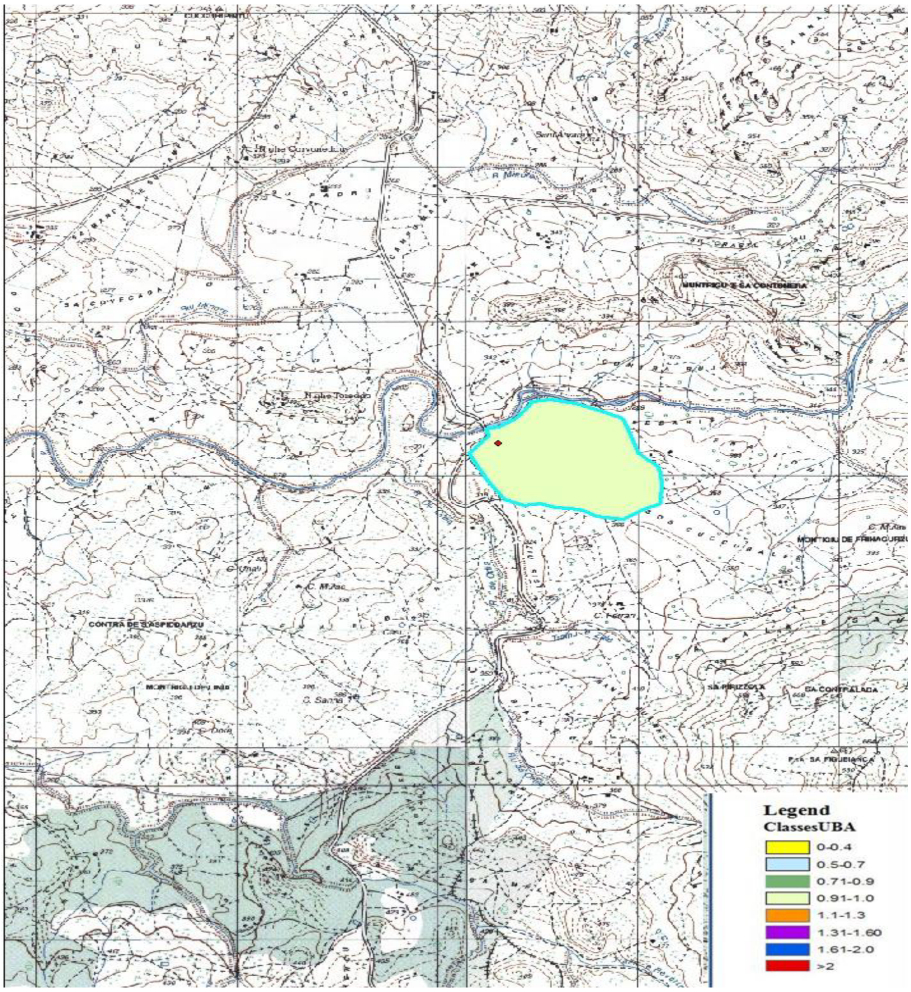


Fig.19 Chart of the stocking rates ABU/ha Grazed, relative to the 11GO farm in scale 1:25000.

The farm is comprised of a single farm body of 50 ha which has a 1 ABU/ha/year including both he ovine and bovine breeding.

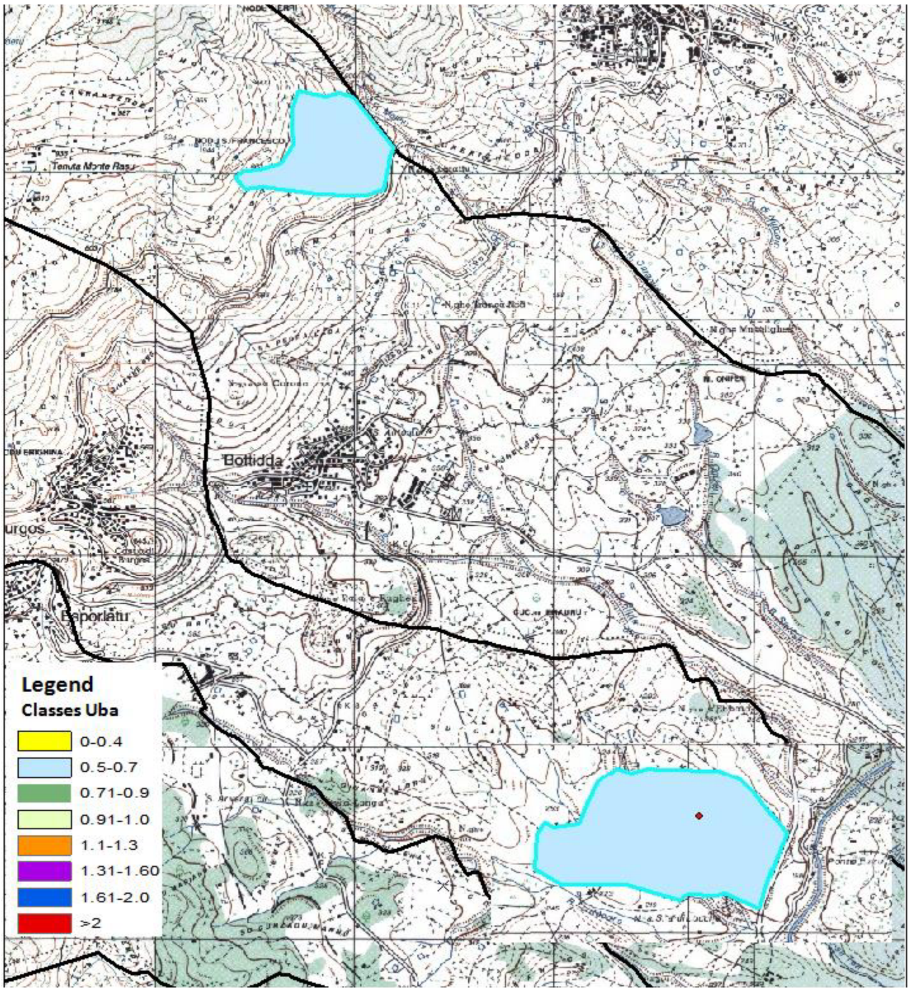


Fig.20 Chart of the stocking rates ABU/ha Grazed, relative to the 12GO farm in scale 1:25000.

The 12GO is comprised of two farm bodies, one of 60 ha and the other of 30 ha which have a 0,5 ABU/ha/year relative to the sheep breeding.

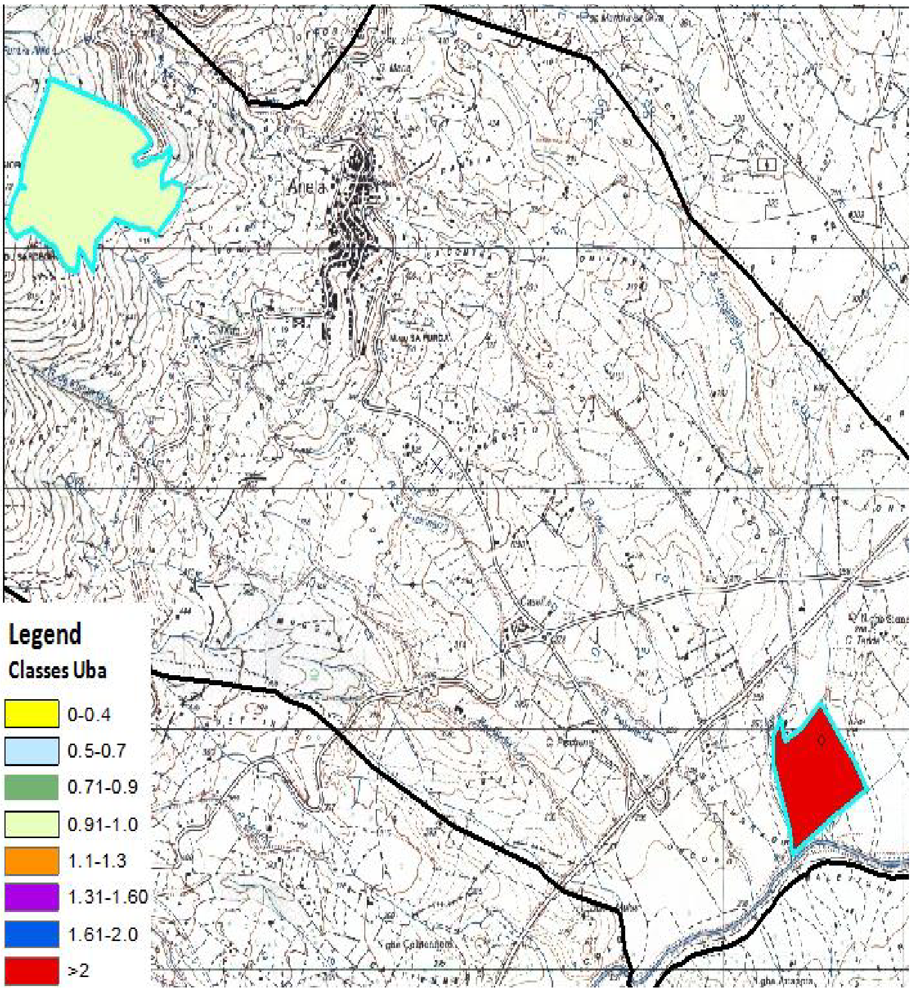


Fig.21 Chart of the stocking rates ABU/ha Grazed, relative to the 13GO farm in scale 1:25000 .

The 13 GO is comprised of two farm bodies of which one is 17 ha and the other is 43 ha. In the first body there is a 2,17 ABU/ha relative to bovines and in the second there is a 1,06 ABU /ha relative to ovine breeding.

The use of the GIS software allowed the spreading out of the stocking rates expressed as ABU/ha/year on the grazed surface by the animals, as well as to discriminate the intensity of the load in relation its spatial temporal use. This can be seen in particular in the chart relative to the 8GO farm were the breeding of 28

ABU ovines on two farm bodies takes place. In the first body comprised of 50 ha, the animals are present for 9 months of the year, determining a ABU/ha/year load equal to 1,66 ABU ha. In the second farm body of 12 ha the animals are only taken to graze for 3 months of the year determining a ABU/ha/year load equal to 0,55.

