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USING NATIONAL FADN DATABASE TO DESCRIBE ITALIAN FARMS AND ARABLE FIELDS. A COMPARISON OF SUSTAINABILITY LEVEL BETWEEN ORGANIC VERSUS CONVENTIONAL REGIMES.

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Abstract

The study defines a new farm classification and identifies the arable land management. These aspects and several indicators are taken into account to estimate the sustainability level of farms, for organic and conventional regimes.

The data source is Italian Farm Account Data Network (RICA) for years 2007-2011, which samples structural and economical information. An environmental data has been added to the previous one to better describe the farm context.

The new farm classification describes holding by general informations and farm structure. The general information are: adopted regime and farm location in terms of administrative region, slope and phyto-climatic zone. The farm structures describe the presence of main productive processes and land covers, which are recorded by FADN database.

The farms, grouped by homogeneous farm structure or farm typology, are evaluated in terms of sustainability. The farm model MAD has been used to estimate a list of indicators. They describe especially environmental and economical areas of sustainability.

Finally arable lands are taken into account to identify arable land managements and crop rotations. Each arable land has been classified by crop pattern. Then crop rotation management has been analysed by spatial and temporal approaches.

The analysis reports a high variability inside regimes. The farm structure influences indicators level more than regimes, and it is not always possible to compare the two regimes. However some differences between organic and conventional agriculture have been found. Organic farm structures report different frequency and geographical location than conventional ones. Also different connections among arable lands and farm structures have been identified.

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1. Introduction

This study focuses on *farm*, *farm context* and *connection* towards them to evaluate some aspect of *sustainability* (by *indicator* level estimation) in different *regimes* among different *farm typologies*. Each of these six topics is a complex system which could be interpreted in several viewpoints.

Farm is the basilar land management unit and it has important role into landscape and society using often common natural resources. The concept of farms and its classifications can be define only after context description in term of considered elements and perceptions of them. The main two elements of context are society and natural environment. In the last decades relations among them and context perception are completely changed.

The old approach concerns society as little aspect of context with a resource request not relevant according the inalterable stocks of natural resources. Ratio is completely overturns between these two elements. The increase of global population changes previous balance and first scientific studies, about pollution phenomenons at planet level, show as natural eco-system is limited and fragile.

Also global approach to agriculture changes. Starting from economical system focused on permanent development, it becomes a diversified system with sustainable aim in all point of view (natural, social, economical, ect).

The future challenge for farms (and all society) will find a durable balance with surrounding context. Some agronomical techniques might support this challenge, especially the environmental friendly ones as organic agriculture. It considers crop rotations toward the conventional usage of synthesis fertilisers and phytopharmacies to preserve soil fertility and environmental quality. The environmental friendly approach of organic agriculture is always more recognised also by social surrounding context.

New tools can be developed to individuate the most sustainable farms and processes as: new farm classification more correlated with farm sustainability, model to estimate farm indicators in each field of sustainability and, finally, analysis of cover patterns to evaluate the most sustainable practices and techniques.

1.1 Farm definition

One common definition of farm considers an area managed by a farmer with aim to product. Three aspects are introduced: production as aim of farm processes, surface which support production and the actor who modifies natural dynamics to obtain products.

Production is the aim of farmer and it could means foods, materials or services. Everything applied to farm activities could be considered a resource. The amount and type of resources required depends from type of farm. The inputs could come from inside farm boundaries or import from other source.

Every farm used at least pedo-climatic conditions as others natural environments (water, soil, air, sun light, temperature, ect). Generally, these types of resources are quickly renewable allowing constant presence of life on Earth. But the regeneration rate could be deeply different and more or less sensible at human perturbance.

Moreover, technologies can open access to other types of resources which can consider different time scale of regeneration (as fossil fuel). The risk is to became addicted by energy source which can finish. In other hand it can mean altered eco-system balance modifying time and quality regeneration of the most common resources/services.

Farm surface concerns physical, geometrical and law boundaries. It is influenced by meteorological condition. It presents natural or artificial covers (fields, farmer house and buildings). It could be described by type of soil. Finally, it takes part at geo-morphological evolution path of surrounding context. All these aspects together are correlated at the same time.

Also last farm aspect is not so fixed entity: often farmer is not a single person, but he can be a family or a group of people. And quite always this “aspect” not interact only with elements inside farm surface. He also interacts/manages out-farm elements and it is contaminated at the same time from context aspects which could influence him and farm management too.

All these considerations introduce how some input and causes of farm management come from external of farm. This underlines as the farm boundaries and the farm processes can not be completely separated by surrounding context. In this approach the farm is always an open farming system with connection and trade with surrounding context.

1.2 Farm context definition and perception

Previous considerations focus attention on elements and perception of farm context. When context is defined, also connections among it and farm are drown. They can be simplified as trades of materials, services, effects or modification of original environment.

Outside farm context has been always considered. In general could be identified as original environment or also as other part of society which is not involved into farm production.

The whole society (as union of context and farmers) needs to maintain the farm production to survive. It means to guarantee availability of farms resources (Diamond, 2005). The perception of this availability could be roughly simplified into two approaches. The first is associated at slash and burn agriculture, the second to settled agriculture.

1.2.1 Slash and burn agriculture

It considers context only as original environment with perception that it was unlimited. Or better: resources required by this farm system are in balance with amount of available natural sources.

However, at first sight, slash and burn farm system could be considered close system because nothing comes outside farm (if also natural surface for hunting and fishing are considered as natural part of farm surfaces). And nothing exits from farm surface because everyone is a farmer and no trade is presented among different groups of populations.

But it is not completely right: slash and burn agriculture stressed so much environment that after few years it becomes infertile. So all population must move into new areas. In a complete dynamic analysis slash and burn farming system is an open system because it is necessary connected in time with no farm surfaces defined as original environment. And its surface amount is wider as wider is time period necessary to stressed environment to return again productive.

1.2.2 Settled agriculture

In general settled agriculture can supplies at diversified society. The population, who is not farmer, is the most important element of farm surrounding context, place side by side with original environment. Farm products overcame farm boundaries to sustain also not farmer people. Otherwise farmers take inputs from outside to manage farm surfaces. Considering different societies, it can mean import stone, wood or metal tools from artisans; or import high technological practices, machineries, synthetic input, meteorological information, ect., from agronomists and factories.

The stress of fields, caused by continuous agriculture, is usually contrasted with better agronomical practices/techniques or converting new natural areas into rural ones. But no others feedbacks to environment are considered coming from agricultural practices and techniques.

Society perception of context is in balance with the society and the farm resource requests. The balance does not overcome environment potential of resource regeneration. And natural areas are considered too much wide to be affected or modified by conversion of some part of them into fields.

1.2.3 Society management of agriculture

Few collective actions could be describe to guarantee resources in slash and burn societies. The size population control is one of them; another is moving of population into new area with more natural resources. They can be considered efficient where slash and burn agriculture is performed for thousands of years, like in Amazonia. But in other part of the world some societies not found this balance running to collapse.

The perception of farm context, previously described for settled agriculture, is generally the ones considered at beginning of the European Community (EC). In 1958 EC defined the farm as first chain of food supply and as holding in relation to the market. For these reason Common Agricultural Policies (CAP) provided action to guarantee safety food, to develop farmers revenue and to increase countries trade, all together to improve life stile. FADN database was established as tool to monitor CAP effects on farm collecting structural and economical farm information in each EC countries since 1965. Farm classification developed in this context are based on this kind of data.

1.2.4 Implementation of farm connections with context: farming system

The perception of context of settled agriculture has not enough complete to describe some pollution phenomenons investigate in about 1950's. Several scientific studies emphasised the feedback of some agronomical techniques on surrounding area (at different scale) outside farm boundaries. Correlations were measured among usage of phytopharmacies and bird health (Moore, 1965) (Ratcliffe, 1970) or among massive usage of fertiliser and watershed pollution (Standford, England, & Taylor, 1970). These observations show the deep connection among farm techniques and quality of surrounding environment. They could affect environmental services and their capability to restore resources. In other hand all connections between farm and outside surfaces have been redesigned. Also connections among techniques and on-farm resources began to taken into account in a new prospective (as linkage among deep tillage, soil, rhizosphere and organic matter).

When all this elements have been integrated in farming system, it is possible to show a lot of connection between inside and outside farm environment. They are so many that it is usually to consider farm as one of the basilar unit of land management. Indeed the farm controls pollutant and natural area health in directly way. This new perception only wakes up again the concept that farm activities can also modify landscape nature. Ancient Romans reclaimed Padana Plain, which was humid zone, creating a net of channel starting from farm field to bring away water. Always in Italy, which is cover for major part by hills and mountain, the terracing practice common is a transformation of hight slope sites which redesigns landscape and its dynamics.

One complete approach to farming system and its context is reported in figure 1.1.

