Presentation of the Basic Farm Structure Survey 2000 using GIS
A case study in some regions of Greece

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Abstract

This work presents an interface between the statistical and geographical databases, by means of the Farm Structure Survey (FSS) and an improved version of the CORINE Land Cover (CLC), and provides a comparison between them. The comparison requires the determination of the aggregation level of the classes for which the correspondence has already been set. Thus, after the reclassification of the above data, common classes are created and presented on a map using an embedded GIS environment. The user is able to relate the above data sources in order to find the best matching. The statistical data used has been provided from the last Census of Agriculture and Livestock breeding in Greece (Basic FSS) 1999/2000 database. To achieve compatibility between census and photo-interpretation the geographical data used has been provided by a recently developed version of the CLC geographical database of Greece. The new geographical database takes into account the FSS nomenclature and definitions, reorganizes the 44 classes of the original CLC into 16 general classes that meet the needs of the Land Use/Cover statistics in Greece and provides better acquisition period. The new CLC is based on comparative optical photo-interpretation of satellite images, gathered in 1998-1999, in order to update the original CLC, compiled in 1987, and to produce thematic maps of land use/cover for 1999 at a scale of 1: 100 000.

To validate the comparison of the respective surface areas of the related classes, as well as, to test the interface and provide the appropriate links between certain classes of the two nomenclatures the Greek regions are used in the pilot study. These regions are the island of Kriti, and the three regions of Makedonia. As it appears, the linkage between the two databases shows the existing differences between the tested administrative areas. The developed software tool is able to relate data from different sources and to display on a map accurately, the combined spatial statistical data along with the geographical information of the area of interest in order to find the best matching. Thus, although the new CLC seems to provide a good mapping base, the imposed minimum mapping unit of 25 ha results in an overall underestimation of the diversity of landscapes something, which is particularly important in the case of Greece for which the average size of the holdings is 4,5 ha.

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1 Introduction

From the agricultural point of view, an important development nowadays is that agricultural activities are more and more combined with other activities such as environmental care, maintaining the landscape, forestry, preserving recreational and tourist areas as well as small scale of agricultural products, aquaculture, fisheries, etc. A sustainable reform should keep productivity high, so that, farmers remain competitive. Assessing the agricultural policies and their impact on the countryside is still a crucial factor. Thus, there is a strong need for statistical data on rural population, and particularly, on landscape and land use. Note that most of the statistical data used for policy purposes are related to populations, activities, features and other events, which are by their nature, spatial in form. The management, the process and the display of statistical data associated with spatial locations that vary geographically is therefore, largely, a spatial process. In agricultural terms, the management of agricultural resources is increasingly complex as conservation and environmental concerns play an expanding role for making conclusions. In this respect, GIS is considered necessary in the production of census maps, for dealing with census logistics, for monitoring census activities, and for data dissemination (Deichmann, 1997).

With the advent of GIS, an extremely wide range of spatial analysis methods has been developed for carrying out data transformations between different spatial structures. These methods help to present the data in a more meaningful and consistent manner and enable different data sets, based on different geographical units, to be brought together and overlaid. They also facilitate the spatial analysis of the statistical data required in the development and/or calculation of some more reliable indicators for the determination of the state and quality of the environment, able to measure the effect of the agricultural economy, across regions and countries. The use of indicators as an aid to policy decision-making in the agri-environmental context is a relatively recent phenomenon and still a developing field; however, indicators are perceived to have considerable potential as policy tools. Most policy makers concerned with agri-environmental issues at the national level are confronted with fragmented information and it is accordingly difficult to use the information in a way that effectively contributes to policy decision-making.

An unavoidable step in the assessment of agricultural policies and of their impact on the countryside and landscapes is the study of spatial units that constitute the underlying structure of these territories. Most statistical data in EU, by means of the Farm Structure Survey (FSS) data, is organized and presented on the basis of NUTS (Nomenclature des Unites Territoriales Statistiques) system, to provide a single, uniform breakdown of a country. Nevertheless, these units are geographical areas that may vary substantially not only in the sizes and shapes, but also over the time. In addition, this geographical level is not appropriate to carry out certain environmental studies. The need of spatial analysis and of the production of environmental indicators requires delineation of the land use data according to their natural depiction on a geographical map, beyond the administrative distribution. As a result, NUTS system cannot be applied in its present form to units that are more relevant from a geographical point of view, such as drainage areas, landscape units, bio-topes, etc.

This study presents an interface between the statistical and geographical databases and provides a comparison between them by means of the FSS and CORINE Land Cover (CLC). As a first step, the spatial disaggregation of the FSS data into an accurate geographical level requires an interface between the two nomenclatures. To reallocate the FSS data into sustainable areas a question arises of how the digital CLC map could be used to describe agro-environmental statistical structures. Note that CLC has so far been focused on land cover, rather than land use and it has been carried out once. As a result it cannot be applied to show trends. However, different countries carried it out in different years, over the period 1985- 1995. Plans already exist to upgrade CLC based on the IMAGE 2000 image data set provided by the JRC. The result is that some of the indicators based on CLC show only a snapshot rather than a trend in land use.

The developed interface is able to display on a map, accurately, the combined spatial descriptive statistical data along with the geographic information of an area of interest. Thus, the user is able to relate the FSS and the CLC data in order to find the best matching. The developed interface is able to query a database, aggregate / disaggregate the data and plot the results on a map. The comparison requires to determine the aggregation level of the classes for which the correspondence has already been set and to validate the result by comparing the respective surface areas of the related classes. After the reclassification of the above data, common classes are created and presented on a map using an embedded GIS environment.

To test the interface and provide the appropriate links between certain classes of the two databases the three regions of Makedonia and the region of the island of Kriti have been chosen. The statistical data used has been provided by the Basic FSS of 1999/2000 (Census of Agricultural for Livestock breeding or simply Agricultural Census). However, to achieve compatibility between census and photo-interpretation a recently developed, improved version of the CLC geographical database has been used. The new CLC takes into account the FSS nomenclature and definitions and has provides much better acquisition period (Landsat-TM 1998 to 1999) which is the same with the census reference period (1998 to 1999). The linkage between the two databases shows the existing differences between the administrative areas of the pilot regions.

The structure of the paper is as follows: Section 2 describes the main characteristics of the FSS nomenclature, particularly addressed in the case of Greece. Section 3 is particularly addressed to the modified CLC geographical nomenclature providing the new classification scheme. Also, in this section, the original CLC nomenclature is discussed briefly. Section 4 presents linkage between the two nomenclatures and way it has been achieved, by means of application development. Section 5, presents the results from the comparison of the related nomenclatures and finally, in the last section the conclusions and the prospects of this work are presented.

2 The FSS database

2.1 Main issues

The effective and balanced implementation of the reformed Common Agricultural Policy requires detailed objective, quantitative data of the structure and performance of the agricultural, rural and environmental sectors. In this context the development of the structure of the agricultural holdings allows analysis of the agricultural sector and its impact to other sectors as the rural sector and the environment.

The FSS is the main source to provide data on various characteristics relating to agricultural holdings, on a regular basis. These data refer to the number and size distribution of the agricultural holdings by type of enterprise, as well as to the land improvements, crop and livestock rotations and farm practices (machinery, equipment etc.). They also refer to other structural data such as the educational level of farmer

and farm labour inputs, the legal status of holder including tenure arrangements and finally other social demographic characteristics of holders.
The FSS data are collected on a regular basis by the Member States and are forwarded to Eurostat, which stores them in the Eurofarm database. In order to harmonize information at the Community level, legal frameworks (Regulation and Decisions) define the methodological framework and the contents of the FSS questionnaires. Table 1 shows the FSS nomenclature, which distinguishes the detailed agricultural land use classes.

2.2 Methodological issues of the FSS in Greece

The FSS is carried out in Greece within the framework of the Community Program for the 'Statistical Surveys in the Agricultural Sector'. All the specifications and terms are defined precisely by the Regulation 571/88 as amended by the Regulation 2467/96 and the related Decisions of the Council of the E.U.
The FSS is intended to collect statistical data on the structure of agricultural and livestock holdings and the employment of the population on them. The data make it possible, besides the classical tabulation of the results, to generate tables, which show the economic size and orientation of the farms (typology). In particular, the Greek FSS system aims to collect data relating to:

- The number of agricultural and livestock holdings in the country, at national, regional and local level.
- The geographical position of the holdings.
- The legal status and management of the holding.
- The agricultural training of its owner.
- The keeping of account books.
- The land uses (arable crops, permanent crops, kitchen gardens, permanent pasture-meadows and rough grazing and other areas).
- The type of ownership of the utilized agricultural area.
- The number of fields constituting the total utilized agricultural area.
- Successive crops, combined crops, irrigated crops, etc..
- Livestock raised on the farm..
- Agricultural machinery and milking equipment used.
- Employment of members of the farm owner's family.
- Employment of family members in other gainful activities besides agriculture.
- Employment of permanent, seasonal and other workers.

Sample FSS is carried out every two years, in the years ending with an odd number. The National Statistical Service of Greece (NSSG) carried out the first sample survey of the Structure of Agricultural and Livestock breeding in 1966/67, when Greece was still an associated member of the EU. The next sample survey took place in 1977/78. After the accession of the country into the EU further surveys were carried out in 1983, 1985, 1987, 1989, 1993,1995 and 1997 i.e. every two years
Every ten years an exhaustive survey (Basic FSS or Agricultural Census) is carried out. The first Agricultural Census conducted in 1950, after the Second World War. Agricultural Census of 1991 was the last census carried out at the same time with the General Censuses for population, households, agriculture etc.. However, Agricultural Census 1999/2000 was the first census carried out before the General Population Census 2001, under the title "Basic Survey for the Structure of Agricultural Holdings 1999/2000" and it was based on the Farm Register.
The reference period for the data collected on crops and employment is from October 1st of year t-1, to 30 September of year t, i.e. the survey year. Exceptions to this are a

farm's livestock and machinery, questions relating to which have a reference date of 30 September in the year t, for the machinery and 1st November for the livestock. The statistical unit for the FSS is defined as an agricultural or livestock holding[4] which during the reference period comprises at least one of the following:

- at least 0.1 ha of utilized agricultural area or at least 0.05 ha of greenhouse area, regardless of its own ship and location, or
- at least one cow, or
- at least two other large animals (oxen, buffaloes, horses, etc.), or
- at least five small animals (sheep, goats, pigs), or
- at least 50 poultry birds, or
- at least 20 beehives.