The spatial analysis carried out with the GIS also allowed to discriminate the modality of the farm management; as can be seen in the chart relative to the 5GO farm. In the underlined farm 35 Sardo-Bruna cows are bred for the production of milk, on two farm bodies. In the first body were the main farm is found the cows in lactation are bred with a recuperation period determining a load equal to 0,75 ABU/ha/year and in the second body of 30 ha the cows in a non lactation state are bred determining a load equal to 0,66 ABU/ha/year. The elaboration highlighted such a difference by attributing to each body a different colour in relation to the ABU/ha/year class to which it belongs.

For the 3GO farm, even though it's comprised of two farm bodies, the elaboration didn't highlight differences in the stocking rates as both bodies were utilised simultaneously in relation to the productivity of the pasture. Such type of farm management is feasible as in both bodies there are areas of recuperation for the animals and due to the low price of remuneration of the milk, that for the year 2006 was equal to 0,53 € per litre of milk given away, the manager decided to put into effect the manual milking in order to reduce the costs of production..

For the 9GO, 10GO and 13GO farms comprised of two farm bodies and in which are bred both sheep and bovines, the division of the ABU/ha/year was carried out between the two farm surfaces. This was in relation to the fact that the manager stated that in one body sheep were bred and in the other bovines were bred. Such modality of farm management was also found by Brandano, (1984).

Almost all the studied farms show an elevated grade of extensiveness within the environmental sustainability range planned by the PSR Sardinia 2007-2013 equal to 0,5 ABU/ha as a minimum value and 2 ABU/ha as a maximum value. Only 13GO and 6GO make an exception. The first relative to the farm body in which bovines are bred of which ABU/ha/year load is of 2,17. Such surplus however, can be easily re-dimensioned, modifying the management of the total farm surfaces, dividing animals between the two farm bodies keeping in mind the fact that between the balance of the ABU/ha/year the ones with a deficit balance are the majority, in the farm the results on the whole lead to a 0,7 ABU/ha/year.

The 6GO farm on the other hand, reaches the minimum value having a load of 0,4 ABU/ha/year. Such a situation is justified by the fact that the manager is the only person who worked in the farm dedicating himself to the breeding of the animals and the cultivation and transformation of all the produced milk. Therefore the breeding of a superior number of animals would require the neglect of other work units.

The high grade of extensiveness, the mixed breeding of sheep with bovines, the division of the farm in more farm bodies located at different altitudes found within the studied area, are in line with what is reported in literature on the management of marginal areas (Bertaglia et al.,2007, Woodhouse et al.,2005 MacDonald et al., 2000).

Chart of nitrogen distribution

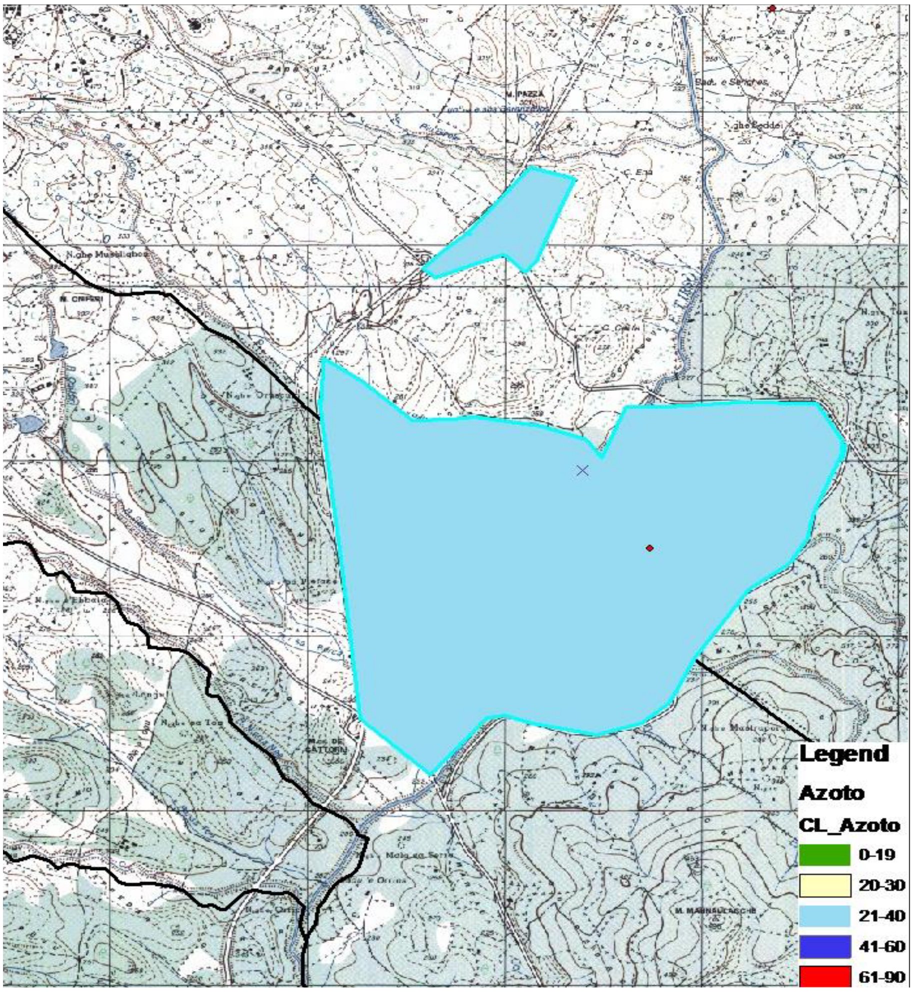


Fig.22 Chart of released N relative to the 1GO farm in scale 1:25000

On the lands of the 1GO farm the breeding of 38 ABU sheep releases 35 kg N/ha/year

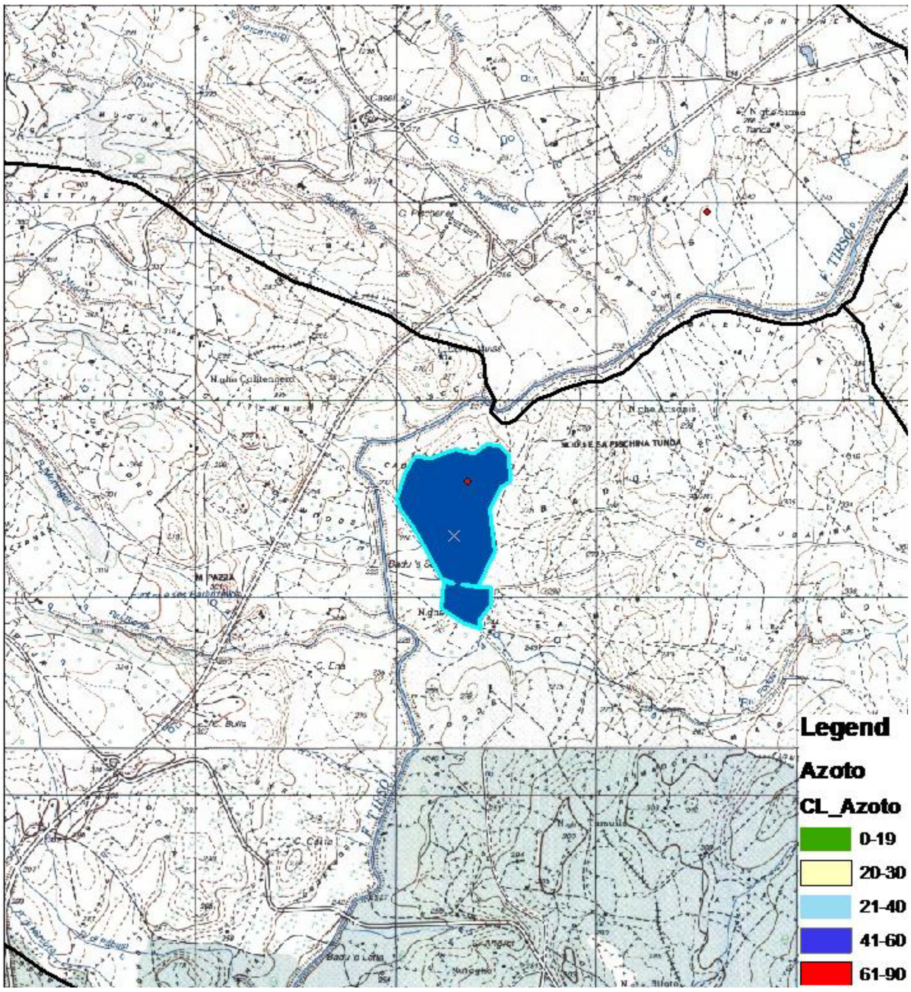


Fig.22 Chart of released N relative to the 2GO farm in scale 1:25000.

In the 2GO farm the breeding of 43 ABU sheep releases 53 kg N/ha/year.

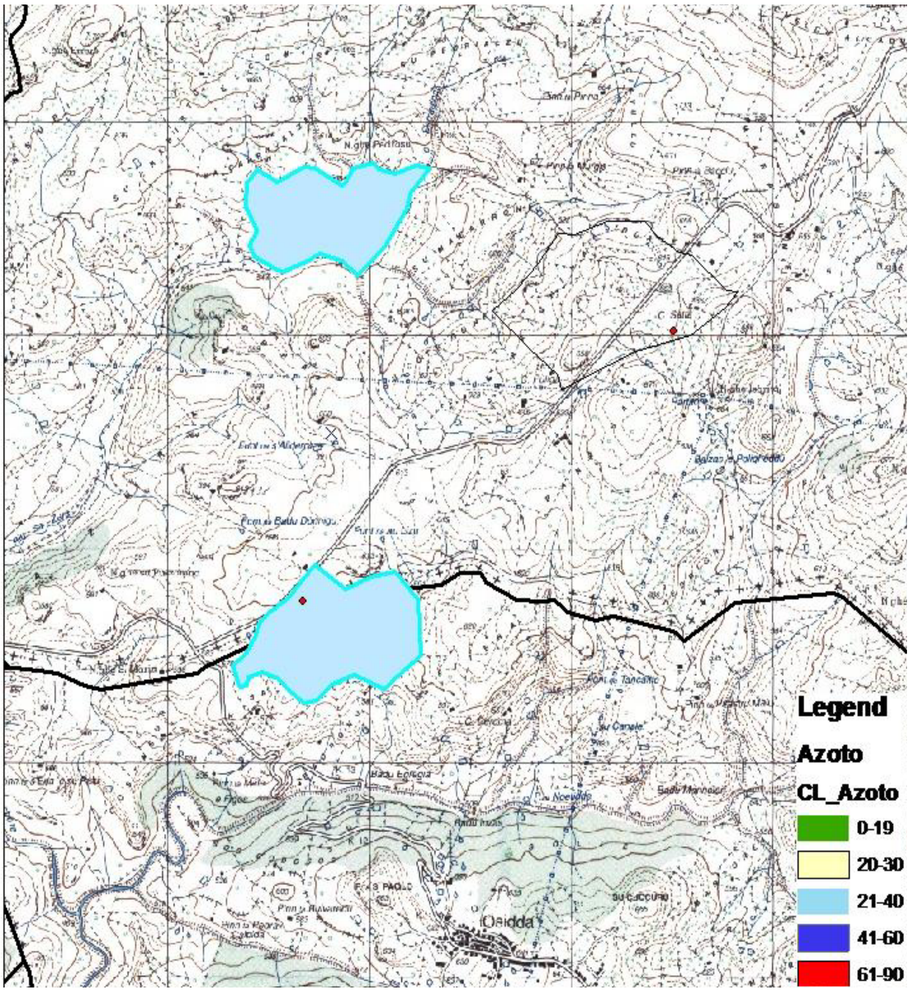


Fig 23 Chart of released N relative to the 3GO farm in scale 1:25000.