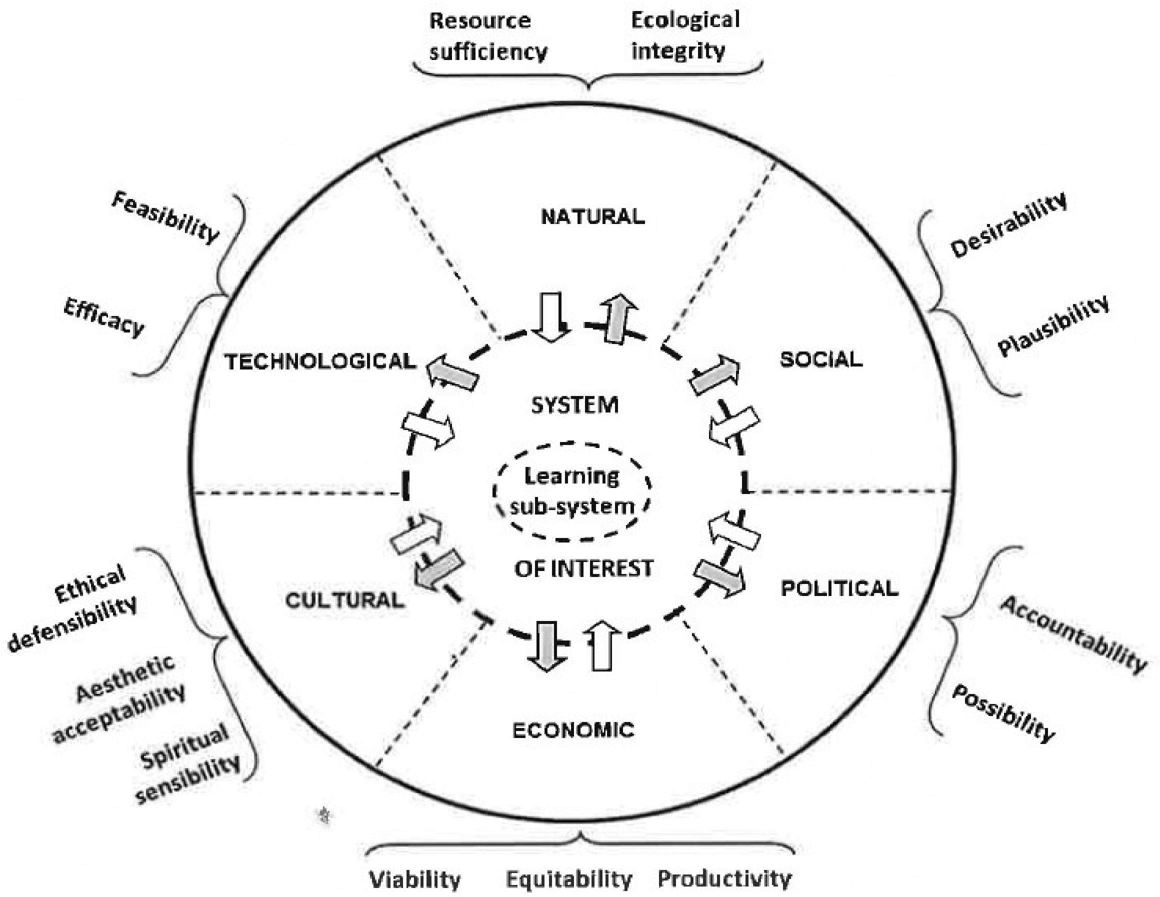


Figure 1.1: farm is the analysed system in the middle. Around it, six aspects of context are shown as trades from and to farm (Darnhofer, Gibbon, & Dedieu, 2012).

In this scheme the three farm elements (production, surface and farmer) interact with several context aspects, especially farmer, who influences and is influenced by all of them. At local scale these interactions start to be taken into account from researcher and management actors (farmers, cooperatives, politics, territorial institutions, ect.).

1.3 Change of context perception

The perceptions of both two major elements of farm context radically change in the last decades. Global population increases overcoming 7 billions of persons in these years (United States Census Bureau, 2014). This value, which is never recorded before, shows an increase trend which is absolutely outside of trend range of previous centuries. Not only amount of persons changes impact perceptions of society on environment. Also life style sensibly improves request of goods and resources.

Life style of "west world" is completely different in new millennium from the same "west" life style after the Second World War. Several studies prove as west life style is not exportable into whole planet. Because it should require to many resources not available on the Earth. However from developing countries, like China and India (which together count about one third of the global population), are improving their life style towards "west" style. This topic considers several prickly aspects (not so new) as equal style of live and relationship among the most powerful countries.

The improving of life style has been possible thanks implementation of technologies. They permit to extract from environment more and different resources. Fossil fuels is the most cited one. But also deforestation to obtain wood or field to industrial crops have become planet phenomenons thanks technologies improving in engineering, agronomical and transport fields.

In other words, environmental capabilities are become to consider limited and sometime fragile under effects of human activities. Since 1970 the Antarctic ozone hole (Solomon, Garcia, Rowland, & Wuebbles, 1986) and deforestation (Poore, 1986) are ones of the first phenomenons which stimulated new perception of environment as entity to protect. Nowadays green house gas (GHG) phenomenon is the most know one. It is caused by anthropic emissions connected with usage of fossil fuel, but also due to land management. IPPC report attributes at agriculture 10-12% of total amount of emission (Smith et al., 2007). All these phenomenons are results of human practices around all the world.

So, in general, this underlines how farm surrounding context considers whole planet surface. It is according to location of consumption of farm production, to input farm provenance and to global range of effects connected with farm practices.

Some power countries, as China, have started to buy surface outside their national boundaries. This phenomenon has different motivations, part of them are economical ones. But this could be considered the turning point into context approach which considers environment definitively limited.

1.4 Concept of sustainability

The adjective sustainable means something durable in the time.

According to previous unlimited environmental context, sustainable approach has been interpreted as improving of new land under human management or deeper resource extraction techniques to collect required resources.

New conception of limited environment, forces to reformulate sustainable approach. A limited environment means limited resource renewal. This focuses attention in two aspects: on one hand into amount of resource request by global society; in other hand into preservation of environmental cycles and balances. They define amount and quality of resources renewal. To stress them could means to reduce future resource amounts or, in the worst event, to stop renewal.

With these presuppositions, sustainability has to take into account present but also future society needs. Nowadays sustainable management has described as the process to satisfy present needs which gets resources from environment without affecting the same capability for future generations.

But several efforts must be faced to apply sustainable approach at whole society. First of all present technologies based on fossil fuels. Their natural regeneration considers time scale outside from human ranges. And their stocks should finish in the next century. The massive usage of fossil fuels in the last 2-3 centuries has brought at present GHG phenomenon and at global climate change (GCC).

Application of sustainable approach just now could not be enough. Indeed initial condition is not in balance to environment and GCC validates this point of view. The Kyoto Protocol, which entered into force in 2005, is an attempt to reduce the carbon emissions (referential level of 1990) which cause GHG effect. With all its weakness, Kyoto Protocol has shown how is clear at global level that human activities have overcome environmental balances starting to modify whole planet context.

Other difficulty to consider a completely sustainable approach is spatial scale of dynamics. Resources come usually from global market. Nowadays the trade links each parts of the world together. So sustainable approach, which considers all resource cycles, should be analyse quite all Earth. This is a relevant problem for scientific research, political actions and also for single citizen or farmer who could fill incapable to change present system.

The sustainable approach has been changed: from the protection of some specific environmental areas to a careful management of whole system. In this prospective agriculture have large opportunities to support a sustainable management of future society.

1.4.1 Sustainability in farming system

Farming system sustainability is connected with global sustainability of society. Moreover, it manages farm surface directly interacting with environment and several its resources and cycles. In figure 1.2 the three main aspects of landscape agronomy are reported. The natural resources define range of farming practices. These practices interact with environment by several feedbacks which constitute landscape patterns. But also landscape pattern disposition influences natural resources and their renewable processes. The scheme, reported in figure 1.2, shows these types of interactions as a continuous cycle.