The FSS is carried out by filling in a special questionnaire after interviewing the owner of the agricultural or livestock breeding farm. The sample survey is carried out by applying the method of multi – stage stratified area sampling.

In the most recent Agricultural Census (1999/2000) the Basic FSS covered all agricultural and livestock holdings in the country, of approximately 814.000 holdings.

3 Description of the geographical nomenclature

3.1 The CLC geographical database

CORINE (Co-ORdination on INformation of the Environment) Land Cover (CLC) is a geographic land cover/land use database encompassing most of the countries of the European Community, with aim to gather information associated with the environment on certain priority topics. It describes land cover (and partly land use) according to a nomenclature of 44 classes organized hierarchically in three levels (Dueker, 1979).

CLC was elaborated based on the visual interpretation of satellite images (*Spot*, *Landsat TM* and *MSS*). The smallest surfaces mapped (mapping units) correspond to 25 hectares. Linear features less than 100m in width are not considered. The scale of the output product was fixed at 1:100.000. Thus, the location precision of the CLC database is 100m.

The CLC database has recently become available for most of the territory of the EU and several PHARE countries (AL, PL, CZ, SV, RO, HU, BG, SI, EE, LV, LT). Although its exploitation is just starting, it offers the potential for a wide array of uses. It can be used on its own for simple cartographic or statistical presentations and as a base for European-wide landscape analyses or more generally in combination with other data sets (spatial analysis, modelling, etc.).

3.2 The new CLC database of Greece

The new CLC database has been developed in Greece in order to cover the needs of land use/cover statistics as far as the distribution of the total area of Greece in the basic categories of land use is concerned. These statistics are included in the preparatory work carried out in the context of every Agricultural Censuses. The aim is

[4] **Agricultural holding** is a single unit both technically and economically which has single management and which produces agricultural products. The holding may also provide other supplementary (non-agricultural) products and services.

Geographical location of the holding: All collected data concerning land uses, livestock breeding etc. are register to the place where the residence of the holder is (natural person), or where the headquarter is situated, if the holding is legal person.

to prepare the census and to obtain data covering all the territory of Greece.
Until Agricultural Census of 1991, this work was done by completing seven (7) months before the Census a ‘pre-census questionnaire of total land area in the municipality or commune’, using estimates by the municipal or communal working parties set up for the census and with the help of local agronomists. To facilitate completion of the pre-census questionnaire, these groups had at their disposal the land distribution data from the previous census, as well as other auxiliary data held by the municipality or commune, such as land registers, land distribution tables, etc.
Land was divided up into seven basic categories of use:

- Cultivated areas and fallow land resting fallow for 1 to 5 years.
- Communal or municipal pasture land.
- Other pasture land (owned by privates, State, monasteries, etc.)
- Forests
- Areas under water (lakes, marshes, seashores, river beds)
- Build-up areas (buildings, courtyards and roads, squares etc.)
- Other areas (e.g. rocky areas, mines, etc.).

Note that the pre-census questionnaire was the only data source covering also the state-owned land, which is mostly, forest and pastures. Nevertheless, since the agricultural census is carried out by interviews of farmers it concerns only private lands that are somehow agriculturally used.
In the light of the recent developments concerning land use statistics, NSSG decided to use an up-to-date methodology using GIS techniques in order to produce more objective information on this sector. Therefore, the use of spatial analysis is required. Spatial analysis of the information to be recorded is realized by determining the area of the minimum recorded surface, which is taken according to the proposed nomenclature, the methodology of use/cover definition, the requirements of 1:100.000 scale and the user needs. The method with which the theme information drawn up, is the comparative photo-interpretation of the new satellite data collected in 1998-99 in relation to those of the time period 1997–98 used for the creation of the CLC database in Greece. The digital photo-interpretation of the new satellite data is made using image processing software and other data such as those from land recordings. The recording planning and the use of the data from the field works are also defining the reliability of the specific photo-interpretation.
The new CLC database is properly generalized as reference data and harmonized with the FSS nomenclature, by means of characteristics and definitions, linkage of the two databases to meet the needs of the NSSG. Thus, the distribution of the main land uses in Greece has been reorganized into the following sixteen (16) classes:

- Artificial surfaces
  1. Urban fabric
  2. Industrial and commercial units
  3. Transport units
  4. Mine, dump and construction sites
  5. Artificial, non-agricultural vegetated areas sport and cultural activity sites
- Agricultural areas
  6. Arable land
  7. Permanent crops
  8. Pastures
  9. Heterogeneous agricultural areas
- Forest and semi-natural areas
  10. Forests

11. Transitional woodland /shrub
12. Shrub and/or herbaceous vegetation associations
13. Open spaces with little or no vegetation

- Surfaces under water
  14. Inland water
  15. Inland wetlands
  16. Coastal wetlands

The new CLC geographical database for the country's area has numerous advantages, the most important of which are the following:

- It provides a land use/cover map covering all Greece for 16 categories, compiled with the seven land use classes in the above mentioned pre-census questionnaire of the NSSG.
- The new geographical database takes into account the FSS nomenclature and definitions.
- It enables comparability between the two sources of information, namely census versus photo-interpretation. In the case of Greece the acquisition period of the data is spread over 2 years for both, the CLC (Landsat-TM 1998 to1999) and the FSS 1999/2000, (reference year the 1998-1999 crop year).
- It enables the integration of the chrono-geographical co-ordinates of the satellite images sources of CLC. This will help in the identification of districts for which CLC's image interpretation is one year apart (minus or plus) from the census year (1990 or 2000, respectively). In addition, using the intermediate FSS data that correspond closely to the date of the satellite image it will be possible to mitigate the effect of time.

4 Linking the two databases

4.1 Issues and problems in spatio-temporal analysis

As it is well known, data collection methods are optimized for a particular need and therefore the resultant data structures are not usually readily comparable in a cross-sectional study. Thus, although a particular census may be analyzed in detail comparing censuses with each other have been proved problematic since they may use different administrative units, or they may use the same unit system, which includes many boundary changes that make the comparison difficult. To the best of our knowledge, three types of data incompatibilities have been distinguished so far [(Frank, 1999), (Ian N Gregory, 2000)] and will be described, briefly, in the sequel:

4.1.1 Differences in Data Models

Raster and vector data models are the GIS approaches for the spatial presentation of natural vegetation, the forest area and generally the development of land use. In a raster data model, a uniform grid, each cell of which is assigned a unique descriptor depending on the coordinate system used, represents space. Raster models can be directly imported into the software and immediately become available for use (Burrough, 1986). They are well suited for the representation of remotely sensed digital data and are commonly employed in the environmental sciences. In contrast, in a vector data model, the spatial data is based on geometric shapes of points, lines, and polygons. This model is object-oriented and is based on the coordinate system used. Vector GIS knows where the spatial feature (line, point, polygon) exists, as well as the relationship with the other features. Vector data models are particularly suited for the representation of linear data features like roads, or clearly delineated areas, such as, property lines and city limits. After the representation of the spatial features, their associated properties must be specified in a separate database.

For simultaneous use of data from both, raster and vector models a conversion of one data set to the respective model of the other data set needs to be performed. Data conversions, however, are often ambiguous and typically result in a loss of information (Maffini, et al., 1987). It is difficult, for example, to derive the best fitting vector representation from a given raster grid. Furthermore, it is likely that a set of transformations from vector to raster and back to vector will result in a target feature whose shape differs from the original source feature. These transformation functions may not be accessible to the end user [(Ehlers, et al., 1991), (Maffini, et al., 1987)]. The data transformation from analog paper maps and tabulations to digital data falls into the same category. Loss of data, spatial inaccuracy and error is introduced by conversion techniques like scanning, digitizing, rasterization, vectorization and manual data input (Goodchild, et al., 1989). Digital data creation is also extremely time consuming.

4.1.2 Inconsistencies of areal units

Comparing census data with other data sources of some specific area of interest may not be the same, either because of boundaries changes over the time or because of the different definition of administrative/areal units used for the data collection (Xie, et al., 1995). Two key issues need to be addressed in terms of areal unit comparability. One is related to data integration and map overlay (non-matching areal units). The other is related to data analysis and statistical comparability of areal units of different sizes and shapes (modifiable areal unit problem).

4.1.3 Non-matching Areal Units

Integrated analysis of spatial and attribute data is based on map overlay operations. Non-matching areal units require a transformation of data from one system of areal units to another in which data values are apportioned to the newly created spatial units. Then, the newly created zones allow data overlay and analysis. These transformations are known as "areal interpolation".

4.1.4 Modifiable Areal Unit Problem (MAUP)

Generally, the statistical data, whose distribution and characteristics are not well known, are presented by an appropriate aggregated variable of some higher class. In addition, censuses base their statistics on well-defined areal units that tend to vary in size and shape leading to inconsistent and misleading statistical results. This is known as a Modifiable Areal Unit Problem (MAUP) (Openshaw, 1984). A possible approach to face this problem would be the reaggreation of the available data into homogeneous subunits and the increase the spatial detail using ancillary land cover data in order to display the census data on a map (Yuan, et al., 1997) .