In the 3GO farm the breeding of 39 ABU sheep releases 32 kg N/year.

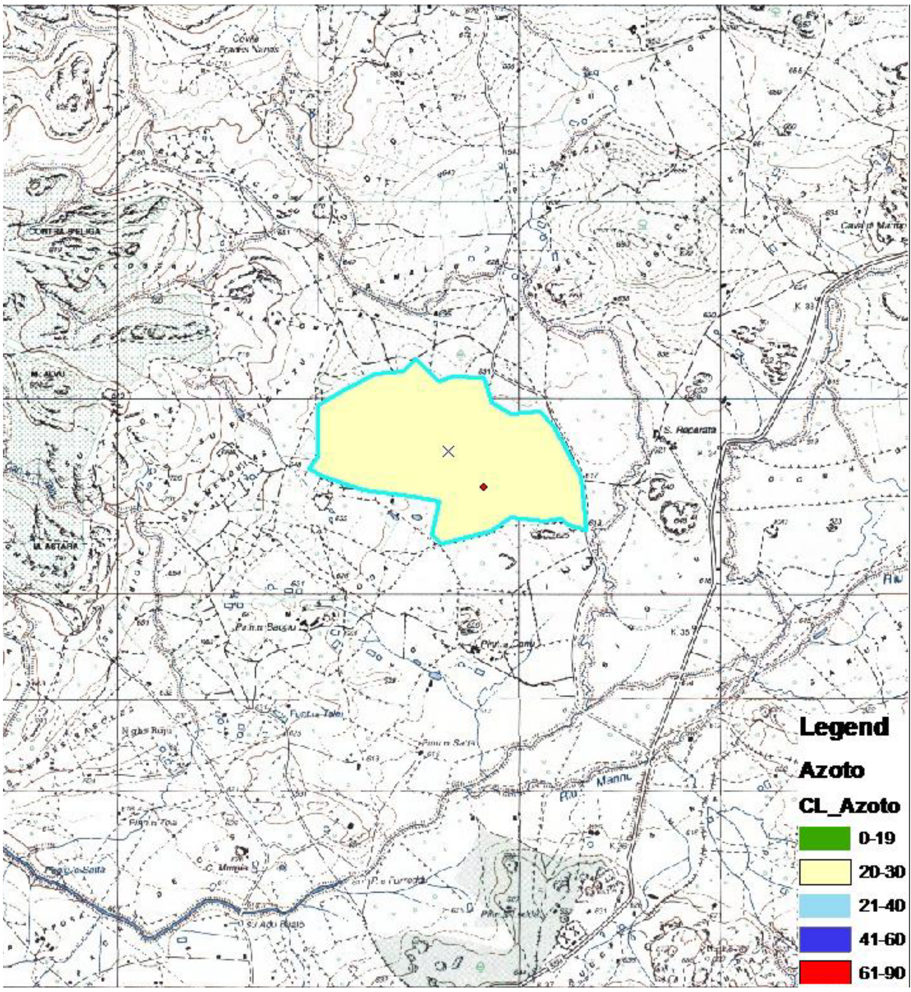


Fig.24 Chart of released N relative to the 4GO farm in scale 1:25000.

In the 4GO farm the breeding of 65 ABU sheep releases 29 Kg N/ha/year.

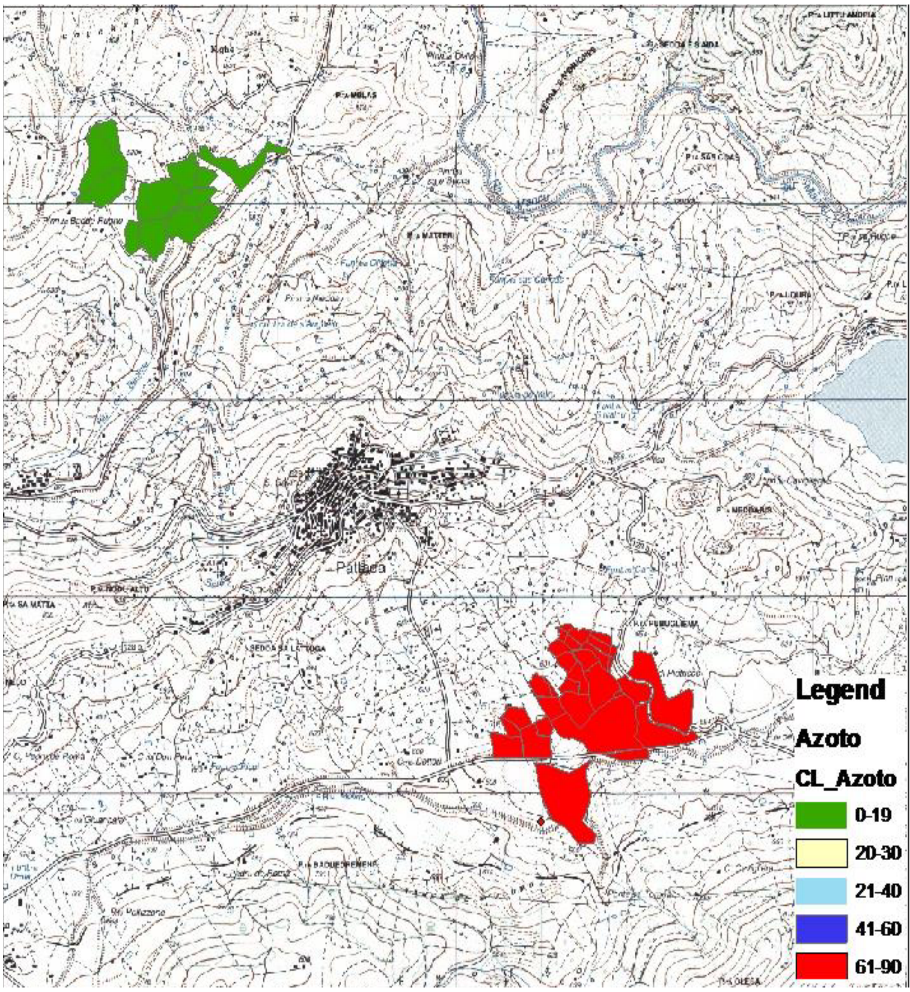


Fig.25 Chart of released N relative to the 5GO farm in scale 1:25000.

In the 5GO farm comprised of two farm bodies releases respectively 85 kg N/ha/year and 15 kg N/ha/year relative to the breeding of Sardo Bruna- bovines.

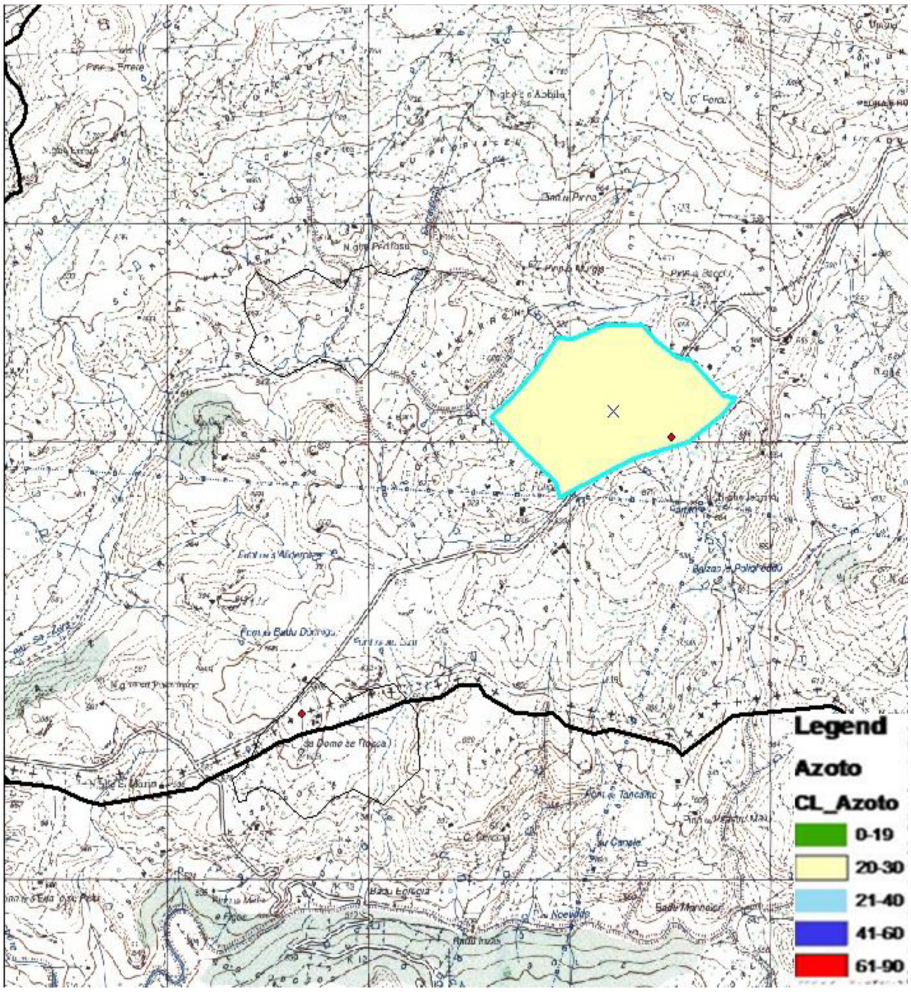


Fig.26 Chart of released N relative to the 6GO farm in scale 1:25000.