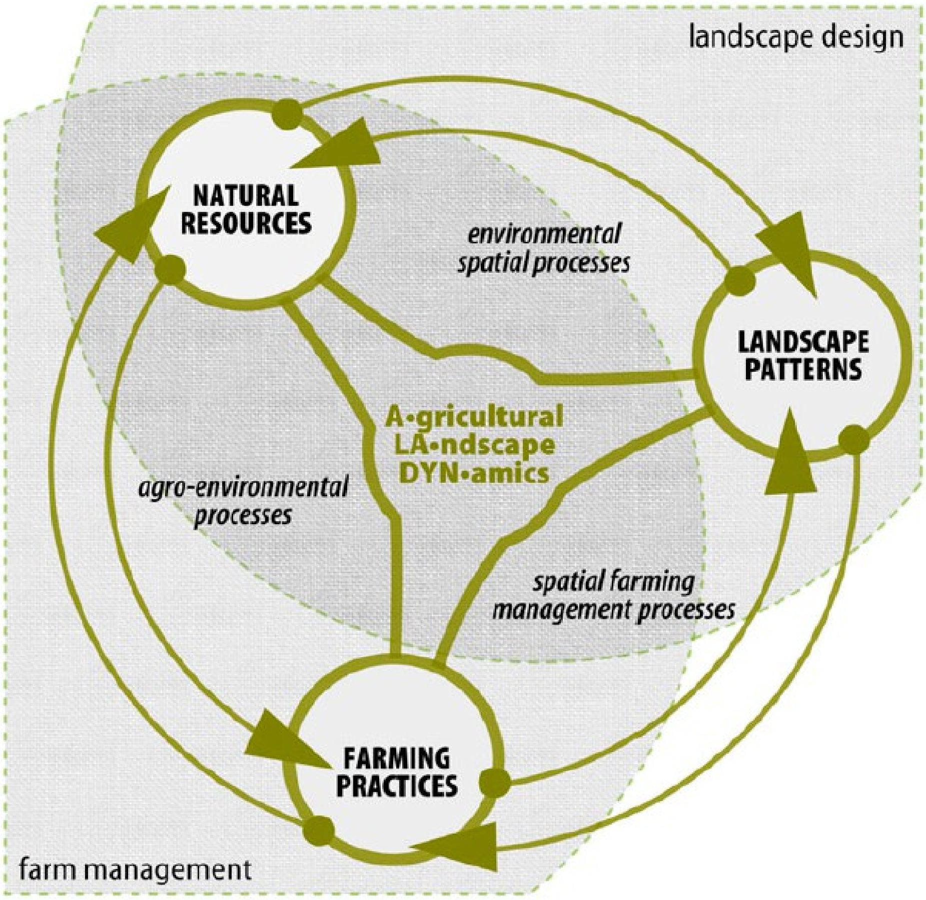


Figure 1.2: the scheme reports the three main topics of farming system in landscape agronomy (Rizzo et al., 2013).

In this study each of these aspects are considered. Farming practices are classified according agronomical technical coefficients and for classes of environmental impacts. In details, the organic and conventional regimes are investigated. Indeed organic regime should be more environmental friendly approach than conventional one. A reason is the frequent presence of crop rotations to maintenance of soil fertility in organic regime. Also synthesis products are under strictly limitation, especially phytopharmacies. In this study all farming practices are codified in several hierarchical categories which are used to define farm typologies.

The sustainability of farm typologies are investigated by estimating several indicator levels. The indicators are selected from the most common ones reported in bibliography. The selected ones describe principally environmental and economic aspects.

Finally, also patterns of arable lands are analysed to investigate variability among conventional and organic regimes. Indeed crop rotation is complex phenomenon difficult to analyse outside experimental fields. It is involved not only in maintainance of soil fertility, but also in landscape dynamics.

1.5 Case study: Italian organic agriculture

1.5.1 Organic regime

In Italy organic production must be certified applying methodology established by the European Community (EEC, 1991). It guarantees no usage of OGM; it limits applying of fertilisers and especially phytopharmacies. It also defines control procedures to use "organic" label for products. At less inputs should correspond less environmental impacts but also less production. For these reasons organic products are generally more expensive than other ones. One of the main organic practices is crop rotations which permit to control weeds and not stress soil fertility thank leguminous crops.

It is possible to define two phases of Italian organic agriculture over the last 20 years, as described in figure 1.3. The first period describes the rise of organic agriculture since 1990 until 2001 when maximum amounts of farmer and surfaces have been recorded. The second period shows quite stability since 2003 until now in terms of number of farmers (except for 2004), amount of surfaces (except for 2008) and husbandry (figure 1.4).

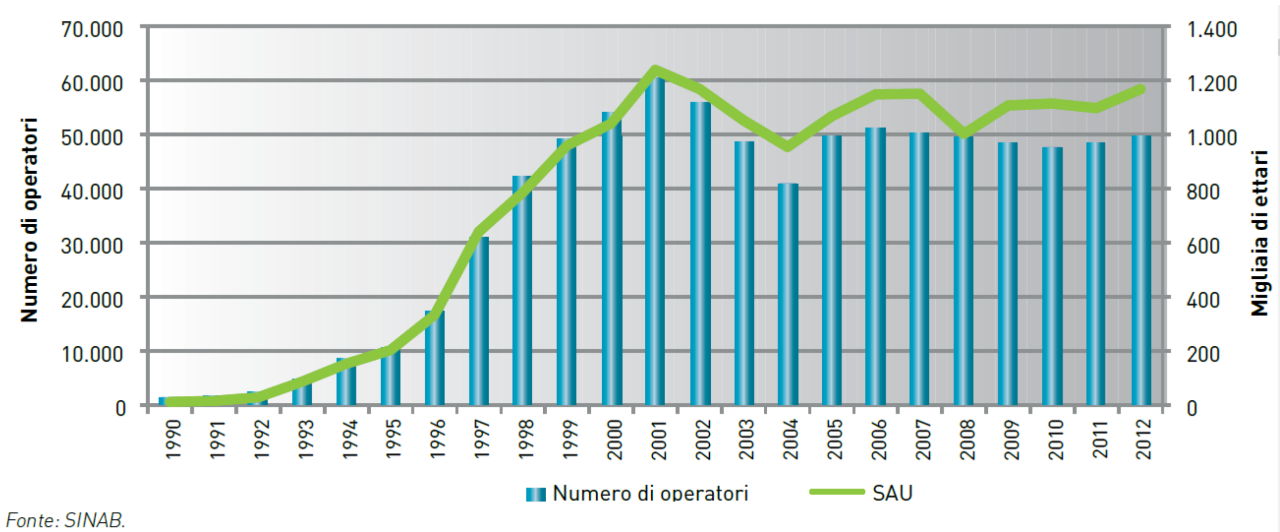
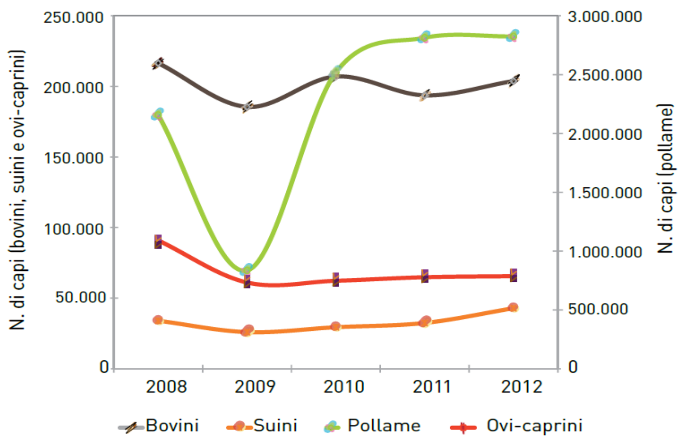


Figure 1.3: the chart describes organic situation in Italy since 1990 until 2012 in terms of amount of farmers (the histogram is correlated with left axis value) and surfaces (the green line is correlated with right axis value in term of thousands of hectares)(AA.VV., 2013).



Fonte: SINAB.

Figure 1.4: the chart describes organic husbandry in Italy since 2008 until 2012 in terms of herbivorous (beef/cow) (brown line), swine (orange line) and ovine (red line) amount correlated to left axis values. The amount of poultry (green line) is correlated to right axis values(AA.VV., 2013).

Italian organic agriculture does not supply all organic products request by country. The types of organic imported products are reported in figure 1.5.