4.1.5 Temporal incompatibilities

Data collection of land cover data and monitoring of physical changes relies on remote sensing via aircraft or satellites. Coverage cycles, for example, for the different LandSat orbiters (Lillesand, et al., 1994) range from 8-14 days. This data density, however, may be deceptive since data for certain regions is usually available for much fewer dates due to the fact that frequent cloud cover prohibits data collection. In the case of agricultural cultivations, the above problem has to be considered in more detail since the cultivations are usually visible on specific periods over the year.

4.2 Methodology

To describe the methodology adopted in the problem we are study, one has to take into account the non-matching areal units and the MAUP problems mentioned in section 4.1. The temporal incompatibilities problem and the procedure of matching the data points by non-matching due to collection cycles will not be considered because in our case, the data used has been interpreted by an independent intuitional organization.

The Non-matching Areal Units problem arises due to the following reasons:

a. The different boundaries definition of the administrative units that have been used in the Hellenic censuses of the year 1991 and 2000. To solve the problem there is the need to transform the data between different spatial structures [Fig.1]. As transformation may be described the process of aggregation and disaggregation within nested and non-nested neighbor polygons. To overlay the data together the conceptual model of Figure 2 has been designed containing and maintaining all polygons and the related geometric data (lines, nodes etc), representing the areal units. To link the descriptive and the spatial information, the data of the geographic area of interest is broken down into smaller parts in order to determine the field that identifies the specific entity ('AreaCode') in order to be used as a reference key to the GIS. A set of spatial queries also has been developed for carrying out the transformations. The link between the spatial and descriptive information is cleared in the scheme of fig. 6

b. The different geodetic datums used for the presentation of statistical and for the ancillary geographical data. To use the ancillary data along with the other geographical data a target datum has to be selected as the reference datum for all data and an automated procedure has to be developed to convert the data between the source and the selected target geodetic datum.

To automate both the transformation between different definitions of administrative units and the conversion between different geodetic datums, an object has been designed, called "Geo-Object". This Object can be used as the basic map layer on any similar application.

The MAUP problem is faced using ancillary geographic data (Flowerdew, et al. 1991) such as contour lines, lines representing rivers or polygons representing lakes. This methodology permits the synthesis of geographical data along with the studied statistical data and allows the combination of different scenarios in order to simulate the plotting of the descriptive data containing quantitative and areal information on a map. For validation and / or prediction purposes, the results are compared visually with other spatial quantitative information or sampling data presented on thematic maps. To achieve the connection between a file containing quantitative data (usually statistical) along with GIS data (ancillary and statistical), a class of objects has been created with the following Properties (P) and Methods (M):

4.2.1 QuantitativeInput Object

This is the basic object with which the link between descriptive and spatial information is obtained in a transparent way.

- FilePath (P): Containing the path of the input file. The user easily can update these properties by selecting graphically the appropriate file.
- FileType (P): is just the type of the selected file (e.g. tab-delimited text file, Excel file 'xls', Access file 'mdb', etc)

- OLEServer (M): is the 'Object Linked Embedded' (OLE) server used to communicate with the object or 'Dynamic Library Links' (DLLs) has given by the owner of the file, containing functions to establish connection and other file processing operations.
- Connect (M): is the method used to establish OLE connection with the object and finally through this method the object inherits all the required file manipulation commands.

4.2.2 QuantitativeRecordSet Object

It is created after the pre-mentioned connection and with this object it is able to manipulate the file. The basic file manipulation methods and properties supported by this object are:

- MoveNext (M): Moves the record pointer to the next record.
- MovePrevius (M): Moves the record pointer to the previous record
- BOF (P): begin of file flag.
- EOF (P): end of file flag.
- FileDescription (P): is a pointer to fields object that describe the size, type and start position of each field.
- SearchEntity (M): is the method that searches in the following DataBaseEntity object and if a match is found a link is established, otherwise the new 'AreaCode' is inserted into the entity "details" and through a graphical environment, the user has to select the appropriate geographic area that this 'AreaCode' is related to.

4.2.3 DataBaseEntity Object

It provides the connection between the conceptual model and the input quantitative data. It has only one method that is used to insert a new 'AreaCode' into the conceptual model and finally it connects the new inserted 'AreaCode' with the appropriate areal information.

In the example of figure 6, a tab-delimited text file contains some quantitative information in a country level. To link this text with the appropriate geographic feature in the GIS environment, the entity "Details" of the conceptual model must be updated with the 'AreaCode' of countries that this text file contains. This can be done easily by using the properties and methods of the above described class of objects.

The advantage of the described methodology is the capability to combine quantitative data from different sources, and to compare them with the available spatial features concerning the distribution of similar quantitative data (thematic map) of the same area of interest, into an integrated geographical environment. This environment can contain more geographical features than the ordinary thematic maps such as contour lines, roads, rivers, airport, etc.

This can also be helpful for the methods that have been developed to solve the problem of geographic missing values. The precision of those methods is depended on the availability and quantity of historical data. Using this methodology, it is obvious that the integration of all types of GIS data with quantitative data available from other sources is crucial for someone to decide about the data correctness.

4.3 Software Development – Case Study

As it has been pointed out, the linkage of the two nomenclatures, by means of the FSS the CLC databases require computer-based application software able to display maps and descriptive data in a tabular form. This has been achieved using geographical information from CLC database linked with tabular information of the multi-

dimensional tables of FSS (Table 2). The user becomes part of the GIS without the necessity of specific skills and intimate knowledge of the data used.
The application consists of the following parts:

- A relational database
- The class of objects for data manipulation
- The class of objects for GIS manipulation
- The main body of the application software containing the above items along with the functions required by the end user.

To begin with, a step-by-step analysis of the software design is required. However, for the purpose of this research it is assumed that the pilot area is already known. Then, the appropriate design steps are as follows:

1. On the CLC's geographic layer of the area of interest we add the remaining geographic characteristics (contour lines, roads, cities, lakes, rivers etc.). This will help in the understanding the exact location of the CLC data.
2. From the FSS database we select only the themes, which associated with agriculture products. The data selected is at prefecture level, in thousands of hectares of agriculture products, reported in 2000 census.
3. The data provided by the FSS and the CLC databases is studied in order to develop the entity relationship model, and then the database system of the application.
4. CLC data is stored in some database tables of the application, using especially developed programs, while NC's data were stored manually. NC provides also the appropriate DLLs in order to develop programs for automated data transfer.
5. We pointed out the appropriate functions and queries, and we developed object classes to satisfy the requirements for uniformity at both, user and developer levels.
6. We developed an application in which are used the RDBMS, the GIS and the pre-mentioned object classes. The basic capabilities offered by this application are the following:
    - Ability to compose (aggregate) a new FSS theme by selecting one or more CLC classes, and vice versa.
    - Ability to decompose (disaggregate) an existing FSS theme to one or more CLC classes, and vice versa.
    - Ability to correspond (relate) the new FSS themes to CLC classes.
    - Ability to classify (sort) the results either by date, or by county (region), or by CLC class.
    - Ability to observe the results plotted on the map and to classify these by geographic characteristics, such as allocation of the selected growth by elevation.

4.3.1 The Relational Data Base

Database Design is important both in terms of ensuring that the information can be readily accessed for the target application, and is available for re-use at a later time. Spatial data are usually stored in formats suited to the type of GIS software being used. Due to this reason, in spatial databases is not relatively easy to extract data for reuse in other type of application.

The GIS tool used for CLC database construction is the 'ESRI ArcInfo' software. This tool stores a set of tables in DBF format, containing both the spatial and descriptive information about map's features, which are logically organized into themes of information. Each theme consists of topologically linked polygons along with the associated descriptive data. Generally, X-Base formats, such as DBF, DBT, MOD, DIF, SDF, etc., cannot easily aggregate, desegregate, isolate, and combine CLC data with other sources. Furthermore, due to severe limitations associated with the temporal component of data in the GIS raster databases, a comparison between geographical data obtained in the past is very difficult in practice (Dragicevic et al., 2000).

To support the exchange of heterogeneous data into an integrated database environment a conceptual model is required (Parent, et al., 1997). The design of such a model has to take into consideration to load and refresh the descriptive geographical data for each attribute of the GIS, at any time it will be required, and then to link them with the information derived from other sources such as FSS data.

The conceptual model of the proposed database is described in Figure 4

In the following a brief description of all the entities of the proposed conceptual model is given

- The entity "fss_area" contains the geographical data of the CLC database
- The entity "POLY" contains the descriptive data of the CLC database. In case a geographical feature changes an automated procedure is raised, which updates the corresponding row of the "POLY" entity. The attribute used to link the geographical information with the database is the "PolyKey". This attribute is used like a Foreign Key between CLC and the database.
- The entitiy "CorDescr" contains the basic agricultural classes of the CLC database.
- The entitiy "fssmaster" contains the basic agricultural categories of the NC database.
- The entity "fsscover" contains agricultural items each one of which is stored per year and per geographical area.
- The entity "fss_clc" contains temporary data designed to support the aggregation and desegregation functionality between the NC and CLC databases.

4.3.2 The class of objects for data manipulation

The class of objects is based on a PowerBuilder object called DataWindow (R. Chandak et al, 1999). This class provides a simple way of retrieving, displaying and updating data from a specified data source. Although the data source is usually a database, it can also be a text file or other data structure. The class of DataWindow objects (PB-DWO), inherits the basic functionality and encapsulates the ability to dynamically, at run time, bind and combine data from different sources.