In the 6GO farm the breeding of 20 ABU sheep releases 22 kg N/ha/year.

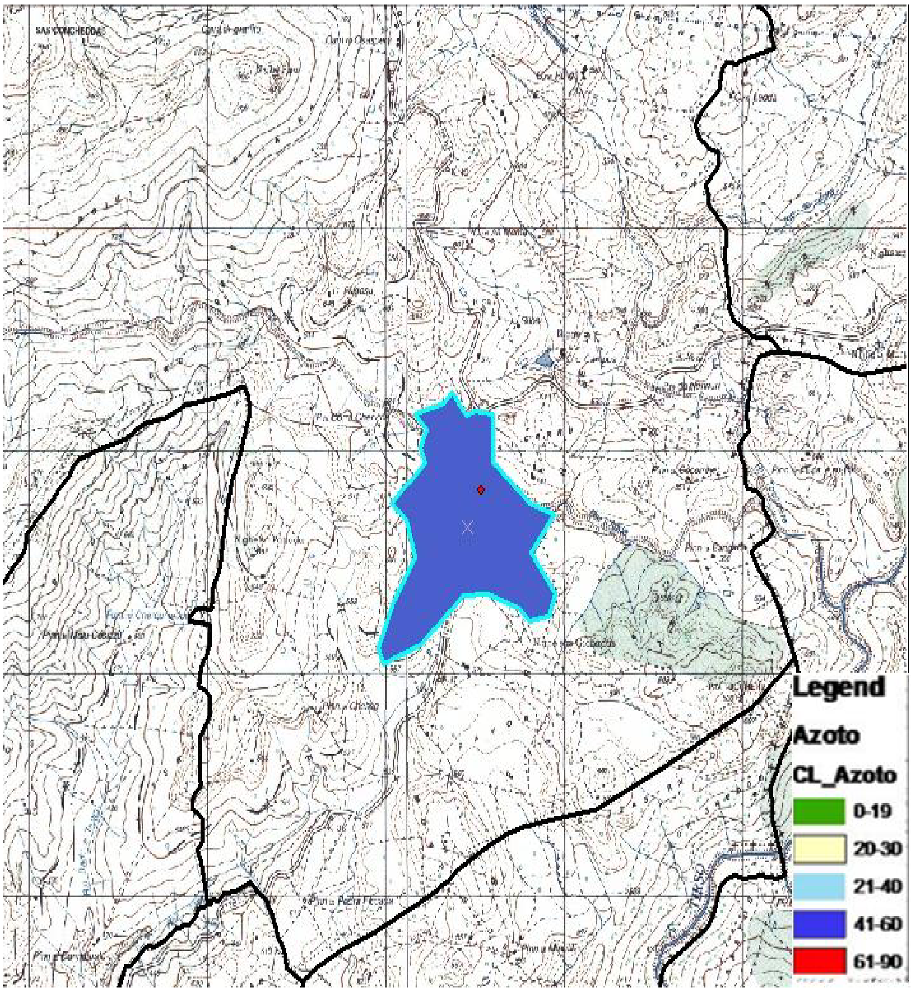


Fig.27 Chart of released N relative to the 7GO farm in scale 1:25000

In the 7 GO farm the breeding of 58 ABU sheep releases 42 kg N/ha/year.

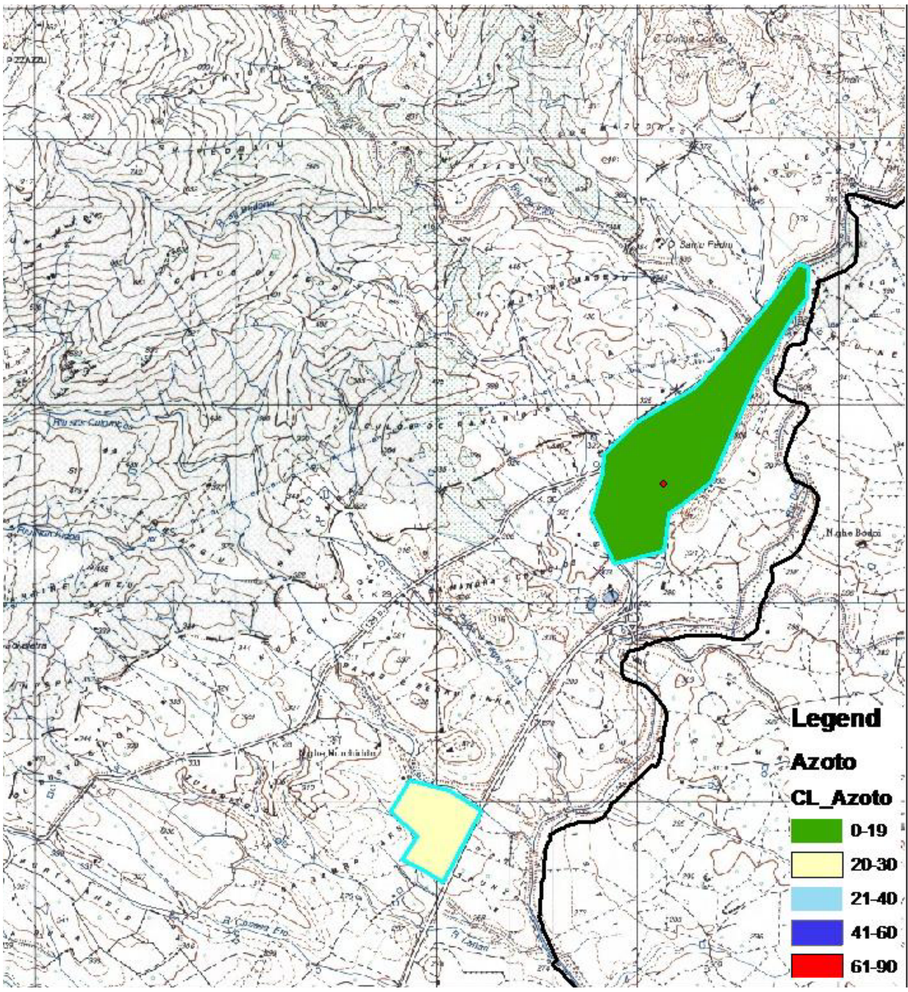


Fig.28 Chart of released N relative to the 8GO farm in scale 1:25000

In the 8GO farm comprised by two farm bodies that are run with different loads throughout the year, the quantities of nitrogen released are equal to 22 kg N/ha/year and 8 kg N/ha/year.

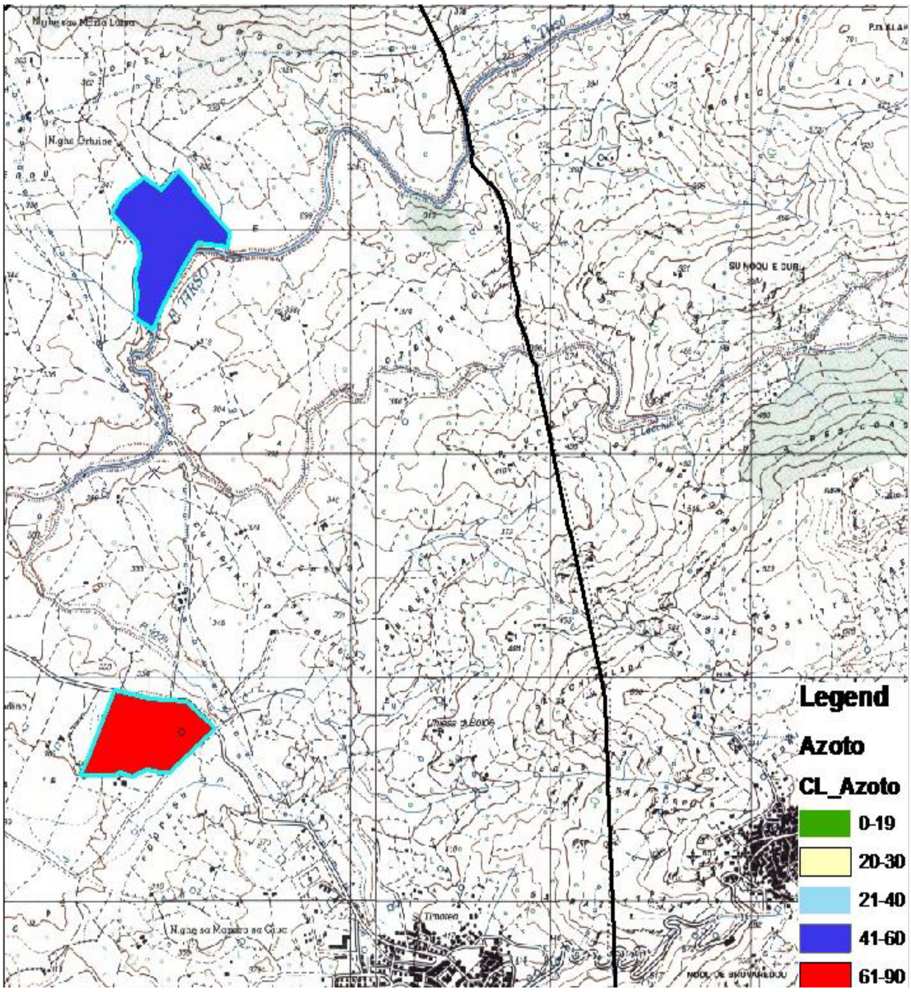


Fig.29 Chart of released N relative to the 9GO farm in scale 1:25000

The 9GO farm is comprised of two farm bodies. In the first one of 20 ha where 30 ABU bovines are bred, the Bovin-latte model's estimated N release was of 52 kg N/ha/year. In the second farm body of 17 ha where 25 ABU sheep are bred, the model's estimated N release was of 88 kg N/ha/year..