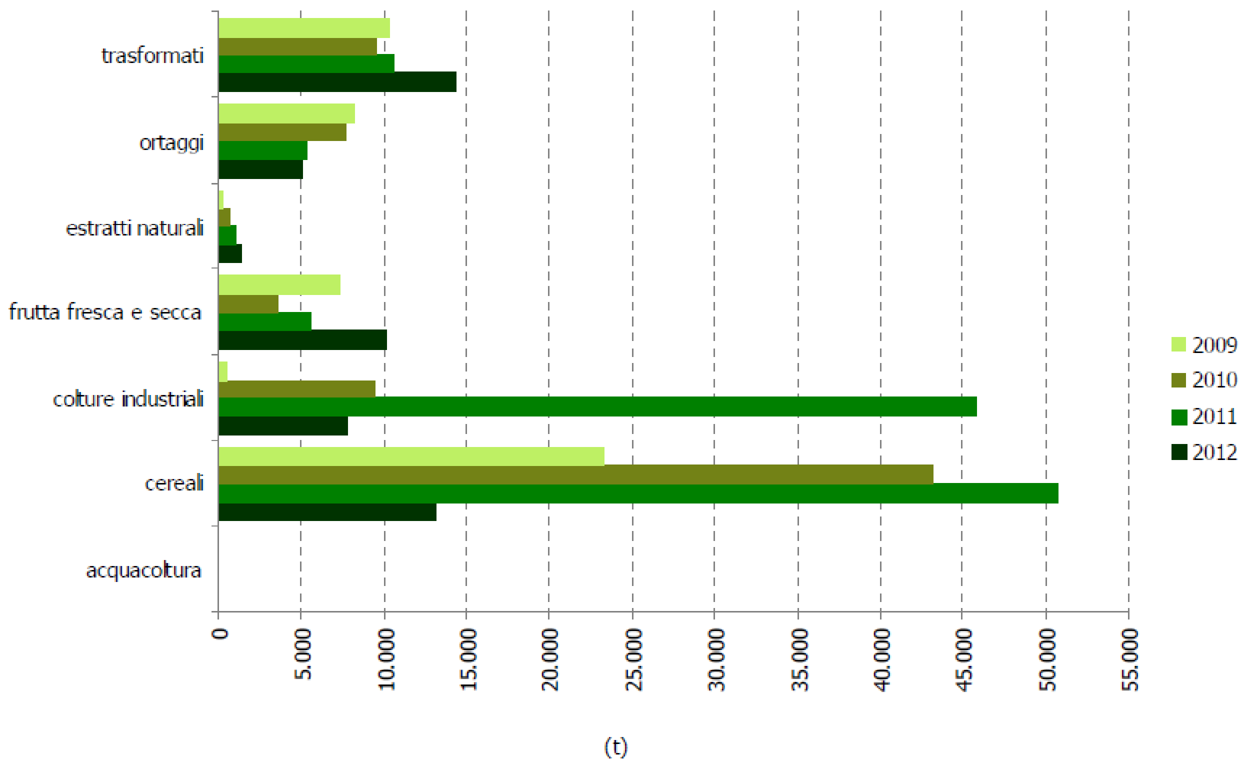


Figure 1.5: the chart describes types of organic imported products in Italy since 2009 until 2012 (SINAB, 2013).

In the last years, the import of organic fruits and transformed products is increased. But, in the other hand, the import of industrial crops and cereal is deeply reduced in 2012. These first two analysed aspects might suggest quite stable situation and not expansions for organic market. To analyse the Italian organic export is more difficult because inside European Community trade is free and products can move without strictly controls.

Other trend is reported in figure below (1.6) which describes some aspects of short supply chain refered to organic agriculture.

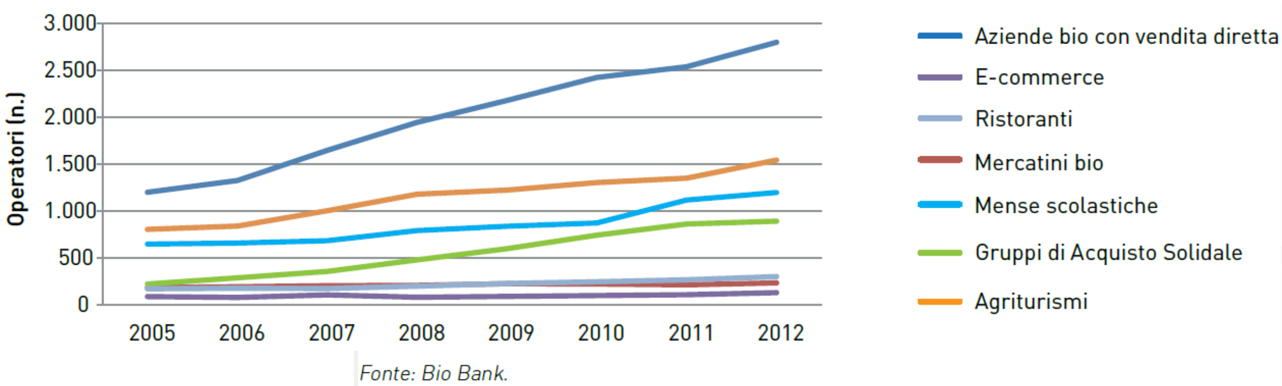


Figure 1.6: the chart describes some Italian aspects of short supply chain releted with organic production which is measured in in terms of operator numbers since 2005 until 2012. From the top to down, the legend reports: farms with direct sell, E-commerce, restaurants, points of sale, school meals, ethical purchasing groups, agritourisms (AA.VV., 2013).

All these aspects double since 2005 in terms of number of operators. Especially organic farms with direct sell increase of 250% and ethical purchasing groups rise of 400% respect the amount of 2005. These are signals which might show a better capacity of organic farmers to connect with local market. This idea is supported also by the following figure 1.7, where the ratio of production sold in farm is compared among organic, conventional and mixed regimes. In all cases (except for the Islands) organic farmers directly sell own products inside farm more than conventional ones.

Figure 1.7: on left side hand, the histogram describes percentage of production directly sold in farm for Italian macro areas (North-West, North-East, Center, South, Islands) and whole country (right side). The blue bars describe conventional farms, the green ones mixed farms and the light blue ones organic farms.
In right side hand, the pie chart reports reasons which support the short supply chain in organic farmer perceptions. From top to down, the legend reports: direct contact with producers, quality more guaranteed, inclination to short supply chain products, price, more environment sustainability, knowledge of specific products (AA.VV., 2013).

The reasons for this inclination to short supply chain by organic farmers could be investigate by considering the perceptions of farmers. In right side hand of figure 1.7, the pie chart reports the reasons to choose a short supply organic chain which farmers attribute at their consumers. Is possible to identify quite all aspects of farm context: environmental (about organic sustainability), economical (price) and also social ones (as knowledge of proper territory and its products and perception of healthy food). Often these perceptions are right and they suggest the organic agriculture as more sustainable than conventional ones.

Comparisons between organic and conventional farms can be developed under several profiles. In the following figure 1.8 some aspects of sustainability are reported. From the top, number of crops is used to estimate biodiversity in terms of genetic heritage and also as indicator of landscape diversity. In anticlockwise way, the second aspect is amount of products sold in farm as indicator of impact on atmosphere (less fossil fuels usage for transport). Soil management is the third one: indicator takes into account tillage techniques, usage of cover crops or residual crop cover and types of crop rotation practised. Hight values are attributed at minimal soil stress. Low values are attributed at intensive soil stress. The fourth aspect is energy: in this case amount of farms with renewable energy is considered. The last one is water consumption, which is evaluated as ratio among not irrigated area with potential irrigated area.

By considering these aspects with these approaches, the organic agriculture shows two sensible better performances, two comparable and one sensible worse than conventional agriculture (water consumption).

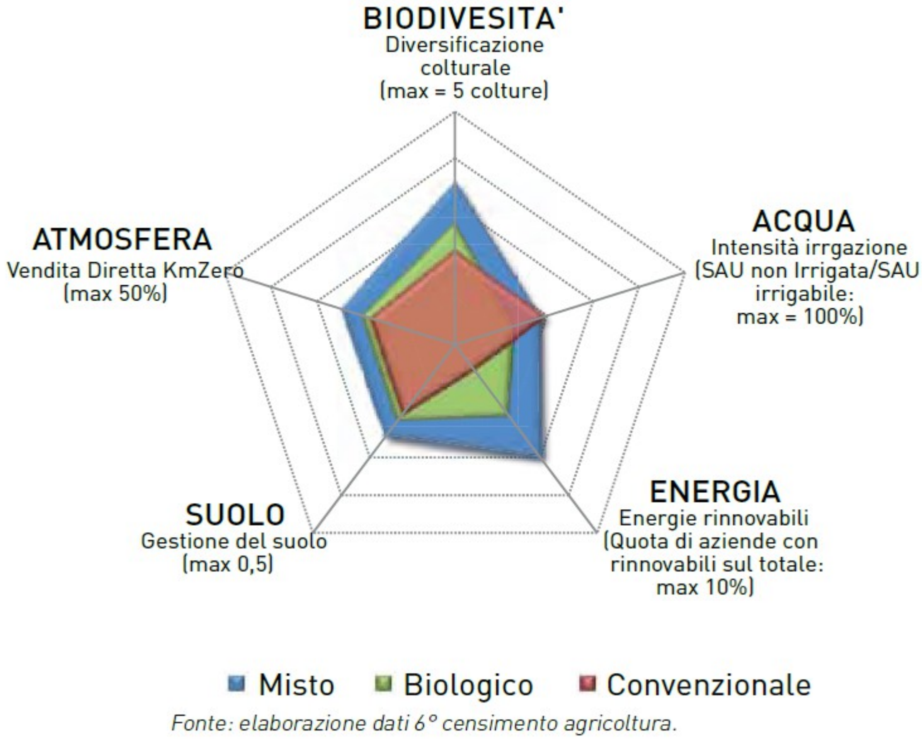
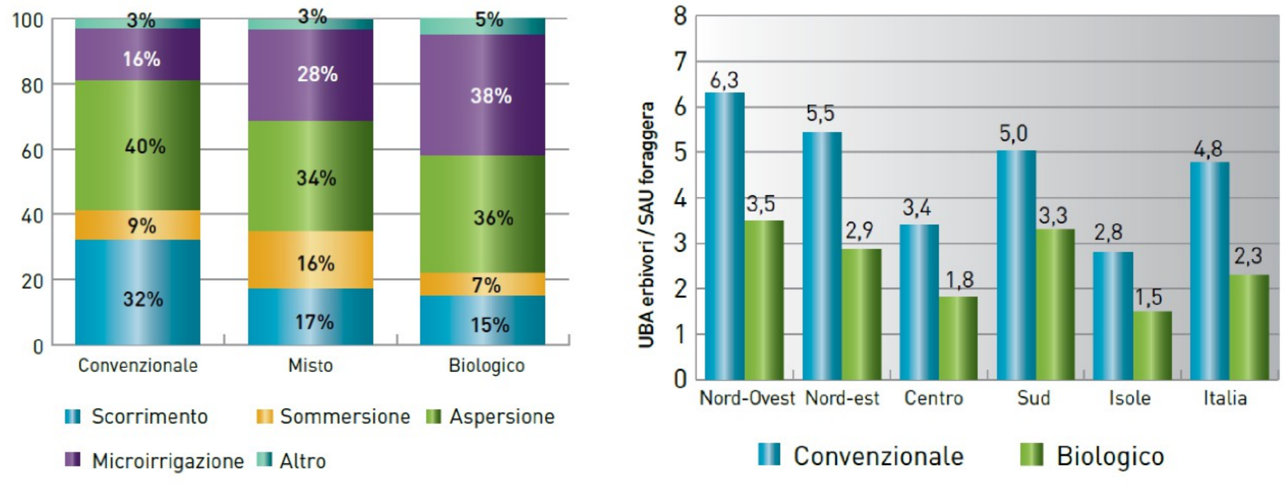