4.3.3 The class of objects for CLC manipulation

Since the CLC contains only agricultural classes able to be mapped on one or more regions it will be interesting to relate these classes with other geographical features such as roads, lakes, contour lines etc.. This requirement suggests the development of a class of objects that inherit the properties, methods and functions required to process geographical data. This class of objects encapsulates more functions and customized events to finally communicate with the database, and vice versa. In the sequel this class will be called “interoperable GEO-Object". For the development of this class the ESRI ‘MapObjects’ is used.

4.3.4 The application software

As it has been pointed out, this application is computer-based software able to display maps and descriptive data in a tabular form. This has been achieved using geographical information from CLC database linked with tabular information of the multi-dimensional tables of NC. The user becomes part of the GIS without the necessity of specific skills and intimate knowledge of the data used.

To test the application software a preliminary study, using the 1991 Basic FSS data of the island of Kriti has been prepared (Figure 5). The island of Kriti is a region (NUTS II level) and consists of four districts (NUTS 3 level); Chania, Rethimno, Iraklio and Lasithi. Note that Figure 5 is based on the original CLC database (1991 and 2000) and is constructed using the Hellenic Geodetic Reference System 1987 (HGRS 87). Any additional geo-data used such as roads, lakes, contour lines are constructed using World Geodetic System 1984 (WGS 84). To solve the problem of geodetic datum transformation without making changes in the application source code a map layer object is added. This object has a property to specify the path of the ASCII file, which contains the appropriate transformation parameters. Thus, in the pilot case, the transformation file from HGRS 87 to WGS 84 is described below:

INPUT PROJECTION TRANSVERSE UNIT METERS SPHEROID GRS80 PARAMETERS 0.9996 24 0000 00 0000 500000 00	OUTPUT PROJECTION GEOGRAPHIC UNITS DD SPHEROID WGS84 PARAMETERS END

In addition, the basic geographic layer is constructed using detailed geographical data, such as coastlines, contour lines, roads, airports etc.

To verify an identical matching between this layer and the transformed CLC data added on the top the following checks have been made:

- A visual check showed a coincidence of polygon lines in a zoom out at about 400%.
- A numeric check showed that the area of each prefecture of both, the basic layer and the CLC layer are equal. Note that to obtain a prefecture area one has to add the appropriate CLC polygons

- A geo reference check showed that the maximum difference measured between the geometrical data of the geographic layers is less than 100 meters, which is the maximum precision allowed for products with scale 1:100.000.

The main application window (fig. 5) includes the standard GUI controls (menu and buttons) as well as the PB-DWO and the interoperable geo-object. The PB-DWO contains the rows of the entity ‘cordescr’ matching the selected area. The interoperable geo-object displays the corresponding polygons of the above entity.

Details of the method followed in order to develop the interface may be found in (Sambrakos, et al., 2001) and as it may be observed one may easily incorporate the new CLC and FSS data of the 2000 year. The actual procedure followed in order to produce the final map is shown in Figures 7 and 8.

4.3.5 Functions

All the functions supported by the commercial GIS, such as, pan, zoom, spatial queries, distance and bearing calculator etc., are included in the interoperable geo-object as methods performed by menu selections.

When ‘View Options’ is selected from menu, then the entity “fss_clc” is loaded with the appropriate temporal data. The interoperable geo-object is responsible to display the map of the selected prefecture(s) containing the CLS agricultural classes, which are selected (‘Selected’ button) from PB-DWO according to the specified year [Temporal GIS and Spatio-Temporal Modeling capabilities].

The "classification" button allows the user to display all the CLC classes of the selected prefecture(s), colored accordingly, and as a result giving rise to the creation of thematic maps.

The basic requirement of this application, is the aggregation and disaggregation of data, namely the ability to stack up and break up the CLC classes, the NC themes, and finally to associate them.

The results of the pre-mentioned procedure (composition-decomposition) are plotted on a map. Although some of the CLC and NC data relations are obvious, some other are not. Therefore this procedure is useful in making new relations.

Internally, the above procedure is executed with the use of recursive queries, the results of which participate equivalently in the database relations in order to build new queries. The resulted queries feed some spatial queries the results of which are presented by the interoperable Geo-Object.

The following query presents how to obtain the comparison results of the aggregated data .

```
SELECT "fssmaster"."fssdesc", "fssmaster"."newcronos", "fssmaster"."fss_key",
"fsscover"."landuse", "fsscover"."land_year", "fss_area"."fss_area",
"fss_from_clc"."total_area", "fss_area"."fss_area_code"
FROM {oj {oj "fssmaster" LEFT OUTER JOIN "fsscover" ON "fssmaster"."fss_key"
      = "fsscover"."fss_key"} LEFT OUTER JOIN "fss_from_clc" ON
      "fsscover"."fss_key" = "fss_from_clc"."fss_key"}, "fss_area"
WHERE ( "fss_area"."fss_area" = "fss_from_clc"."fss_area" ) AND
      ( "fss_area"."fss_area_code" = "fsscover"."fss_area_code" ) AND
      ( ( "fsscover"."newcronos" = 0 ) )   ;
```

Note that the entity 'fss_from_clc’ arises from the following query:

```
SELECT fss_area.fss_area,    fss_clc.fss_key, Sum(poly.areastr)/10000000
FROM dba.cordescr, dba.fss_area, dba.fss_clc, dba.poly
WHERE (fss_clc.corcode=cordescr.corcode) and
(poly.fss_area_code=fss_area.fss_area_code)
AND (poly.corcode=cordescr.corcode)
```

This query is executed in the constructor event of PB-DWO and then it participates in the query that is presented in [fig. 3].

5 Results

Table 2 presents the linkage between the 2000 FSS and the new CLC nomenclatures. Although the new CLC nomenclature has been harmonized with the FSS nomenclature there are still some problems related to the two different methodologies. The analysis of the above problems has been carried out throughout of a comparison between the respective areas of the related classes, and has been allowed to make proposals for a future work. The available data from the 2000 FSS has been based at Municipality/Commune level (NUTS IV), whereas the data has been drawn from the new CLC at the district level (NUTS III). The data of two databases has been compared in a pilot study of four regions of Greece at a district level (NUTS III). The comparison shows large deviations in the agricultural areas. Generally, the examined agricultural areas in new CLC are greater than the corresponding agricultural areas in the 2000 FSS. The problem of large deviations is caused mainly because of the difficulties in correlating the pastures areas between the two databases, whereas the differences of the arable areas and the areas under permanent crops are related to the different methodologies.

The results found so far are presented in Tables 3 to 6. Table 3 presents the differences (%) in arable areas, areas under permanent crops, and cultivated areas (aggregation of D+E), as they recorded in the districts (NUTS III) of the examined regions, between the two nomenclatures. Positive sign is in favor of the new CLC nomenclature, whereas negative sign is in favor of the FSS nomenclature. Note that the actual differences in the above classes are not as high as they are in the remaining classes, namely pastures and meadows (Table 4), heterogeneous areas (Table 5) and agricultural areas (Table 6). To facilitate the comparison for the last cases the actual values are presented.

As it may be observed (Table 3) the above differences (%) in the regions (NUTS II) are generally smaller from the corresponding inter-regional ones (district level; NUTS III). This is due to the fact that the mapping unit of 25 ha in the new CLC is not able to identify parcels of smaller size. This is the case of Greece, in which the average holding size is around 4,5 ha and the average parcel size is around 0,7 ha. An additional reason is that in FSS all the holdings are recorded at the place of residence of the holder (natural person) or headquarter (legal person) of the holding. In the following some preliminary comparison of these results are summarized:

- *Arable areas*

  Region comparison shows that the difference for the region of Kriti is about 66% in favor of the FSS nomenclature. However, the differences in the regions of Makedonia are not as high (at most 33%) and are in favor of the new CLC nomenclature (Table 3). Generally, the differences in the arable crop areas are moderate and are in favor either of the FSS nomenclature or of the new CLC nomenclature (NUTS III level). Interesting to note that in some districts of the regions of Kentriki and Dytiki Makedonia the results are almost the same.

- *Areas under permanent crops*
  In general terms the situation is opposite of the one described in the arable crop areas. As it may be observed from Table 3 in the region of Kriti the differences (%) between the two nomenclatures are very small (about 6%). In the regions of Makedonia these differences (%) are moderate (at most 61%) and are in favor of the FSS nomenclature (NUTS II). Furthermore, in the districts of some regions these differences are substantial and/or in the opposite direction (e.g. districts of Evros –93%, Rodopi 89%, etc.).
- *Pastures and meadows*
  The total areas of pastures and meadows are generally larger in the new CLC than the corresponding areas recorted by the FSS. In all regions (NUTS II) the differences are very high. In the region of Kriti, the two districts of Rethimno and Chania the recorded areas in the new CLC are smaller than the corresponding areas of FSS. This is because only the private areas are recorded in the FSS, whereas all pastures (such as state-owned pastures, private pastures, etc.) are recorded in the new CLC.
- *Heterogeneous areas*
  FSS and new CLC present very high actual differences in the class of the heterogeneous areas. Even the two nomenclatures are harmonized there is still a methodological problem of how to relate the two nomenclatures. In particular, in the FSS the survey unit is the agricultural holding, which comprises of at least 0,1 ha. Therefore the heterogeneity (combined crops) of these areas is referred to this small area. In new CLC the heterogeneity is examined within the mapping unit of 25 ha. Under these circumstances a polygon in the new CLC that includes different parcels of a single crop is recorded as heterogeneous area, whereas in the FSS the corresponding parcels are recorded as single crops.
- *Agricultural areas*
  All the Agricultural Areas (AA=D+G+F) resulting from the new CLC nomenclature show larger values than the corresponding areas in the FSS nomenclature, particularly in the districts. The differences are generally high with exception of two districts of the region of Kriti. As it has been pointed out previously, the large deviations observed between the agricultural areas as they recorded in the new CLC and the FSS are due to the large deviations in the pastures.
- *Cultivated areas*
  Given the problems of the large deviations in the total agricultural areas that are caused mainly from the pastures, the aggregation of the arable areas and the areas under permanent crops into the new class of "Cultivated areas" shows that the differences presented in this class are not significant.