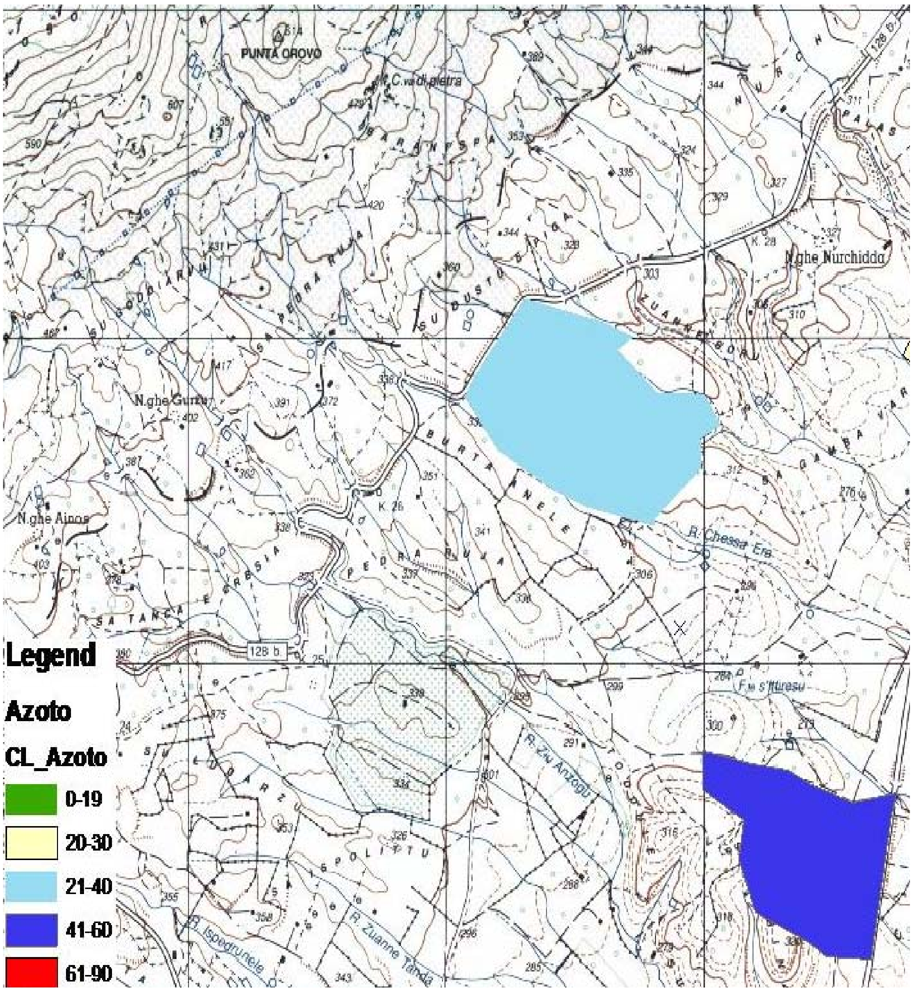


Fig.30 Chart of released N relative to the 10GO farm in scale 1:25000

The 10GO farm is comprised of two farm bodies, one of 30 ha and the other of 40 ha. The first releases 60 kg N/ha/year by the breeding of 45 ABU bovines, while in the second releases 40 kg N/ha/year relative to the breeding of 45 ABU sheep.

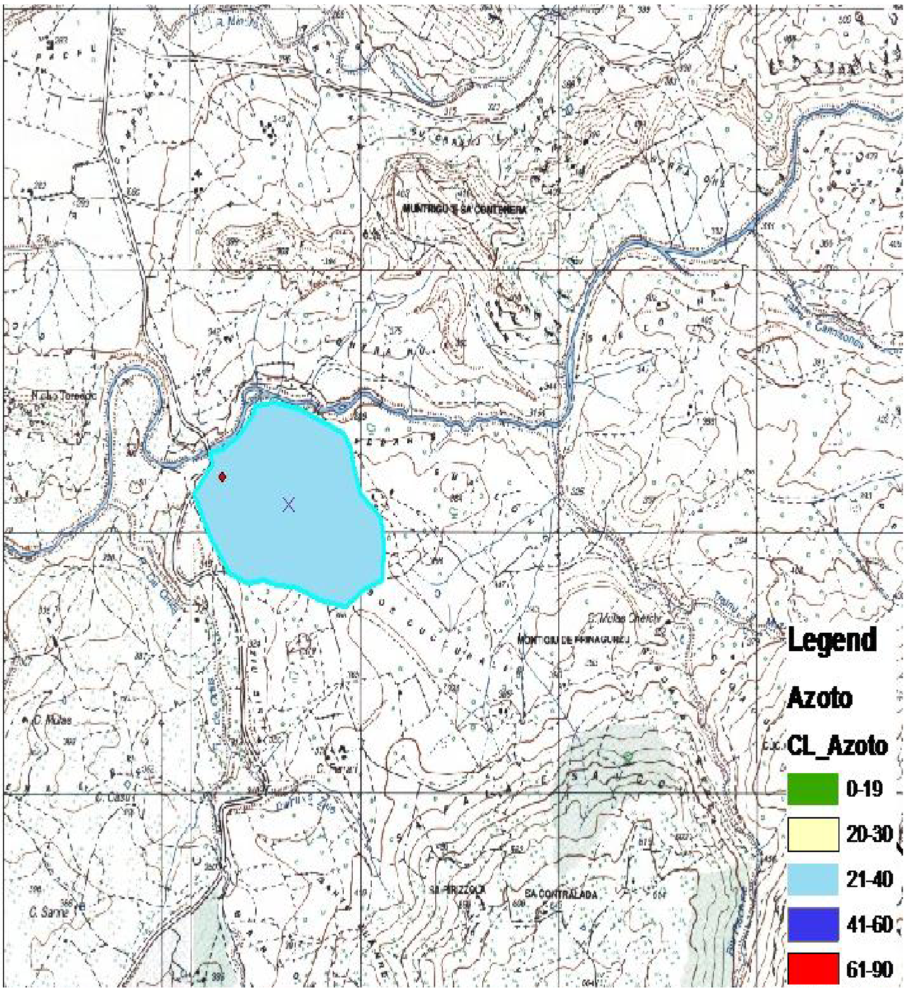


Fig.31 Chart of released N relative to the 11GO farm in scale 1:25000.

The 11GO farm comprised of a single farm body of 50 ha releases 37 kg N/ha/year relative to the breeding of 39 ABU sheep and 11 ABU bovines.

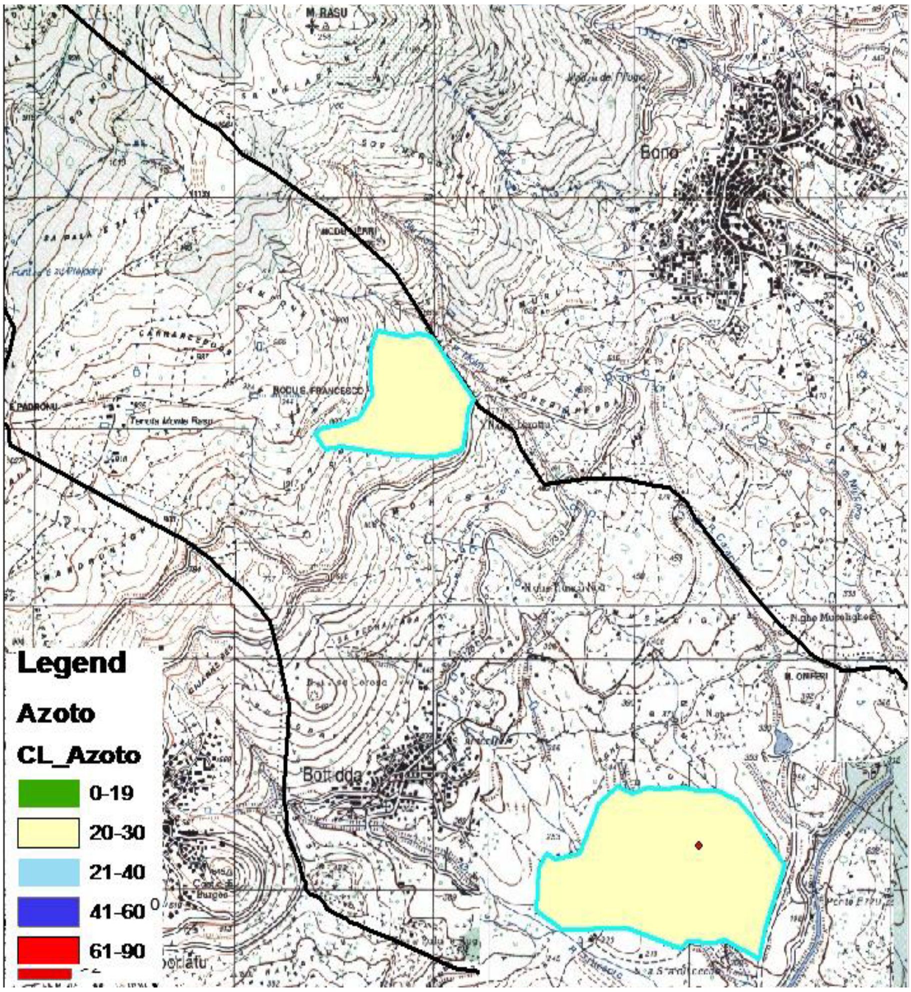


Fig.32 Chart of released N relative to the 12GO farm in scale 1:25000.

The 12GO farm is comprised of two farm bodies, one of 60 ha and the other of 30 ha that release 24 kg of N/ha/year relative to the breeding of 42 ABU sheep.