Figure 1.8: on the left side hand, the radar chart reports five aspects of agriculture sustainability estimated for conventional farms (red area), organic ones (green area) and mixed one (blue area). From the top into anticlockwise way the topics are: biodiversity (maximum 5 crops), atmosphere (maximum 50% of production sold on farm), soil (maximum 0.5 value considering soil and crop practices), energy (maximum 10% of farms with renewable energy respect all farms per regime), water consumption (maximum 100% ratio among irrigated surface and potentially irrigated surfaces)(AA.VV., 2013).

The water consumption is the only worse organic performance than conventional. On the left side of the figure 1.9, the chart of irrigation types is reported for different regimes. All types of irrigation with low efficiency are less common in organic farms than in conventional ones. It is the case of furrow, sprinkler and flooding irrigations which lose a lot of water by evapotranspiration. In the other side micro irrigation, which sensibly limited water loss, is more common in organic farms more than twice respect conventional ones.



Fonte: elaborazione dati 6° censimento agricoltura.

Figure 1.9: in the left hand side, the histogram reports types of irrigation for three bars: from the left side conventional, mixed and organic farms. From down of bars to top, the irrigation types are furrow (light blue), flooding (yellow), sprinkler (green), micro (violet), others (ice blue).
On the right hand side histogram of husbandry intensity is reported for conventional (blues bars) and organic farms (green bars) in terms ratio between the amount of herbivorous (UBA Adult Bovine Unit) and forages surface (hectares) (AA.VV., 2013).

Also other aspects can be taken into account to evaluate organic impact on environment as showed in the right hand side of figure 1.9. The levels of Italian husbandry intensity always report lower values in organic farms. A lower level of husbandry intensity generally means lower water pollution and soil degradation. Moreover it also means less GHG emission for surface units, especially of methane ones which are produced by herbivorous.

The organic agriculture has a heterogeneous distribution at local level as shown in figure 1.10.

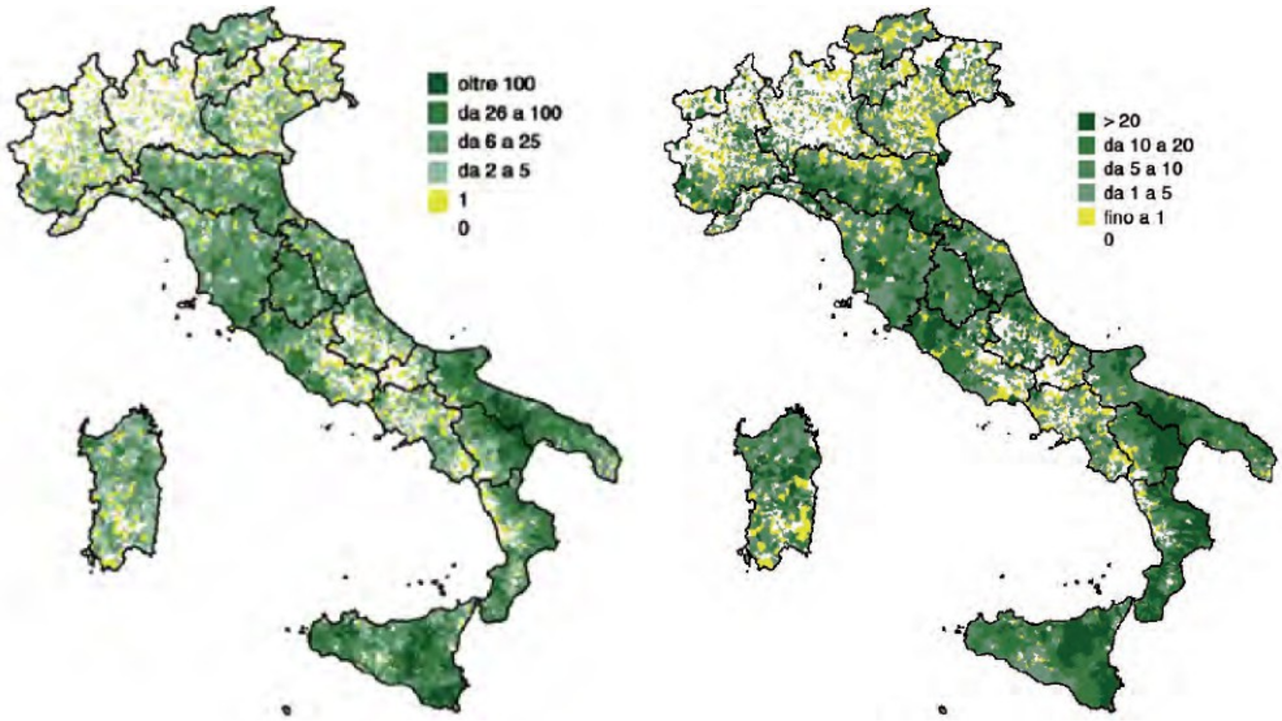


Figure 1.10: in the left hand side, the map of Italy reports number of farms for each municipalities in year 2010. The map on right hand side shows percentage of organic surfaces for each municipalities in year 2010 (AA.VV., 2013)

The major part of Italian municipalities present 5-20% of surface at organic agriculture. Only three areas report less presence of organic farms: one in north-west among Piemonte, Valle d'Aosta and Lombardia regions; in centre among Lazio, Campania Abruzzo and Molise and in the south of Sardigna. The distributions of farms and surfaces are similar suggesting quite homogeneous situation in terms of organic farm size for Italy which is about 28 hectares (referred to year 2010, (AA.VV., 2013)).

The distribution of organic farms is not affected by mountain presence. Indeed all Italy is crossed by Appennini mountains which run as back bones of country. The figure 1.10 shows high presence of organic farms in the mountain area defined between the south of Emilia Romagna, east part of Toscana and all Umbria. In other hand organic (and maybe also conventional) agriculture are less present on Alpi mountains in the north, where climatic condition are more extreme and slope is higher than in Appennini areas.

Indeed 60.7% of organic farms are in hilly areas, 20.8% in mountain and 18.6% in plain. The organic surfaces follow same trend. By considering also conventional farms, the organic ones are 3.4% on mountain side and 3.3% on hilly side, but just 1.6% on plain. In other side the organic surfaces are 12.7% on hilly sites, 9.4% on mountain sites and just 6.0% on plain sites (referred to year 2010, (AA.VV., 2013)). This shows as organic farms have marginal role on plain zones where conventional and intensive agriculture has main importance. In other hand organic farms became a relevant presence on mountain and especially on hilly side. It can be an advantage in terms of land management. Indeed organic farms, which better manage landscape as previous describe, are more present where surfaces are more unstable and need more precise management.

1.5.1.1 Comparison of organic agriculture in Italy an in other European countries

Italy (IT) has 8% of agricultural areas covered by organic farms, a value higher than the European Community average. In the figure 1.11 the percentage of organic agriculture presence is reported for each European Community countries at national and regional levels.