6 Conclusions

This study has been based on the provisional data of the 2000 FSS and the new CLC databases and it may be considered as a first step in the direction of present geo-reference statistical data. The difficulties appeared in the linkage of the two databases can be generally explained from the following:

- The different methodology used as far as the data collection methods and the coverage are concerned. In particular, the FSS is a census using as a reference unit the farm, whereas the new CLC is based on photo–intepretation of the whole area of the country using as a reference unit the mapping unit of at least

25 ha. In addition, CLC has so far been focused on land cover, rather than land use.

- The minimum size of 25 ha of CLC mapping units presents the difficulty of identifying parcels of smaller size. Thus, a number of non-agricultural areas are classified as agricultural whereas they are only partially agriculture. This is a common problem in areas with forest and olive-trees. Besides, areas classified as non-agricultural areas in CLC may include part of an agricultural area. This explains a number of differences within the agricultural classes. For example, part of meadows or permanent crops can be included in areas with arable crops and conversely.
- Despite the harmonization between the new CLC and FSS nomenclatures there are still problems as far as pastures and heterogeneous areas are concerned. In the new CLC, the non-agricultural classes defined by the codes 11, 12, and 13 ("Transitional woodland/shrub", "areas with mixed shrub/grass vegetation" and "areas with little or no vegetation" respectively) may include surfaces classified as "permanent meadows and pastures" in the FSS. Furthermore the FSS does not record the state-owned meadows, which in the new CLC are recorded under the code 8 ("areas under meadow or pastures").
- The special features of Greek agriculture that is marked by the diversity of the holdings in terms of area of production (mixed holdings), the small size of the holdings (average size 4,5 ha), the fragmentation of their area (6 parcels approximately per holding and average parcel size of 0,7 ha). In quite a number of cases the parcels of the same holding are normally located far away from the farmhouse or from the headquarter, but they are recorded at the place of the farmhouse or the headquarter (by definition).

The methodology of using the 'interoperable geo-object' in conjunction with RDBMS settings and the OOP logic meaning that many of the objects can be used in similar GIS applications with a little effort of maintenance.

The application developed is an easy-to-use tool, ideal for comparison of descriptive census results and interpreted geo-data, in order to conclude about the correctness of these data. If the expert combines the ability of simultaneous comparison and appearance of results of different years, the conclusions will be more reasonable.

7 Summary and future work

The work presented so far is a pilot study merging, by means of a software tool, the statistical data, available at the administrative level, with the geo-referenced land cover in order to identify and explain the most significant differences encountered between the aggregates of agricultural land cover classes. This has been achieved with the use of the 2000 FSS and the new CLC databases already under development in Greece.

The new CLC seems to provide a good mapping base for Greece, which could be improved further by using suitable satellite images that are able to produce scaled maps of at least 1:50000. Note that the imposed minimum mapping unit of 25 ha results in an overall underestimation of the diversity of landscapes something, which is particularly important in the case of Greece for which the average size of the holdings is 4,5 ha.

Apart of CLC, additional sources may be used providing detailed complementary information, such as aerial ortho-photographs, the cadastral map of Greece, IACS (Integrated Administrative Control System), MARS (Monitor Agriculture with

Remote Sensing), NATURA2000 database, or other ongoing analysis of the European landscape.
When the final data from the remaining regions of Greece will be available a quality analysis of the two databases will be carried out and a finer level of nomenclature will be examined. This will allow final conclusions to be drawn and further actions to be taken in the future.

Future research is to continue improving the idea of interoperable geo-object by adding methods and properties for uncertainty manipulation and to investigate requirements of GIS in a fuzzy object data model. Our final objective is to embody in the Geo-Object, the ability to generate and visualize transitions from one state to another, using the rules of an expert spatiotemporal system.

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D: ARABLE LAND	D01-D08: CEREALS	D01	Common wheat and spelt
		D02	Durum wheat
		D03	Rye
		D04	Barley
		D05	Oats
		D06	Grain maize
		D07	Rice
		D08	Other cereals
	D09: DRIED PULSES	D09C	Pulses-fodder peas
		D09D	Pulses-fodder field beans
		D09E	Pulses-other than fodder peas and field beans
	D10-D12: ROOT CROPS	D10	Potatoes
		D11	Sugar beets
		D12	Fodder roots and brassicas
	D13: INDUSTRIAL PLANTS	D13A	Tobacco
		D13B	Hops
		D13C	Cotton
		D13D	Other industrial plants
		D13D1	Other oil seeds or fibre plants
		D13D1A	Rape and turniprape
		D13D1B	Sunflower
		D13D1C	Soya
		D13D1D	Other oil seeds or fibre plants-others
		D13D2	Aromatic-medicinal and culinary plants
		D13D3	Industrial plants-others
	D14-D15: FRESH VEGETABLES, MELLONS, STRAWBERRIES	D14A	Fresh vegetables, mellons, strawberries-outdoor-openfield
		D14B	Fresh vegetables, mellons, strawberries-outdoor- market gardening
		D15	Fresh vegetables, mellons, strawberries under glass
	D16-D17: FLOWER AND ORNAMENTAL PLANTS	D16	Flowers and ornamental plants outdoor
		D17	Flowers and ornamental plants under glass
	D18: FORAGE PLANTS	D18A	Forage plants-temporary grass
		D18B	Forage-plants-other green fodder-total
		D18B1	Forage-plants-other green fodder-green maize
		D18B2	Forage-plants-other green fodder-leguminous plants
		D18B3	Forage-plants-other green fodder-others
	D19-D20: OTHER ARABLE CROPS	D19	Seeds and seedlings
		D20	Other crops
	D21: FALLOW LAND	D21	Fallow land
E: KITCHEN GARDENS	E: KITCHEN GARDENS	E	Kitchen gardens
F: PERMANENT PASTURES AND MEADOWS	F: PERMANENT PASTURES AND MEADOWS	F01	Permanent grassland and meadow-pasture and meadow
		F02	Permanent grassland and meadow-rough grazing

G: PERMANENT CROPS	G01: FRUIT AND BERRY PLANTATIONS	G01A	Fruit and berry plantations-temperate climate
		G01B	Fruit and berry plantations-subtropical climate
		G01C	Fruit and berry plantations-nuts
	G02: CITRUS PLANTATIONS	G02	Citrus plantations
	G03: OLIVE PLANTATIONS	G03A	Olive plantations-table olives
		G03B	Olive plantations-oil production
	G04: VINEYARDS	G04A	Vineyards-quality wine
		G04B	Vineyards-other wines
		G04C	Vineyards-table grapes
		G04D	Vineyards-raisins
	G05: NURSERIES	G05	Nurseries
	G06: OTHER PERMANENT CROPS	G06	Other permanent crops
	G07: PERMANENT CROPS UNDER GLASS	G07	Permanent crops under glass
H: OTHER LAND	H0103: UNUTILIZED AGRICULTURAL LAND	H01	Unutilized agricultural land which is no longer farmed, for economic, social or other reasons
		H03	Other land occupied by buildings, pleasure gardens, etc.
	H02: WOODED AREA	H02	Woodland
I: COMBINED AND SUCCESSIVE SECONDARY CROPPING, MUSHROOMS, IRRIGATION, GREENHOUSES	I01: SUCCESSIVE SECONDARY CROPS	I01A	Successive secondary crops-non fodder cereals
		I01B	Successive secondary crops-non fodder pulses
		I01C	Successive secondary crops-non fodder oil-seed plants
		I01D	Successive secondary crops-others total
	I02: MUSHROOMS	I02	Mushrooms
	I03: IRRIGATED AREA	I03A	Total irrigable area
		I03B	Irrigated once a year-total
	I04: AREA COVERED BY GREENHOUSES IN USE	I04	Area covered by greenhouses in use
	I05: COMBINED CROPS	I05A	Combined crops-agricultural-forestry
		I05B	Combined crops-permanent-annual
		I05C	Combined crops-permanent-permanent
		I05D	Combined crops-others

AA = D+E+F+G (Utilized Agricultural Area).
AA+H = Total Agricultural Areas.
I repeat areas entered in classes D, F and G.

Table 1: Classification of land use in the 2000 FSS nomenclature.