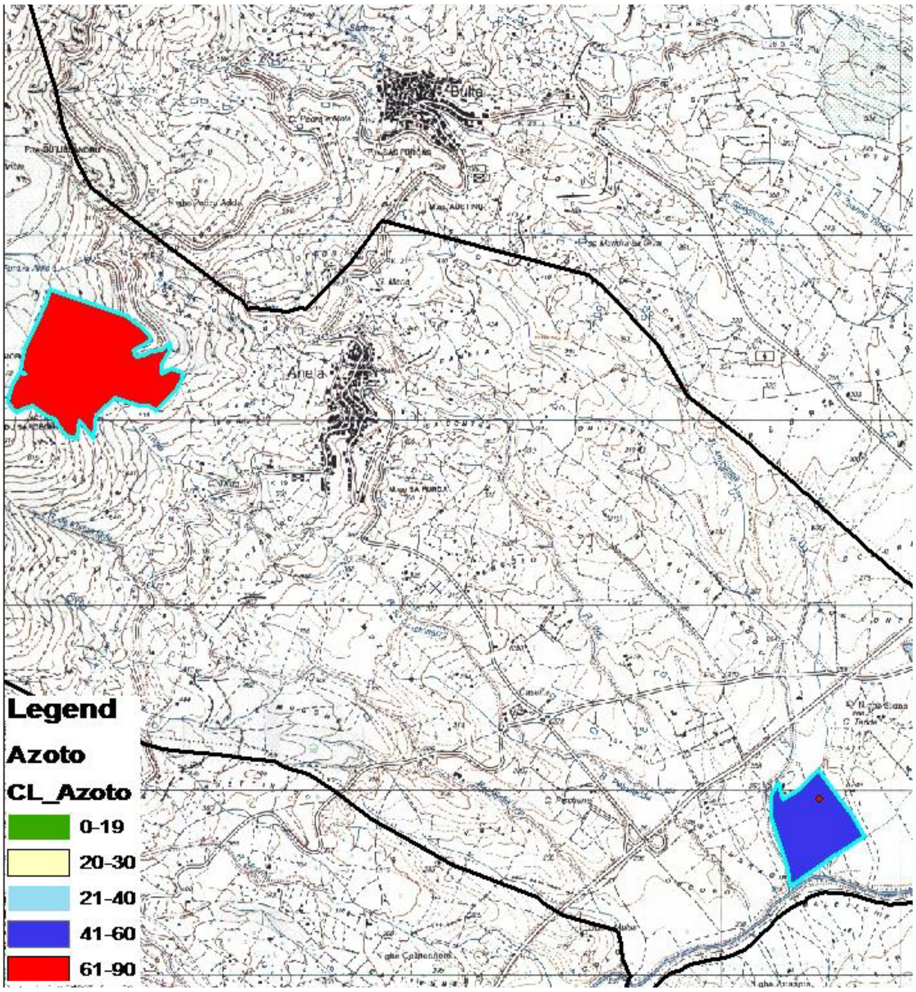


Fig.33 Chart of released N relative to the 13GO farm in scale 1:25000.

The farm is comprised of two farm bodies, one of 17 ha and the other of 43 ha. The first body releases 60 kg N/ha/year relative to the breeding of 37 ABU bovines and the second releases 67 kg N/ha/year relative to the breeding of 46 ABU sheep.

The use of the Bovin-latte and Ovisoft models, allowed the evaluation of the nitrogen excretions relative to the breeding of sheep and bovines, expressed as kg N/ha/year.

The spreading out of the output data obtained by the models via GIS software, allowed the ratio differentiation of kg N/ha/year to the permanency of the animals on the field and the physiological state of the animals.

In the 5GO farms the net nitrogen excretions on the field are noticeably different between the two farm bodies, in relation to the fact that, one farm body is grazed by cows in a non lactation state of which nitrogen excretions are two thirds compared to the cows in lactation that graze in the second farm body. For the 8GO farm, the GIS software allowed to discriminate the nitrogen quantities that are released in the field in relation to the days of grazing.

In fact, the farm is comprised of two farm bodies of which one is grazed for 3 months of the year and the other for 9 months of the year, both with the same animal load.

For the 1GO 3GO and 12GO farms, even though they're comprised of two farm bodies, the released nitrogen quantities were estimated to be the same for both bodies, as what was stated by the managers, both surfaces were utilised simultaneously via the technique of rotation grazing according to the availability of biomass and the re-growth curve of the grass (Molle et al., 2001).

In the 9GO and 10GO the kg N/ha/year are different between the farm bodies that make up the farms, seeing as in one farm bovines are bred, and in the other sheep are bred. The differences of excreted nitrogen found between the farms are linked to the different protein content of the ration, with regards to extensive breeding farms. This is dependent on the PG content of the pasture, which varies according to seasons, phenologic state of the plants and nitrogenised fertilizers to which they are often exposed to, Cannas (2001).

All the farms fall widely within the set limits of the law 152-99 art.38. on the nitrate regulations, presenting elevated deficit values that are on average around 300 kg N/ha/year in virtue of the strong extensiveness of the farms and of the animal production levels.

CHART OF NET PROCEEDS € ABU

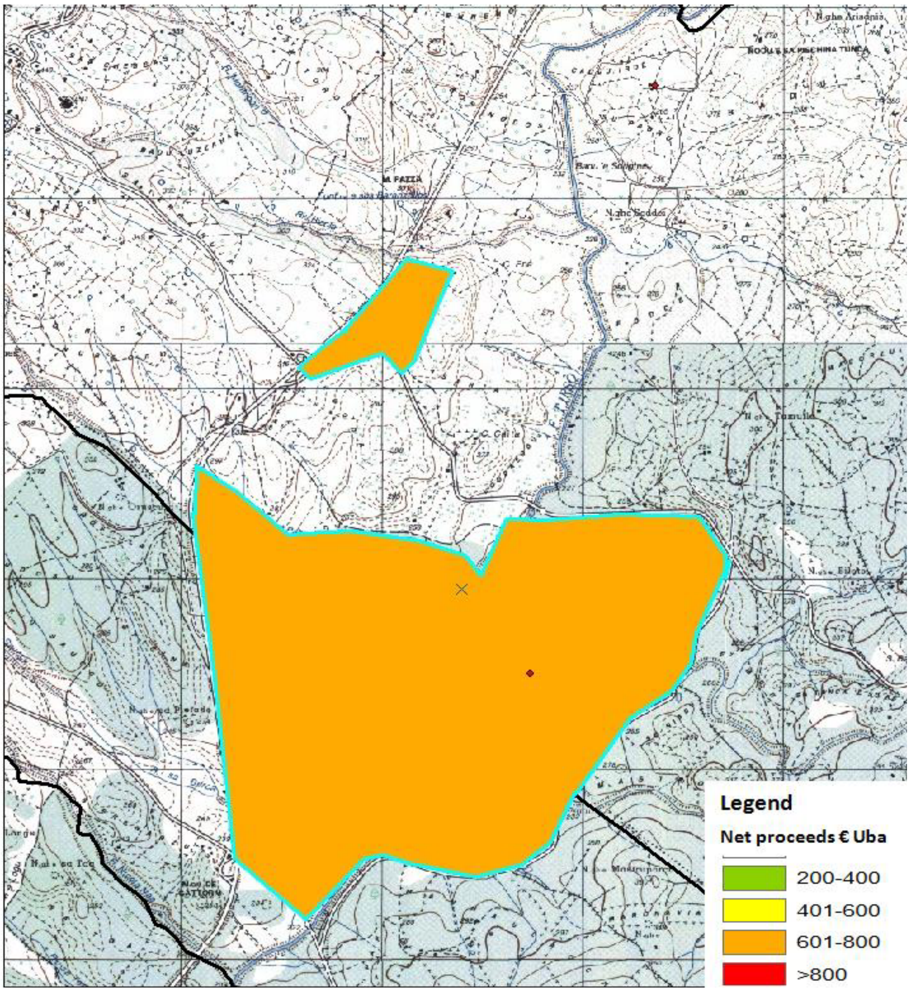


Fig Chart of the Net proceeds € / ABU relative to the 1GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 1GO farm were calculated to be 726€.

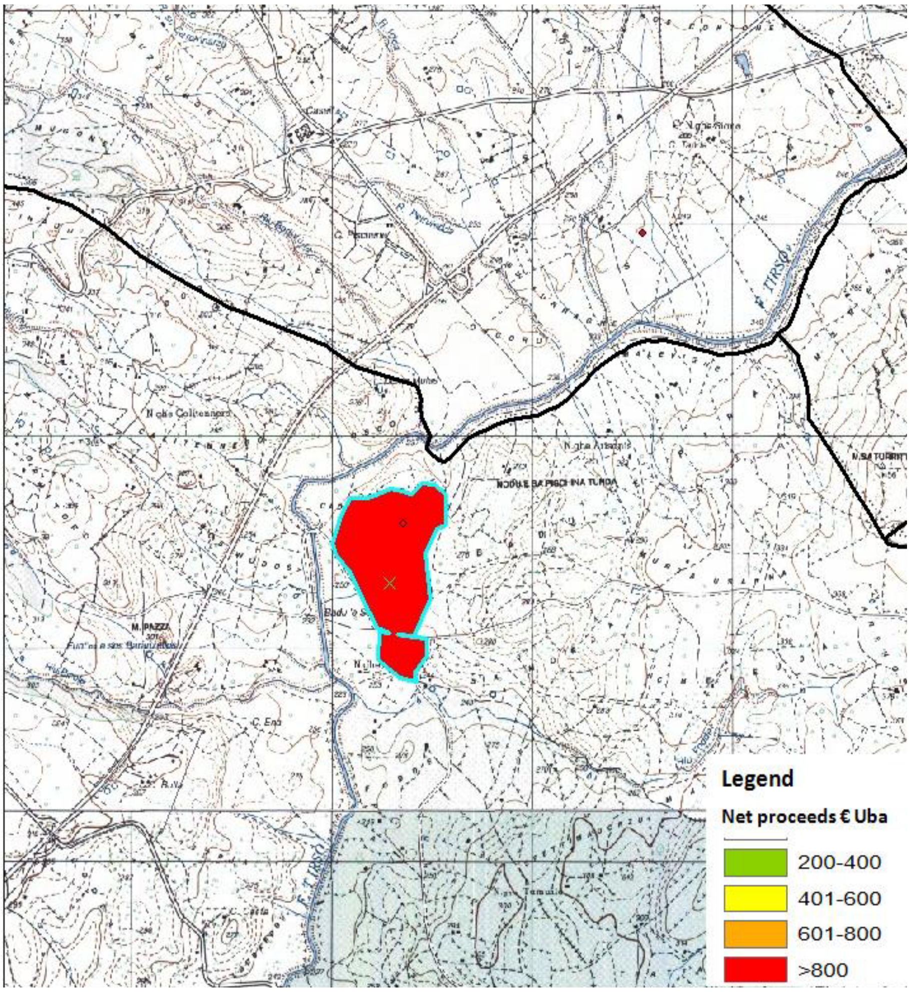


Fig Chart of the Net proceeds € ABU relative to the 2GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 2GO were calculated to be 822 €.