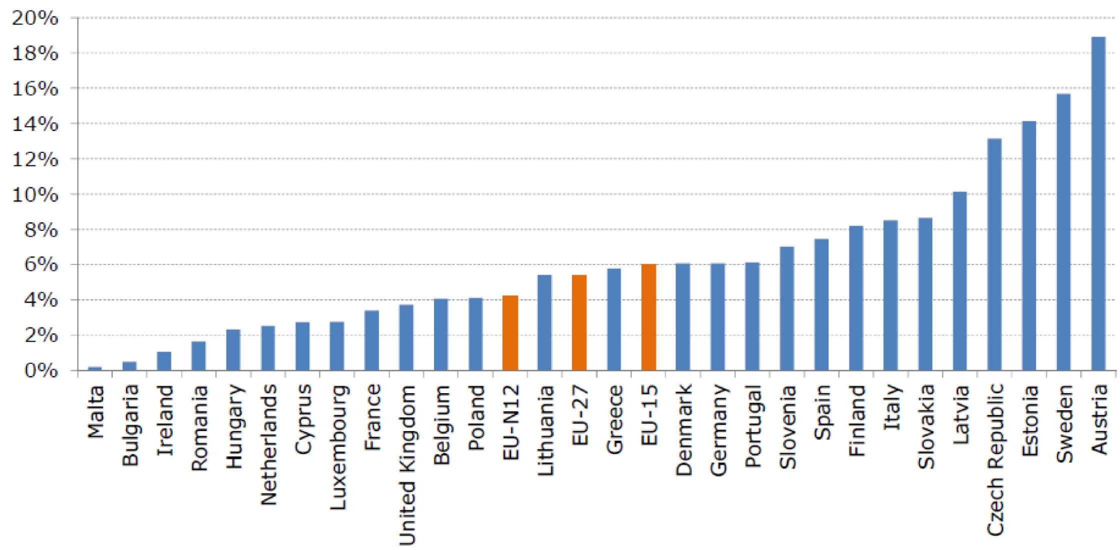
The organic agriculture dynamics are reported in figure 1.12 in terms of number of farm and amount of surface in the last years. For whole reported period Italy has the highest number of organic farms, but Spain has the widest amount of organic surfaces. This means that these two countries have different types of farms, at least for farm size.

As previous mentioned, in Italy the organic agriculture situation is quite stable in terms of number of farms and amount of surfaces. Also Germany (DE) and Austria (AT) show the same trend. On the other hand, France (FR), Spain (ES), Greece (EL) and Poland (PL) report improving in both aspects. The Italian behaviour for organic agriculture appears different from other relevant Mediterranean countries under organic profile. Indeed in Italy, the organic density is higher than Spain and Greece at regional and national level too. The Mediterranean part of France show density comparable at Italian ones.

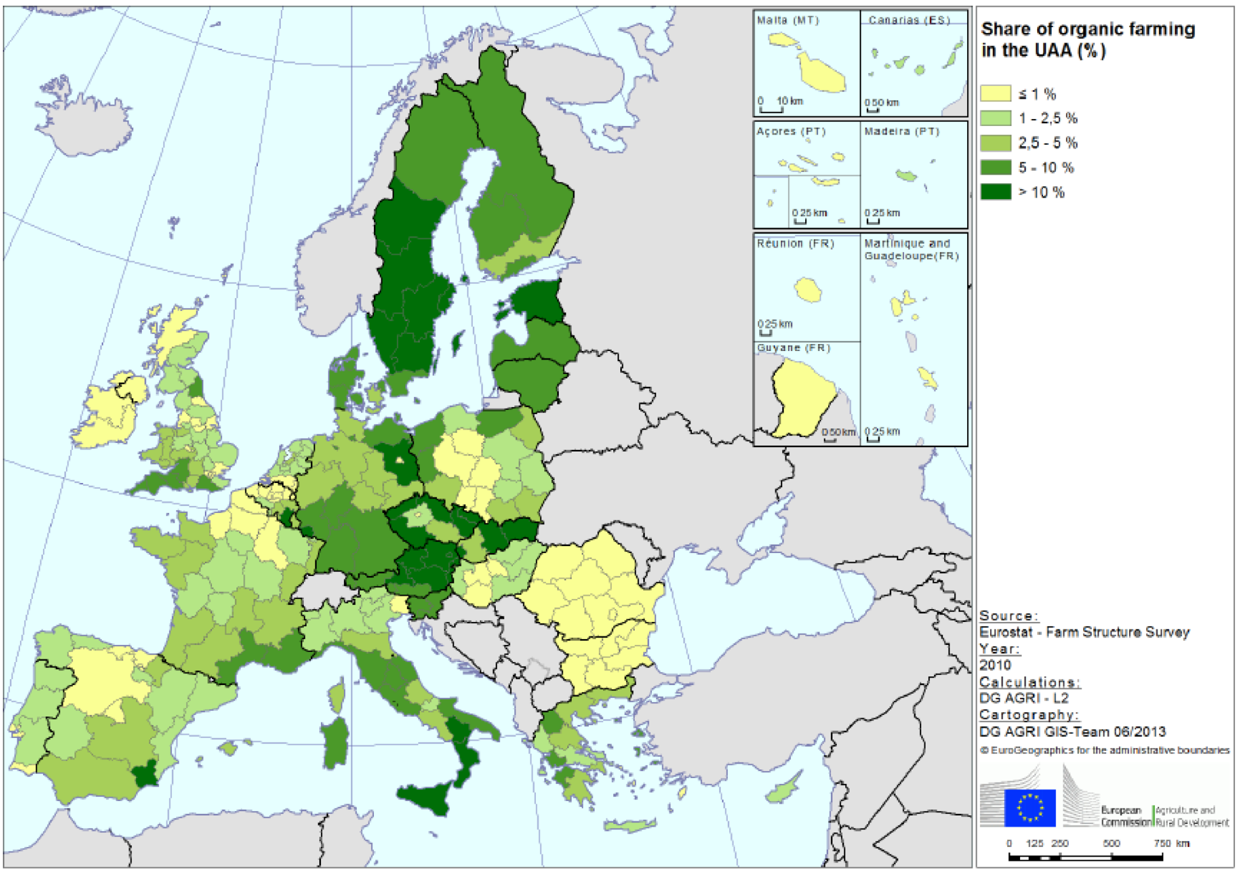
About the crop covers (reported in figure 1.13), Italy, Spain, Greece and France show different patterns. Italy shows more green fodder areas than Spain and Greece in percentage, but less than France. Spain reports more permanent crops in percentage than Italy which is quite similar to Greece, but with more tree crops than France. Different trends are reported for permanent grasslands. Spain and Greece report percentages higher than Italy as a lot of other north countries (France, Germany, United Kingdom (UK) and Czech republic (CZ)). Italy and Germany report the most highest percentage areas at cereals than other analysed countries.

All these considerations about country cover patterns, place Italy in middle point among Mediterranean countries and more colder ones. But the national level analysis are useful to describe and not to compare farms situations, especially for countries with high geomorphological diversity as Italy. Indeed permanent grasslands describe different field situations in Spain than Germany or United Kingdom. To consider these surfaces as similar could not be correct for agronomical and environmental aspects.

Share of the organic area in the UAA in the EU Member States, 2011



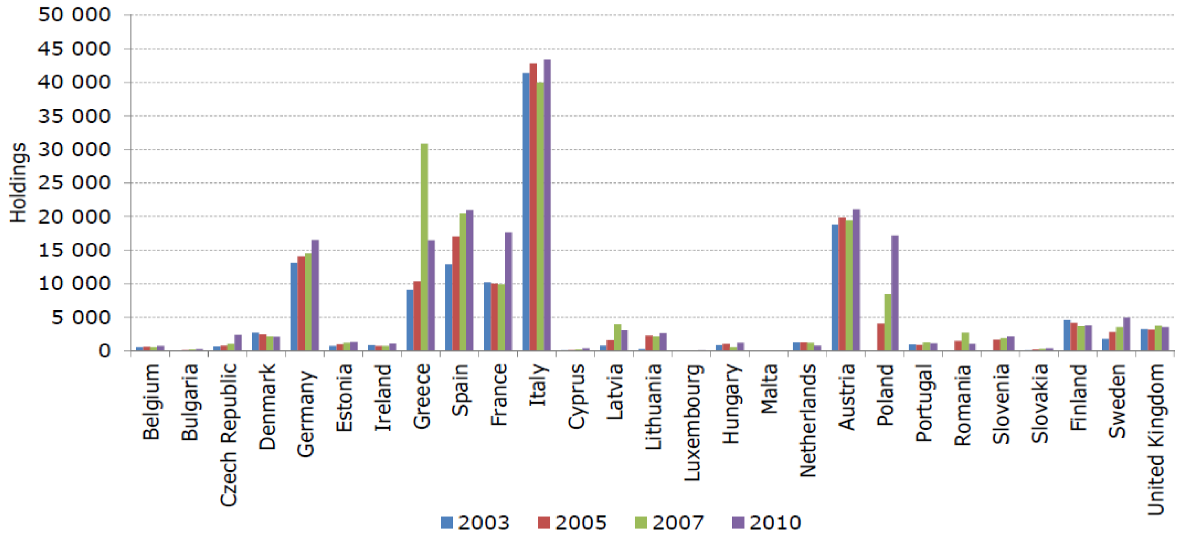
Source: Eurostat data on the basis of Council Regulation (EC) No 834/2007 on organic production (online data code: food_in_porg1) and land use statistics (online data code: apro_cpp_luse). Estimated data for organic production for IE, CY and LU. Estimated data for land use statistics for BE, EL, ES and IT.