New CLC		FSS	
LEVEL 1	**LEVEL 2**	**LEVEL 1**	**LEVEL 2**
1. Artificial surfaces (Man-made areas)	1.1 Urban fabric (Build-up areas, urban agglomerations)		-
	1.2 Industrial and commercial units (Industrial or commercial zones)		-
	1.3 Transport units(Communication networks)		-
	1.4 Mine, dump and construction sites (Mines, waste disposal sites and construction sites)		-
	1.5 Artificial, non-agricultural vegetated areas sport and cultural activity sites (Artificial or non-agricultural green areas)		-
2. Agricultural areas	2.1 Arable land (Areas under arable crops)	Utilized agricultural areas D+G+E	D=D01+D02+D03+ D04+D05+ D06+D07+D08+D09+D10+ D11+D12+D13+D14+D15+ D16+D17+D18+D19+ D20+D21
	2.2 Permanent crops (Areas under permanent crops)		G=G01+G02+G03+G04+G05 +G06+G07
	2.3 Pastures (Areas under meadow or pasture)		F=F01+ F02
	2.4 Heterogeneous agricultural areas (Areas with mixed uses -mixed farmland)		I05A+I05B
3. Forests and semi-natural areas	3.1 Forests (Forested areas)		H02: only the private forests
	3.2 Transitional woodland /shrub		H01: only the private uncultivated areas for economic, social or other reasons
	3.3 Shrub and/or herbaceous vegetation associations (Areas with mixed shrub/grassy vegetation)		
	3.4 Open spaces with little or no vegetation (Areas with little or no vegetation)		
4. Surfaces under water	4.1 Inland water		
	4.2 Inland wetlands		
	4.3 Coastal wetlands		

Table 2: Linkage between the 2000 FSS and the new CLC nomenclatures in Greece

Regions (NUTS II)	Districts (NUTS III)	Arable Areas (% difference)	Areas under Permanent Crops (% difference)	Cultivated Areas (% difference)
ANATOLIKI MAKEDONIA & THRAKI	DRAMA	45	-93	42
	KAVALA	64	-45	31
	EVROS	24	44	25
	XANTHI	33	-67	32
	RODOPI	31	89	32
TOTAL		33	-27	30
KENTRIKI MAKEDONIA	IMATHIA	42	-91	-12
	SALONIKI	4	-49	3
	KILKIS	-7	-39	-7
	PELLA	-31	-77	-47
	PIERIA	-7	-79	-14
	SERRES	42	-81	37
	CHALKIDIKI	54	-9	34
TOTAL		15	-61	4
DYTIKI MAKEDONIA	GREVENA	20	-68	18
	KASTORIA	-21	-35	-22
	KOZANI	4	27	5
	FLORINA	-3	-44	-4
TOTAL		3	-14	2
TOTAL MAKEDONIA		18	-52	12
KRITI	IRAKLIO	-71	4	-4
	LASITHI	54	47	48
	RETHIMNO	-91	-7	-24
	CHANIA	-72	4	-4
TOTAL		-66	6	-3

Table 3: Results showing the differences (%) in arable areas, areas under permanent crops and cultivated areas (D+E) as they recorded by the 2000 FSS and the new CLC nomenclatures.

7.1.1.1.1	Districts	Pastures and meadows (ha)		
(NUTS II)	(NUTS III)	2000 FSS	new CLC	Difference
ANATOLIKI	DRAMA	1,294	31,380	30,086
MAKEDONIA	KAVALA	760	19,810	19,050
	EVROS	4,353	13,870	9,517
	XANTHI	81	11,910	11,829
	RODOPI	1,733	13,520	11,787
TOTAL		8,221	90,490	**82,269**
KENTRIKI	IMATHIA	860	9,840	8,980
MAKEDONIA	SALONIKI	473	25,020	24,547
	KILKIS	5,310	40,680	35,370
	PELLA	2,458	25,910	23,452
	PIERIA	3	6,570	6,567
	SERRES	6,246	28,520	22,274
	CHALKIDIKI	2,780	5,330	2,550
TOTAL		18,130	141,870	**123,740**
DYTIKI	GREBENA	315	25,890	25,575
MAKEDONIA	KASTORIA	822	29,840	29,018
	KOZANI	794	70,610	69,816
	FLORINA	5,477	27,200	21,723
TOTAL		7,408	153,540	**146,132**
TOTAL MAKEDONIA		33,759	385,900	**352,141**
KRITI	IRAKLIO	36,412	69,070	32,658
	LASITHI	16,817	61,631	44,814
	RETHIMNO	62,470	53,241	-9,229
	CHANIA	63,410	40,167	-23,243
TOTAL		179,109	224,109	**45,000**

Table 4: Results showing the actual values and the corresponding differences in the class of pastures and meadows as they recorded by the 2000 FSS and the new CLC nomenclatures.

7.1.1.1 (NUTS II)	Districts (NUTS III)	Heterogeneous Areas (ha)		
		2000 FSS	new CLC	Differences
ANATOLIKI MAKEDONIA	DRAMA	16	8,000	7,984
	KAVALA	17	14,820	14,803
	EVROS	9	35,040	35,031
	XANTHI	2	9,010	9,008
	RODOPI	3	11,130	11,127
TOTAL		47	78,000	**77,953**
KENTRIKI MAKEDONIA	IMATHIA	324	39,420	39,096
	SALONIKI	19	65,020	65,001
	KILKIS	5	38,510	38,505
	PELLA	313	86,260	85,947
	PIERIA	21	29,440	29,419
	SERRES	26	16,140	16,114
	CHALKIDIKI	9	42,210	42,201
TOTAL		717	317,000	**316,283**
DYTIKI MAKEDONIA	GREBENA	0	19,220	19,220
	KASTORIA	6	25,540	25,534
	KOZANI	24	4,020	3,996
	FLORINA	0	18,360	18,360
TOTAL		30	67,140	**67,110**
TOTAL MAKEDONIA		794	462,140	**461,346**
KRITI	IRAKLIO	143	54,339	54,196
	LASITHI	12	34,433	34,422
	RETHIMNO	159	33,372	33,213
	CHANIA	14	32,420	32,406
TOTAL		328	154,564	**154,237**

Table 5: Results showing the actual values and the differences in the class of heterogeneous areas as they recorded by the 2000 FSS and the new CLC nomenclatures.

Regions (NUTS II)	Districts (NUTS III)	Agricultural Areas (ha)		Agricultural Areas (% difference)	Average parcel area (ha)
		2000 FSS	New CLC		
ANATOLIKI MAKEDONIA	DRAMA	47,193	104,720	122	0.78
	KAVALA	44,860	92,390	106	0.55
	EVROS	150,252	231,060	54	0.64
	XANTHI	37,214	69,940	88	0.69
	RODOPI	74,941	121,230	62	0.62
TOTAL		354,460	619,340	75	0.64
KENTRIKI MAKEDONIA	IMATHIA	53,894	95,690	78	0.82
	SALONIKI	129,483	222,840	72	0.79
	KILKIS	106,027	172,420	63	0.90
	PELLA	77,660	151,640	95	0.61
	PIERIA	45,543	74,950	65	0.75
	SERRES	144,947	234,670	62	0.58
	CHALKIDIKI	77,274	147,270	91	0.77
TOTAL		634,828	1,099,480	73	0.72
DYTIKI MAKEDONIA	GREVENA	41,432	93,810	126	0.80
	KASTORIA	24,887	74,260	198	0.58
	KOZANI	88,170	166,260	89	0.58
	FLORINA	52,952	90,960	72	0.55
TOTAL		207,441	425,290	105	0.60
TOTAL MAKEDONIA		1,196,729	2,144,110	79	0.67
KRITI	IRAKLIO	139,733	221,982	59	0.40
	LASITHI	37,864	127,252	236	0.44
	RETHIMNO	101,182	115,842	14	0.87
	CHANIA	109,191	116,472	7	0.83
TOTAL		387,970	581,548	50	0.57

Table 6: Results showing the actual values and the difference (%) in the class of agricultural areas as they recorded by the FSS and the new CLC nomenclatures, It also shows the average parcel area,