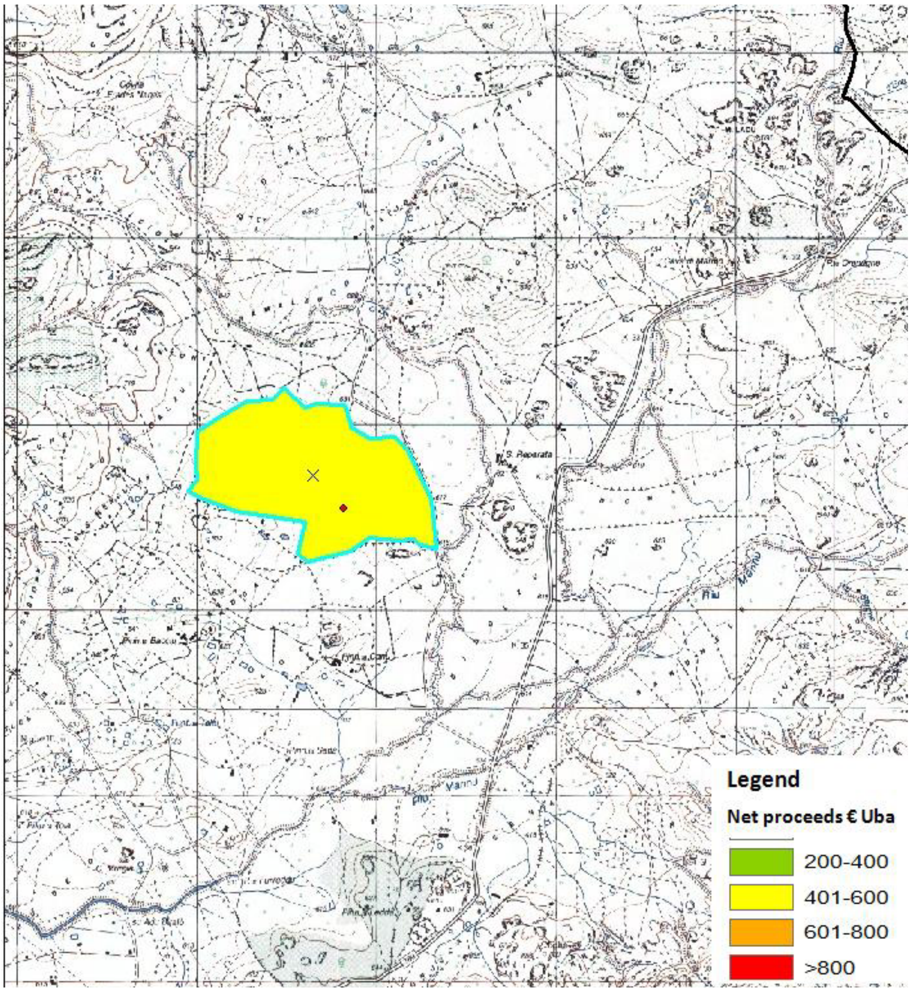


Fig Chart of the Net proceeds € / ABU relative to the 4GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 4GO were calculated to be 446 €.

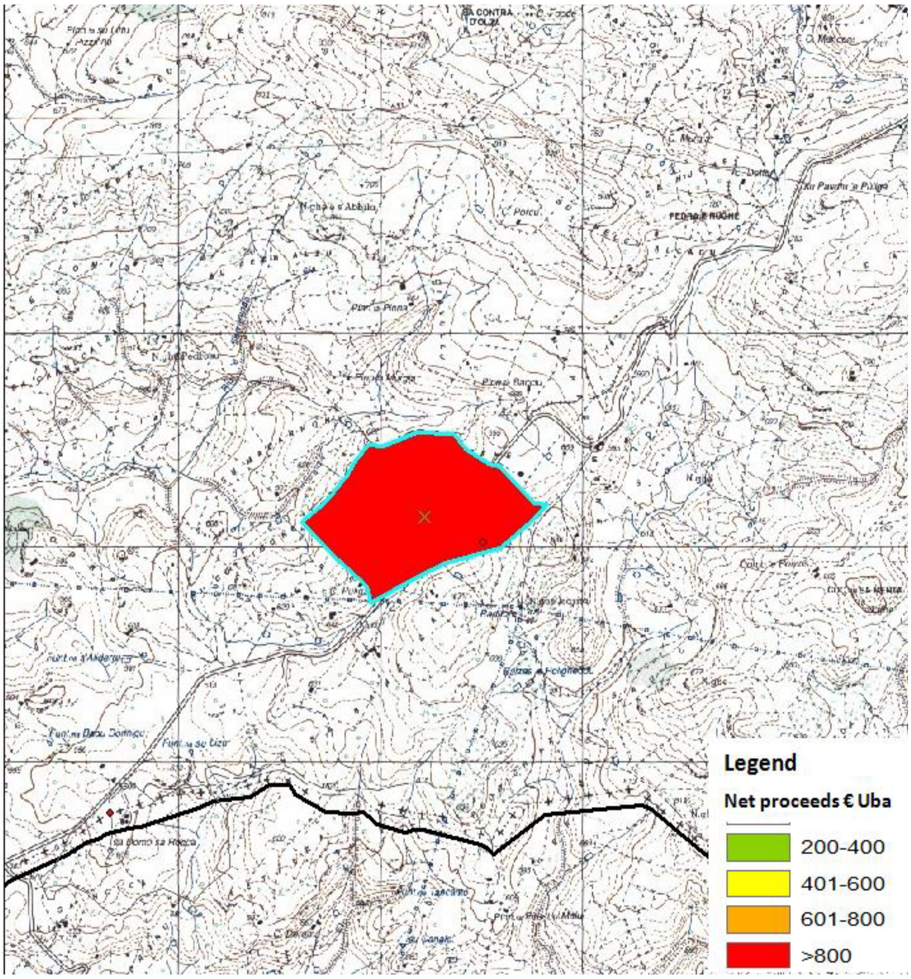


Fig Chart of the Net proceeds € / ABU relative to the 6GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 6GO farm were calculated to be 894 €.

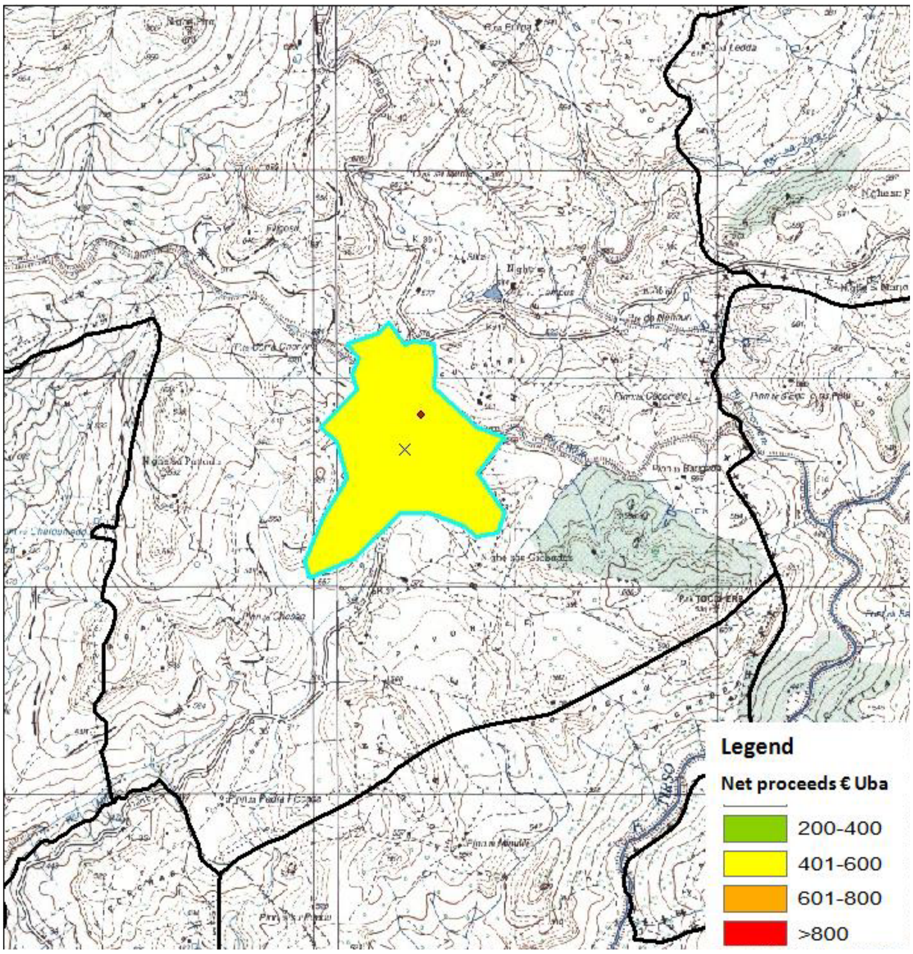


Fig Chart of the Net proceeds € / ABU relative to the 7GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 7GO were calculated to be 587 €.