Source: Eurostat FSS data.

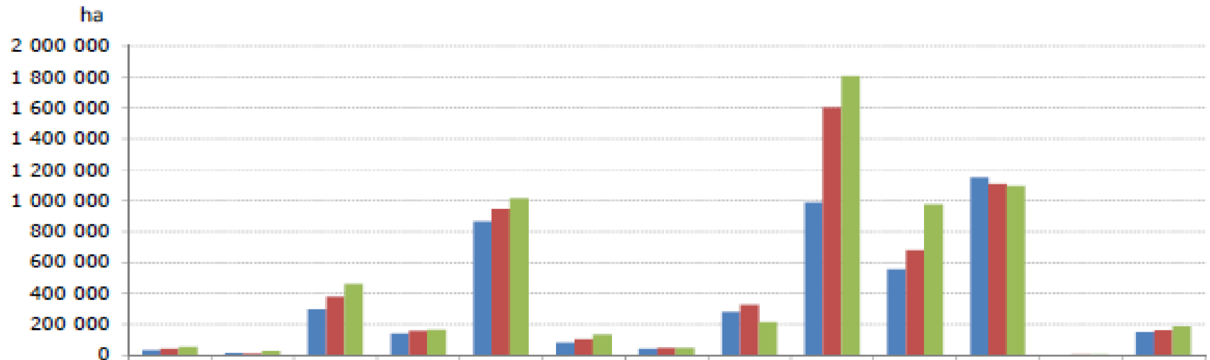
Figure 1.11: the top chart reports percentages of organic surface for each EC countries. The below map reports organic area presence (in term of percentage) in European Community at regional level (E.C., 2013).

Graph 10. Number of organic holdings in 2003, 2005, 2007 and 2010 in the EU Member States

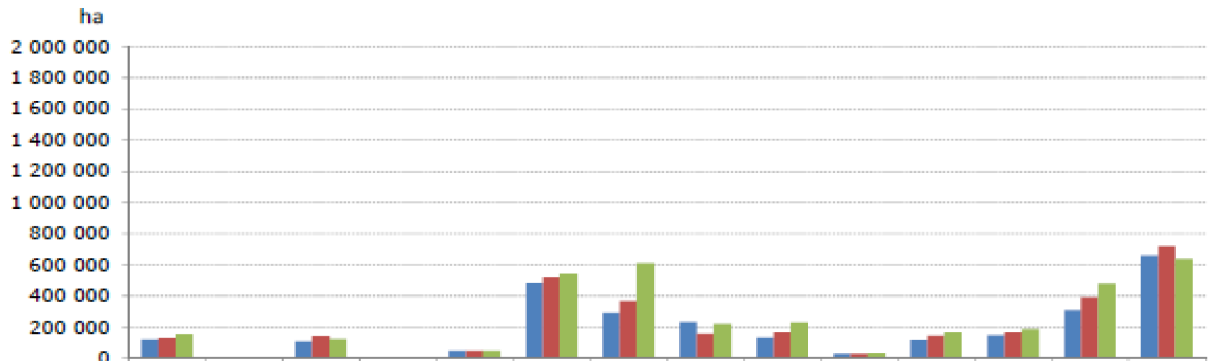


Source: Eurostat FSS data (online data code: ef_mporganic). No available data for MT (2003-2007) and for PL and SI (2003).

Graph 2. Organic area (certified organic + in-conversion) in the Member States in 2007, 2009 and 2011



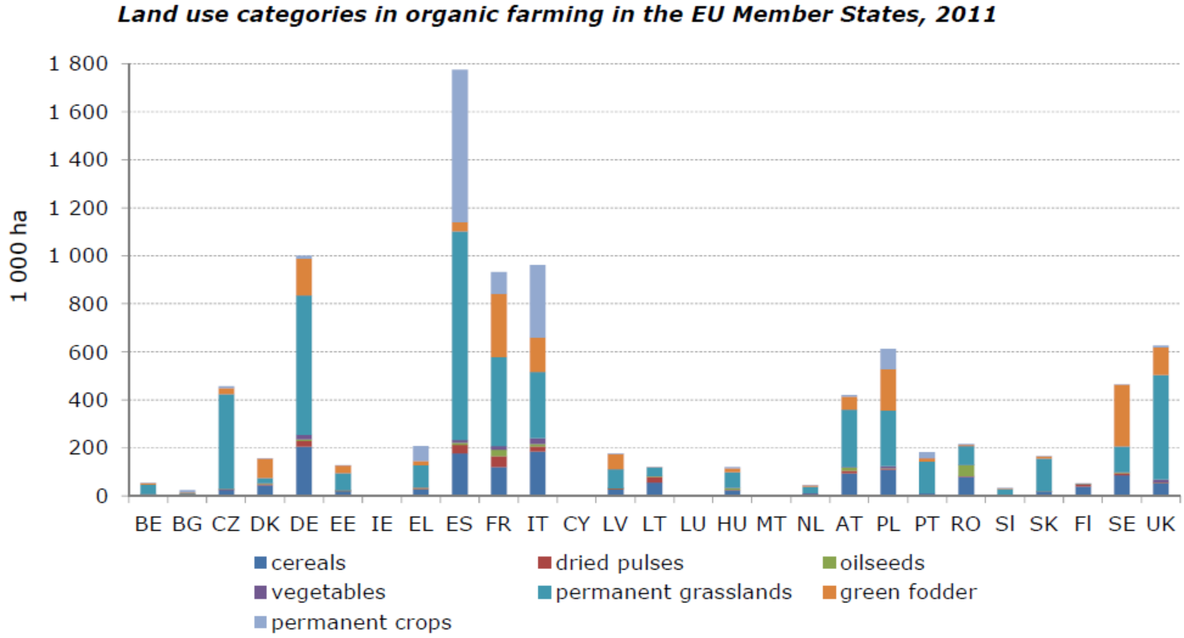
	BE	BG	CZ	DK	DE	EE	IE	EL	ES	FR	IT	CY	LV
2007	32 627	13 646	293 650	138 079	865 336	79 531	41 122	279 895	988 323	557 133	1 150 25	2 323	148 134
2009	41 459	12 321	376 923	156 433	947 115	102 305	47 864	326 252	1 602 87	677 513	1 106 68	3 184	160 175
2011	55 304	25 022	460 498	162 173	1 015 62	133 779	47 864	213 276	1 803 66	977 234	1 096 88	3 184	184 096



	LT	LU	HU	MT	NL	AT	PL	PT	RO	SI	SK	FI	SE	UK
2007	120 418	3 380	106 785	20	47 019	482 337	289 440	233 475	131 456	29 322	117 906	148 760	308 273	660 200
2009	129 055	3 614	140 292	26	49 330	518 757	367 062	157 179	168 288	29 388	145 490	166 172	391 524	721 726
2011	152 305	3 614	124 402	23	47 205	542 553	609 412	219 683	229 946	32 149	166 700	188 189	480 185	638 528

Source: Eurostat data on the basis of Council Regulation (EC) No 834/2007 on organic production (online data code: food_in_porg1). Estimated data for DK and MT (2007) and for IE, CY and LU (2011).

Figure 1.12: the top chart reports organic farm number for years 2003, 2005, 2007, 2010. The second histogram (separated in two parts) shows amount of organic areas for years 2007, 2009, 2011 for each EC countries (E.C., 2013).



Source: Eurostat data on the basis of Council Regulation (EC) No 834/2007 on organic production (online data code: food_in_porg1). Data for DE, AT, LU and FI from FIBL. Missing data for IE (except vegetables, which sources from FIBL), CY, LU (certain categories) and MT. No data for other crops, not included.

Figure 1.13: the histogram reports land use categories (in hectares) covered by organic agriculture in each EC countries in year 2011(E.C., 2013).

1.5.2 FADN database

The Farm Accountancy Data Network (FADN) was established by the European Community in 1965 (with Regulation EC No 79/65). This database was designed to monitor and to evaluate agricultural dynamics according to Common Agricultural Policies (CAP). It collects information from a sample of real farms which are representative of national agricultural situations. Structural and economical information about farms is collected by a specific agency in each EC countries. National Institute of Agricultural Economics (INEA) is the Italian agency which collects FADN database (DPR n. 1708/65), called RICA (Information Web of agronomical Accounting).