Figure 1. Spatial information levels

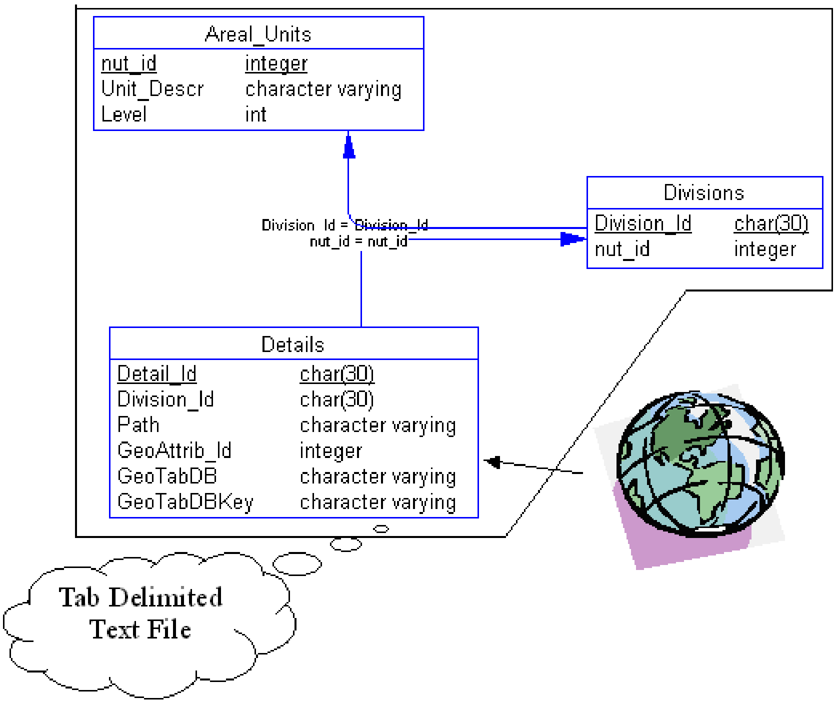

Figure 2. Link between the spatial and descriptive information

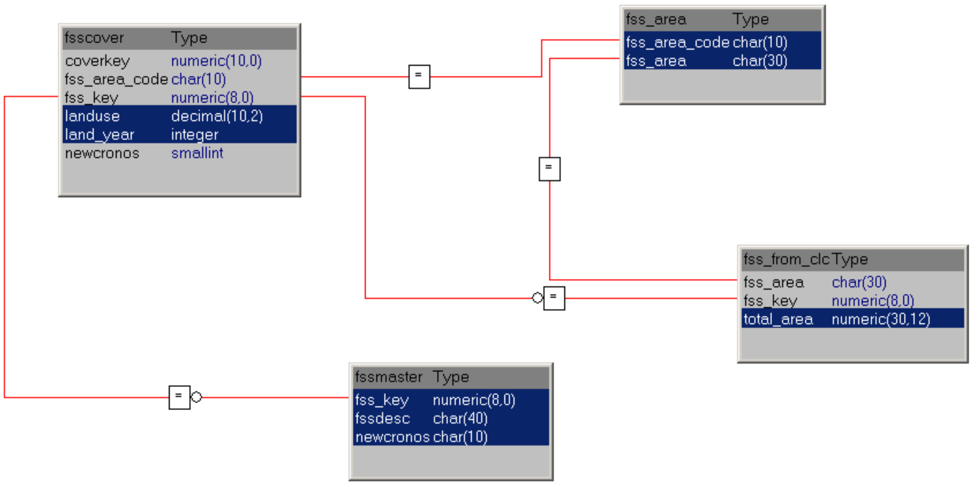

Figure 3. PB-DWO representation

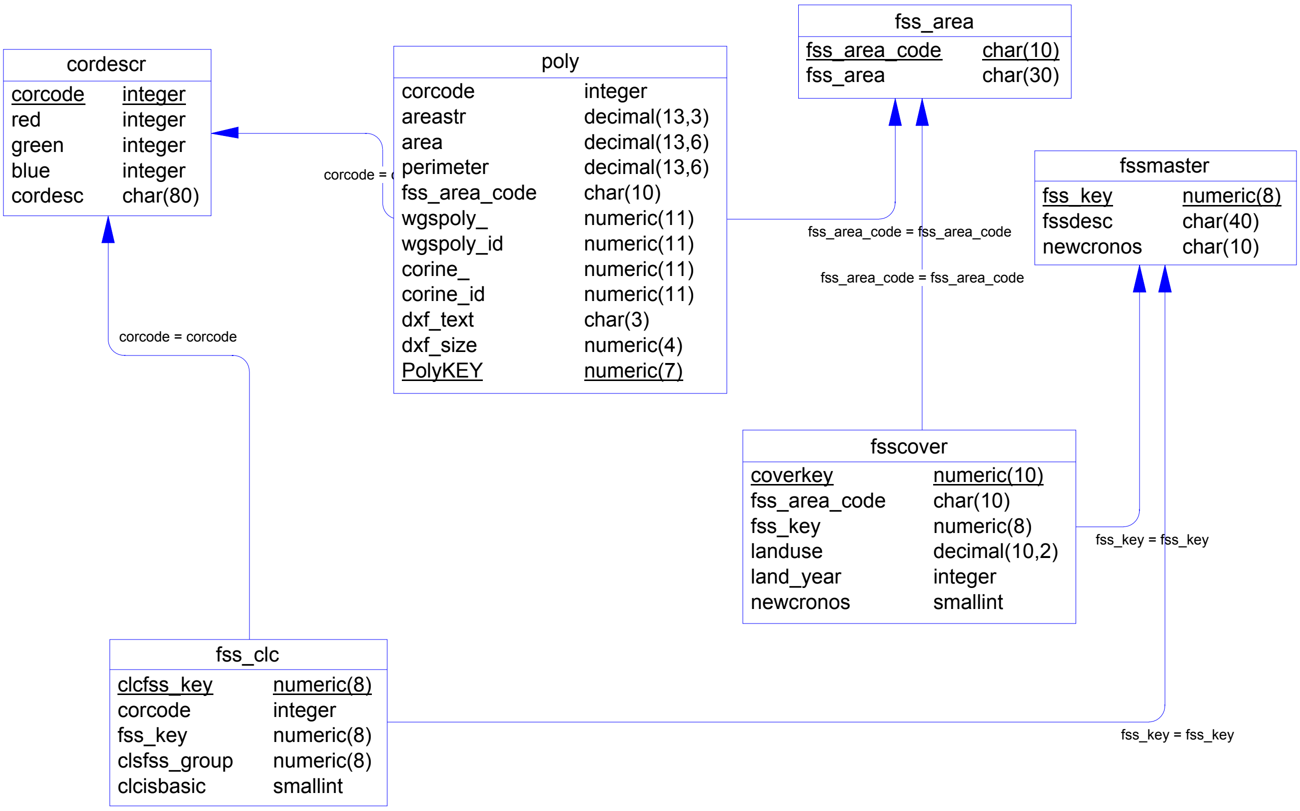

Figure 4. Conceptual Model

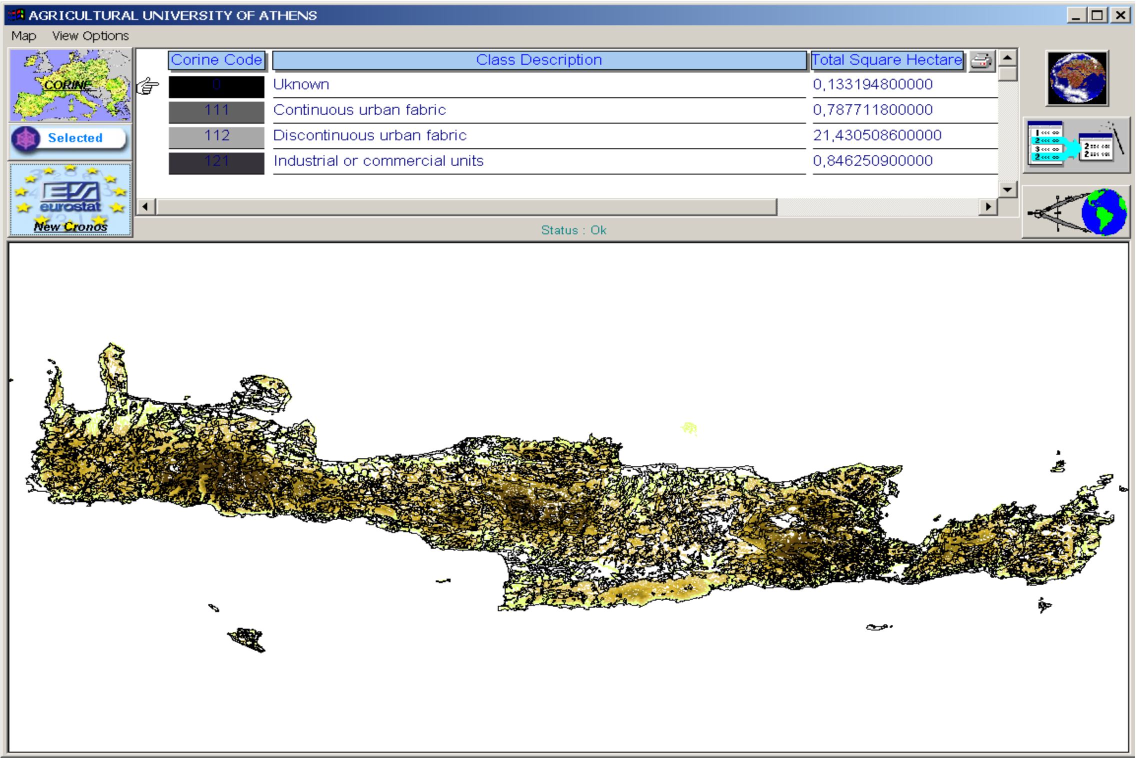

Figure 5. Main window of the application

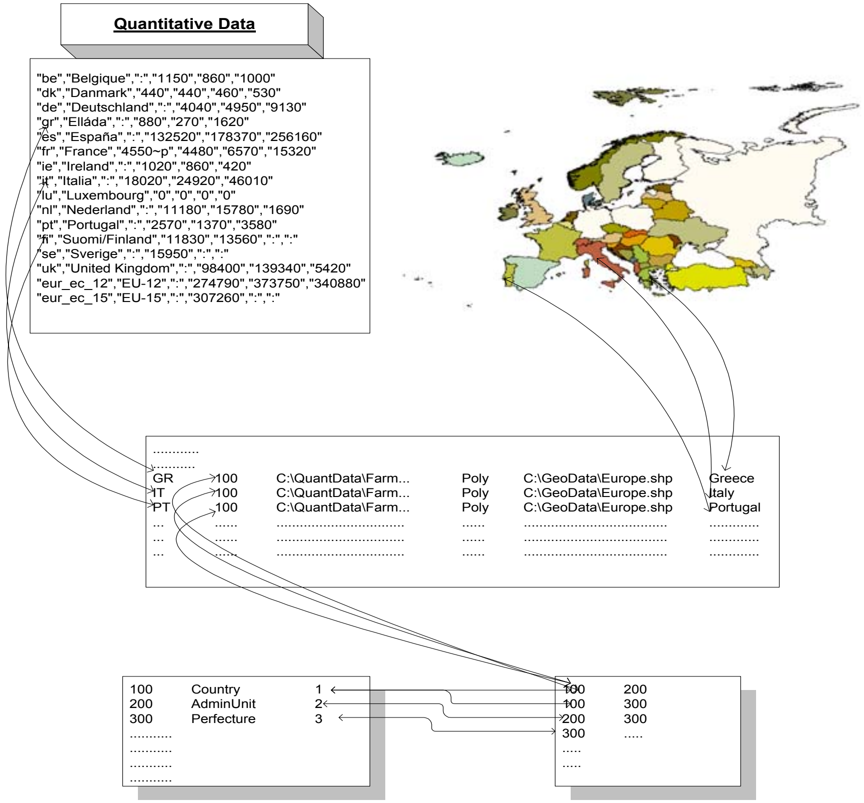

Figure 6. Link of a text file with quantitative data in a country level with geographic features in GIS environment