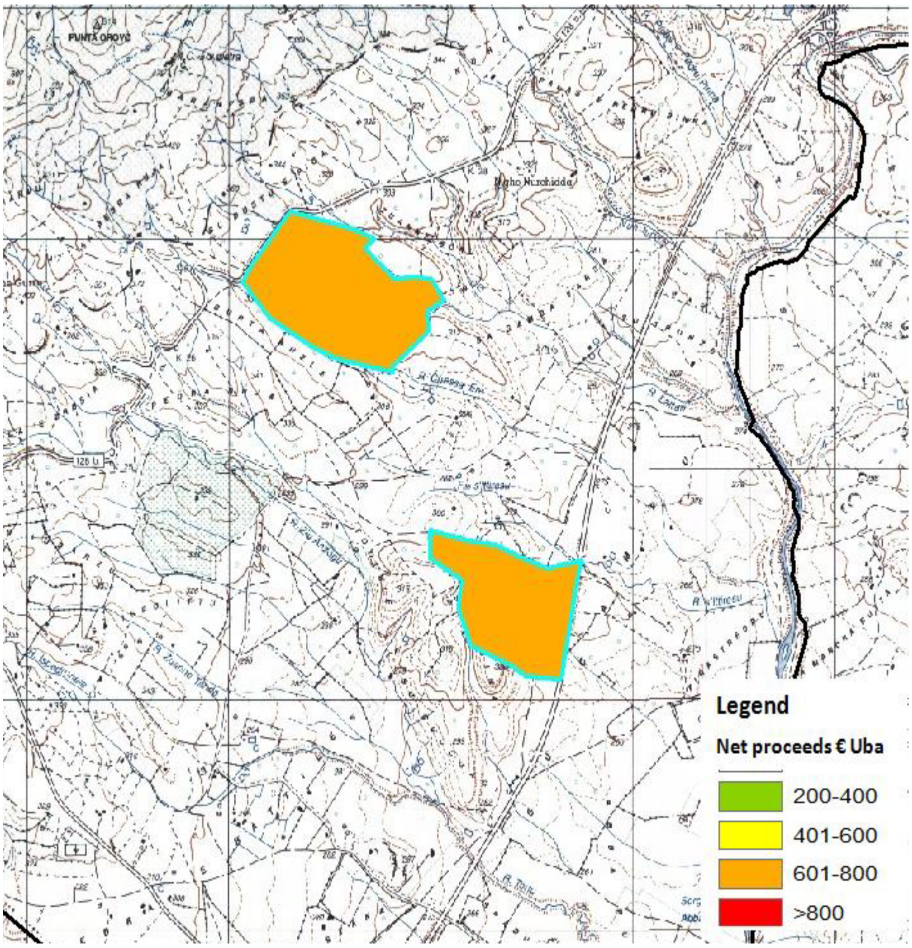


Fig Chart of the Net proceeds € / ABU relative to the 10GO farm in scale 1:25000.

The Net proceeds € /ABU relative to the 10GO farm were calculated to be 582 € in regards to the breeding of sheep.

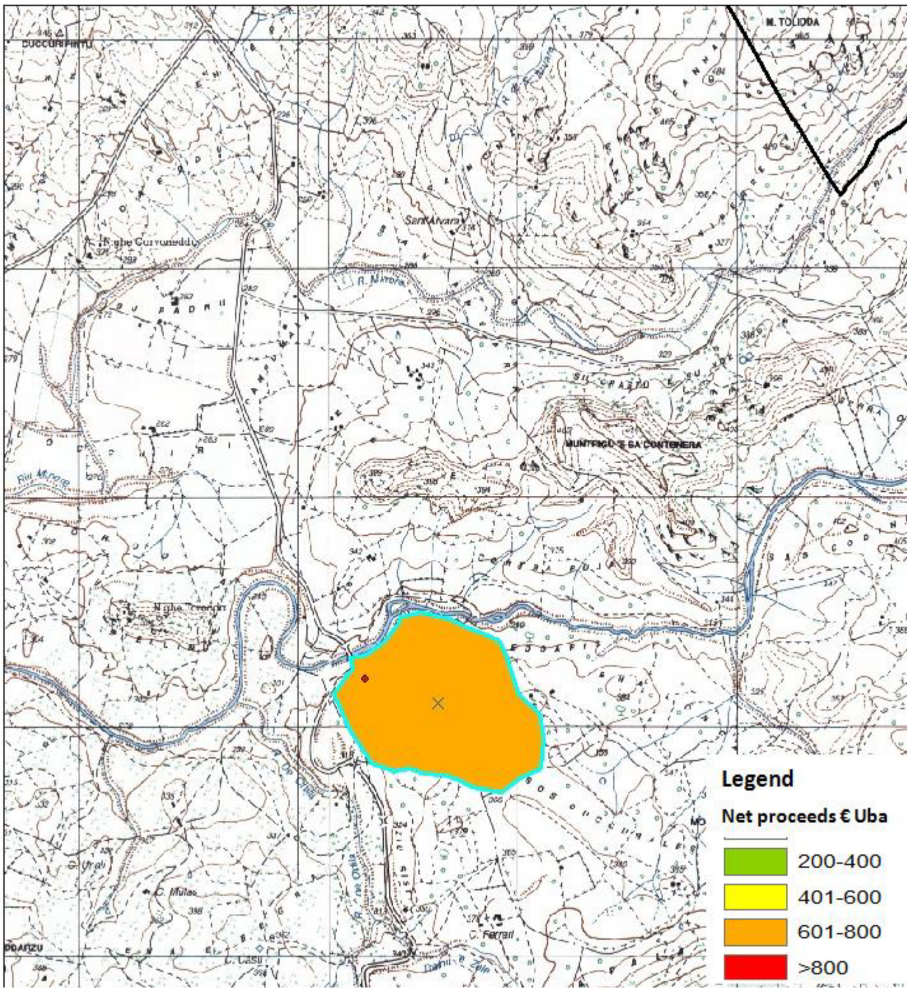


Fig Chart of the Net proceeds € / ABU relative to the 11GO farm in scale 1:25000

The net proceeds € /ABU relative to the 11GO farm were calculated to be 621 € in regards to the breeding of sheep.

The choice was taken to create the chart of Net proceeds € ABU as the model showed that the grants and the subsidies for the studied year had a significant weight on income of the farms, on average 34% of the PLV. Such subsidies also included bonuses in order to compensate the breeders for the damages caused by the spreading of the Blue Tongue disease. The net earnings of the subsidies express the effective income of the farm productions.

The gross profit per litre per milk was superior to the cost per litre of the milk produced only thanks to the grants and subsidies. This shows how, still today the economical results of the Sardinian ovine farms are tightly linked to public interventions and how the elimination of these, would entail the exclusion of an elevated number of farms from he market (Mura, 2008). Such was found even by Lorent et al., (2008) in a study carried out on the marginal areas of Greece.

The economic analysis showed that the 6GO farm had the most Net proceeds €/ABU for the 2006 year. This is due to the fact that while the other farms gave their milk to private creameries or cooperative associations with a remuneration milk per litre equal to 0,53 €, the manager of the 6GO farm transformed its own milk that he would later sell to the local market obtaining a price of milk per litre of 1,21€.

The farm with the lowest Net proceeds was the 4GO farm. This is explained by the fact that for the studied year, according to what was declared by the manager, health problems occurred within the breeding farm, leading to very low production levels, averaging at 0,75l of milk/sheep/day.

Even the 1GO and 2GO farms have had good Net proceeds € /ABU equal to 726 and 822 respectively. Such is explainable with the fact that the animals had high production levels, on average 1,5L of milk/sheep/day were milked. Even the production costs for such farms were lowered, the model estimated a production cost per litre of milk to be around 0,80 € in virtue to the fact that the managers autonomously run the farm without having to turn to outside labour and to the correct cultural division within the farms that allowed the reduction of feeding costs down to the acquisition of only concentrates.

The 10GO, 11GO and 7GO had an average Net proceeds € ABU, 582, 621 and 587 respectively.

The detailed analysis of the individual cost sections showed that the feeding of the cattle is the section that influences the farm balance the most, equalling to 44% of the effective costs, as also found by Mura, (2008). In fact the feeding cost was calculated to be equal to 23,6 € per t of milked milk.

From an earnings point of view, the studied farm showed relatively positive results, on average 49% of the profits was designated to remunerate the capital investment and the work done by the farm man. This was demonstrated in a management of the farm that focuses on minimising the capital investments and the use of external labour.

In conclusion, from an economic point of view, the analysed farms can be considered sustainable even though it's necessary to underline that the dependency on external income sources, such as council, National and regional grants is very high. The farm man should find farm management strategies that focus on making more stable and secure profit results, independently from the subsidy sources.

A solution could be the self transformation of milk and meat as done by the 6GO farm, as well as allocating the products in niche markets. This could be feasible in virtue of the fact that the food base for the animals is predominantly spontaneous vegetation productions, obtained in conditions similar to natural ones or at least with a reduced use of machinery. Consequently the products that are obtained (milk and meat) present noticeable characteristics such as to be able to differentiate them on the market from analogous productions obtained in situations of higher intensification. Therefore, these could obtain much more favourable prices, as the consumer appears more and more oriented towards food genuinely proven. The marginality, tied to the system of extensive breeding, can become a valorisation element for the territory.

CONCLUSIONS

Through the GIS system it is possible to summarize the territorial analysis results: quantitative information, of a metric nature, with qualitative data, both symbolic and descriptive, connecting the world by the acquisition of data (cartographic and descriptive) and the management world (the users of cartography and the decision makers), and activating interactive interrogations that give the user different options while choosing the more significant synthesis.

The GIS via a relational architecture allows " to tie" to the cartographic database, fiscal and environmental phenomena non directly co relatable to punctual territorial entities, even though they are tightly connected, such as social-economic factors, demographical, normative, statistical etc.

Thus within the model, different typology data is organised: geometrical, alphanumerical, digital models of the territory, statistical economical and demographical data, all having the unfixable characteristic of spatial entity.

In the carried out analysis, the application of the GIS systems implemented with the input data elaborated by the mathematical models, allowed an objective representation of some aspects of the reality of the zoo-technical farm placed in marginal areas.

The proposed approach for the study of zoo-technical reality in marginal areas, benefits from a few advantages:

- The transparency of the evaluations, that makes every step taken traceable and allows the obtainment of results without ambiguity;

- The flexibility, that allows to incorporate further data or to update the existing one.

On the other hand, the system revealed the necessity to dispose of detailed information on the management modalities of the breeding farms, on the farm surfaces and most importantly on what concerns the economic analysis and the knowledge of input data not always easily obtained.The proposed approach for the study of a small Sardinian area can be taken into consideration as a method of objective analysis to use during processes of territorial planning. The elaboration of thematic charts on a council, provincial and regional scale, would allow to have a cognitive picture of what are the weak or strong points of the zoo-technical farms in the different geographical farms, and to propose interventional measures focused on the specific realities.

Exploiting the provisional capacities and the proposals of alternative solutions by the simulation models, combined with the capacity of the GIS software to elaborate and analyse a vast quantity of spatial data, it would be possible to evaluate in real time those which would be the effects of eventual intervention measures.

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