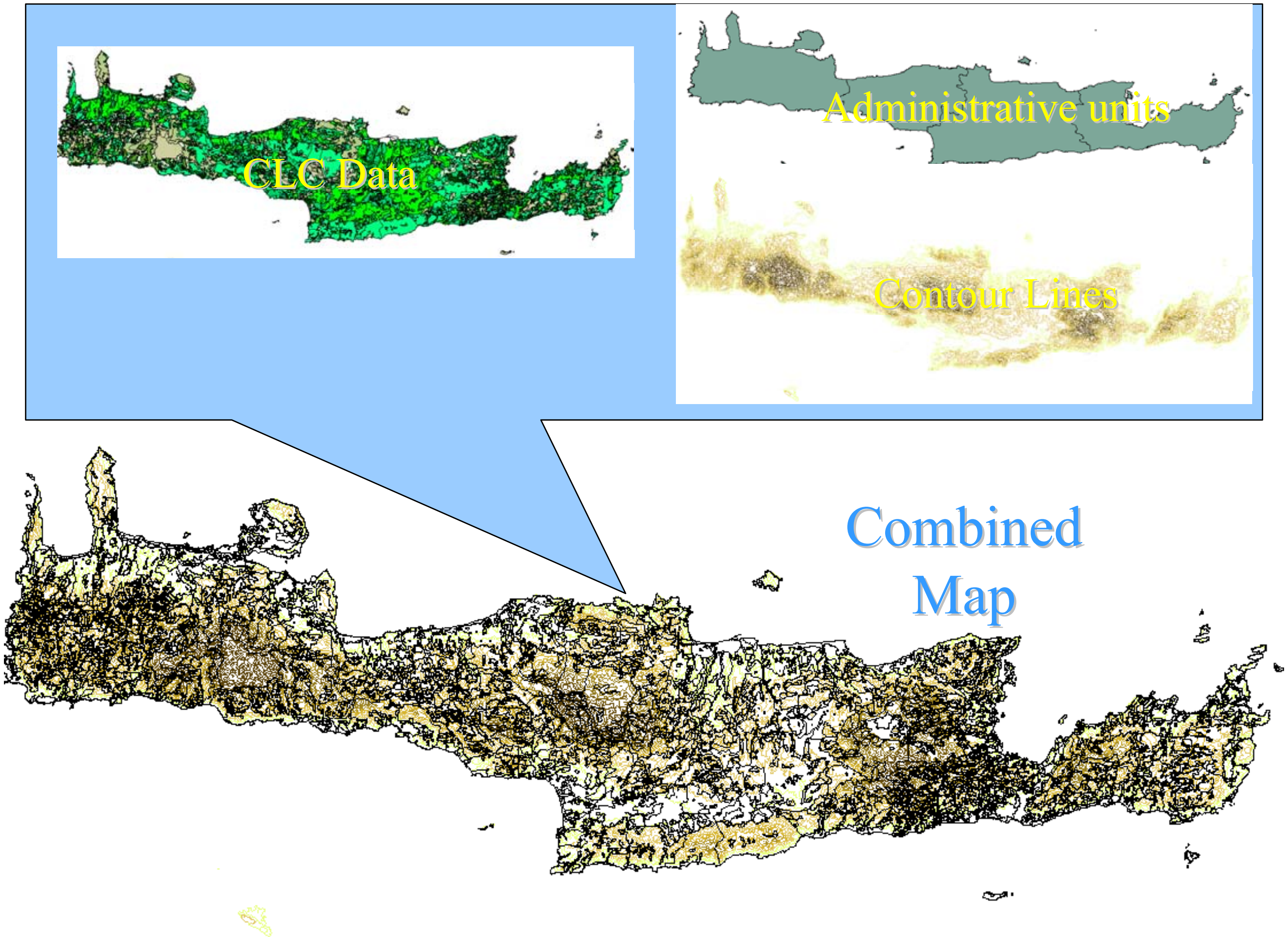

Figure 7. The combined new CLC map of the region of Kriti

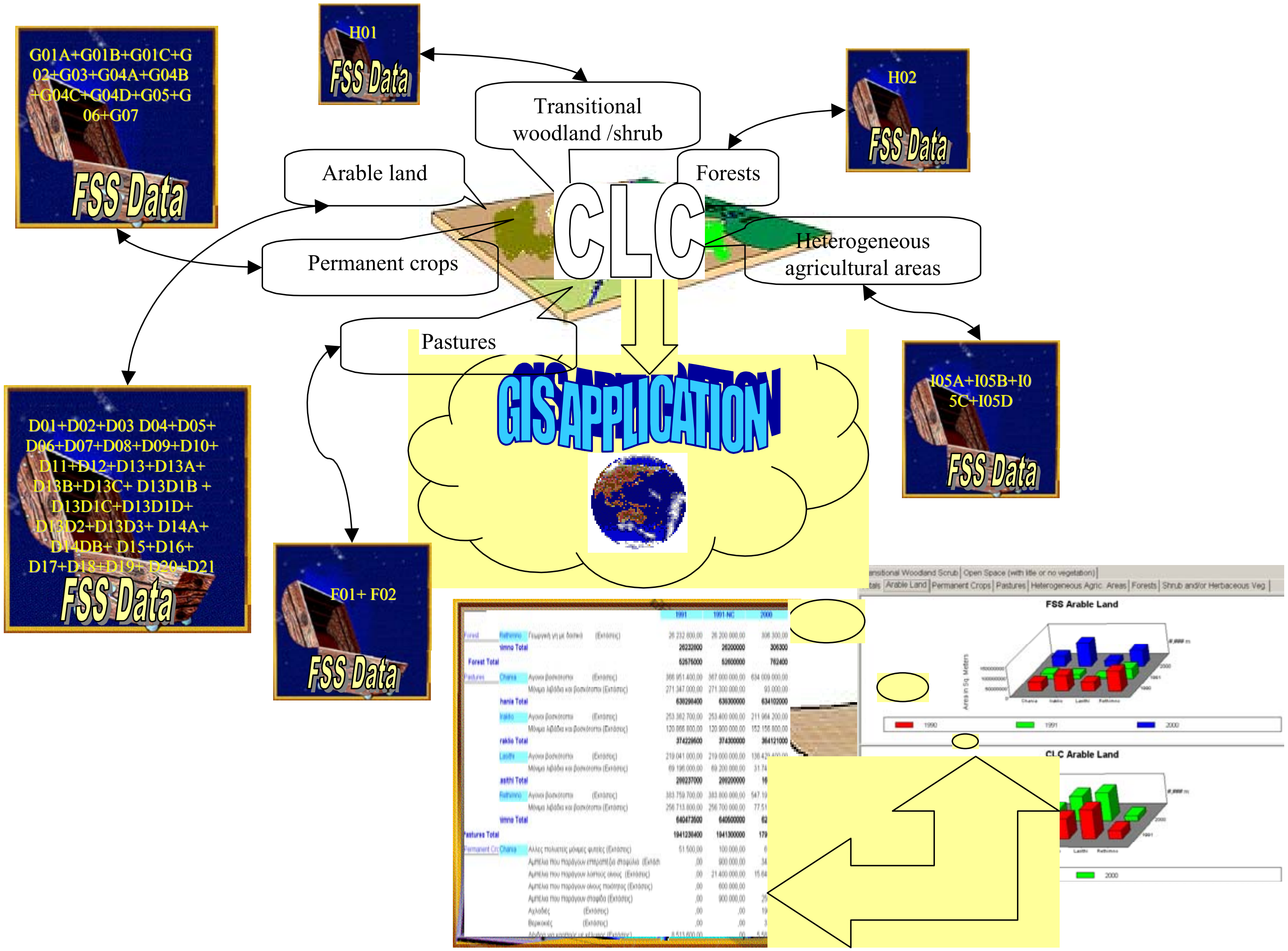

Figure 8. Merge of the new CLC and the 2000 FSS nomenclatures

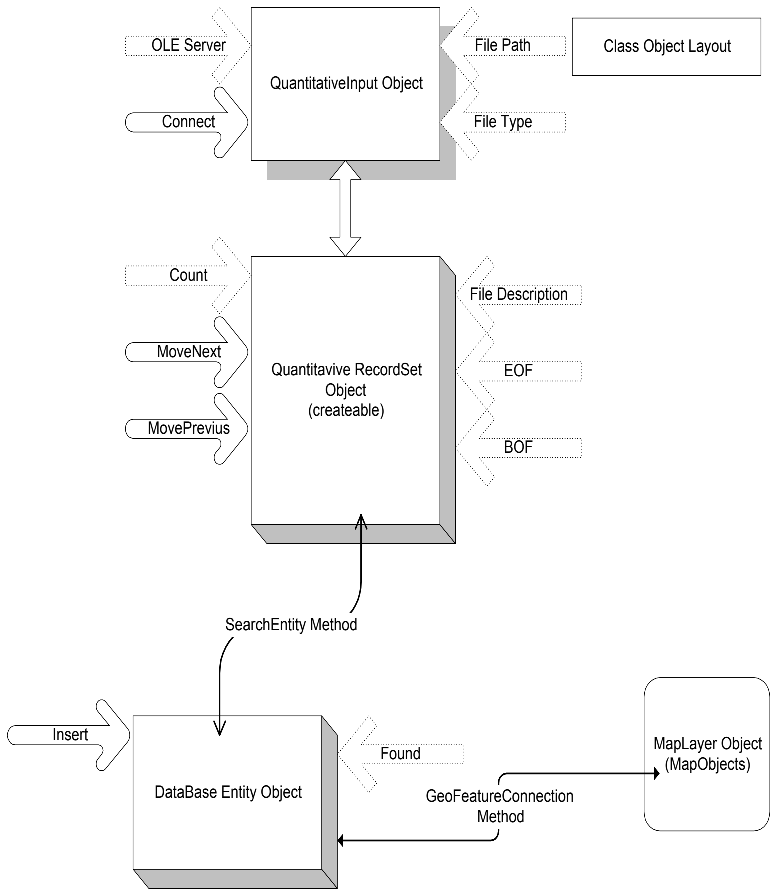

Figure 9. Class of objects with Properties and Methods