Historically, RICA database sampled volunteer farms. Since 2003 the sample plan has been coordinated with Economic Results of Farms sample plan (REA sample) managed by Italian National Institute of Statistic (ISTAT). ISTAT also collects general agricultural census every 10 years which counts all Italian farms (ISTAT universe). It is possible to connect the RICA sample to the ISTAT census. This connection is updated every year by REA analysis and other specific ones. The aim is to improve the representativeness of the RICA sample with improving of statistical parameters as required by Reg. CE 2236/96.

The ISTAT universe is separated into several layers (homogeneous groups of farms). Layers are defined by three aspects: administrative location (Italian regions), economic dimension (UDE: Economic Size Unit of holdings until 2009 and then in euros) and OTE (*Orientamento Tecnico Economico* or classification of agricultural holdings by type of farms). Tables 1.1, 1.2 and 1.3 describe classes for these three aspects.

Administrative Italian Regions	
ABR	Abruzzo
BAS	Basilicata
BLZ	Alto Adige
CAL	Calabria
CAM	Campania
ERO	Emilia Romagna
FVG	Friuli Venezia Giulia
LAZ	Lazio
LIG	Liguria
LOM	Lombardia
MAR	Marche
MOL	Molise
PIE	Piemonte
PUG	Puglia
SAR	Sardegna
SIC	Sicilia
TOS	Toscana
TRN	Trentino
UMB	Umbria
VDA	Valle d'Aosta
VEN	Veneto

Classes of UDE	
I	less than 2 000 euro
II	from 2 000 to less than 4 000 euro
III	from 4 000 to less than 8 000 euro
IV	from 8 000 to less than 15 000 euro
V	from 15 000 to less than 25 000 euro
VI	from 25 000 to less than 50 000 euro
VII	from 50 000 to less than 100 000 euro
VIII	from 100 000 to less than 250 000 euro
IX	from 250 000 to less than 500 000 euro
X	from 500 000 to less than 750 000 euro
XI	from 750 000 to less than 1 000 000 euro
XII	from 1 000 000 to less than 1 500 000 euro
XIII	from 1 500 000 to less than 3 000 000 euro
XIV	equal to or greater than 3 000 000 euro

Table 1.1 and 1.2: on the table on the left side Italian administrative regions are reported (INEA, 2000); on the table on the right side classes of UDE since 2010 are reported as established by Regulation (EC) No 1242/2008 Annex II (EC, 2008).

The historical path of sampled farms is not the main priority of RICA database. Indeed the sample is random inside the layer because all farms of a specific layer, with the same trend for strategic aspects, are considered equivalent. For this reason the list of sampled farms changes every year. So farms are sampled just once or more times in the RICA database with no strictly plan. If a farm is sampled more than once, it is possible that sample years are not all consequential.

ISTAT universe counts about 750 000 holdings, RICA about 10 000-15 000 ones depending on the year. The connection between RICA sampled farms and ISTAT universe is updated each year by REA and other types of specific analysis operated by ISTAT. RICA does not describe the whole ISTAT universe, indeed it does not consider farms with no relevant economic weight. Until 2009, the farms which have economical dimension under 4,800 euro, were not considered. In 2010 the limit was reduced at 4,000 euro.

INEA operators collect interviews with selected farmers, and data are firstly controlled and collected at regional level, then joined into the national database. Here information is checked again and then submitted to the European Commission. INEA operators use specific software to collect and manage RICA data which was “CONTINEA” until 2007 and “GAIA” since 2008.

The information managed by RICA database describes all administrative elements which interact to accounting year. There is information about types of farms, location, subsidies, labour, ect. Surfaces and productive processes are detailed in crop/animal types and also in products details. For each of them, the main technical coefficients are reported such as insurance expense, water expense, phytopharmacies/medicines expense, fertilisers/feeds expense, human and machinery labours, prices of fresh and transformed products, ect.

In Italy, as in other European countries, FADN database is one of the most complete and guaranteed analysis of organic farms, especially for agronomical aspects. For this reason RICA database is chosen as the major data source in this study.

Specialist holdings — crops		
General type of farming	Principal type of farming	Particular type of farming
1. Specialist field crops	15. Specialist cereals, oilseeds andprotein crops	151. Specialist cereals (other than rice), oilseeds and protein crops
		152. Specialist rice
		153. Cereals, oilseeds, protein crops and rice combined
	16. General field cropping	161. Specialist root crops
		162. Cereals, oilseeds, protein crops and root crops combined
		163. Specialist field vegetables
		164. Specialist tobacco
		165. Specialist cotton
		166. Various field crops combined
2. Specialist horticulture	21. Specialist horticulture indoor	211. Specialist vegetables indoor
		212. Specialist flowers and ornamentals indoor
		213. Mixed horticulture indoor specialist
	22. Specialist horticulture outdoor	221. Specialist vegetables outdoor
		222. Specialist flowers and ornamentals outdoor
		223. Mixed horticulture outdoor specialist
	23. Other horticulture	231. Specialist mushrooms
		232. Specialist nurseries
		233. Various horticulture
3. Specialist permanent crops	35. Specialist vineyards	351. Specialist quality wine
		352. Specialist wine other than quality wine
		353. Specialist table grapes
		354. Other vineyards
	36. Specialist fruit and citrus fruit	361. Specialist fruit (other than citrus, tropical fruits and nuts)
		362. Specialist citrus fruit
		363. Specialist nuts
		364. Specialist tropical fruits
		365. Specialist fruit, citrus, tropical fruits and nuts: mixed production
	37. Specialist olives	370. Specialist olives
	38. Various permanent cropscombined	380. Various permanent crops combined
Specialist holdings — animal production		
General type of farming	Principal type of farming	Particular type of farming
4. Specialist grazing livestock	45. Specialist dairying	450. Specialist dairying
	46. Specialist cattle - rearing and fattening	460. Specialist cattle – rearing and fattening
	47. Cattle - dairying, rearing and fattening combined	470. Cattle – dairying, rearing and fattening combined
	48. Sheep, goats and other grazing livestock	481. Specialist sheep
		482. Sheep and cattle combined
		483. Specialist goats
		484. Various grazing livestock
5. Specialist granivores	51. Specialist pigs	511. Specialist pig rearing
		512. Specialist pig fattening
		513. Pig rearing and fattening combined
	52. Specialist poultry	521. Specialist layers
		522. Specialist poultry-meat
		523. Layers and poultry-meat combined
	53. Various granivores combined	530. Various granivores combined
Mixed holdings		
General type of farming	Principal type of farming	Particular type of farming
6. Mixed cropping	61. Mixed cropping	611. Horticulture and permanent crops combined
		612. Field crops and horticulture combined
		613. Field crops and vineyards combined
		614. Field crops and permanent crops combined
		615. Mixed cropping, mainly field crops
		616. Other mixed cropping
7. Mixed livestock holdings	73. Mixed livestock, mainly grazing livestock	731. Mixed livestock, mainly dairying
		732. Mixed livestock, mainly non-dairying grazing livestock
	74. Mixed livestock, mainly granivores	741. Mixed livestock: granivores and dairying combined
		742. Mixed livestock: granivores and non-dairying grazing livestock
8. Mixed crops — livestock	83. Field crops — grazing livestock combined	831. Field crops combined with dairying
		832. Dairying combined with field crops
		833. Field crops combined with non-dairying grazing livestock
		834. Non-dairying grazing livestock combined with field crops
	84. Various crops and livestock combined	841. Field crops and granivores combined
		842. Permanent crops and grazing livestock combined
		843. Apiculture
		844. Various mixed crops and livestock
9. Non-classified holdings 90. Non-classified holdings		900. Non-classified holdings

Table 1.3: the classification of agricultural holdings by type of farming (OTE) is reported as described in Regulation (EC) No 1242/2008 Annex I (EC, 2008).

1.6 Environmental context of farms

In this study also the environmental context of farm is considered. It describes the farm conditions where practices are applied and it usually forces the crop selection operated by farmer. Environmental conditions are the result of natural processes useful to estimate efficiency of farm and also some types of pollution. Moreover, two farms are comparable only if their context is similar, especially for environmental aspects. Usually this point does not receive a lot of importance in the most common farm classifications and indicators analysis.

Environmental conditions could be described by several viewpoints. The potential phyto-climatic zones are taken into account according with analysis level and data availability. It is possible to estimate each environmental farm conditions using vegetative information. Specific information about soil nature is not available to describe all farms at national level and for all period of analysis. For this reason the soil features are not considered. Also irrigation, which deeply changes micro habitat, is not considered.

For all these reasons potential natural covers are analysed and classified in this study. At local scale, they show evaluation of general climatic conditions. Moreover, at specific site spontaneous vegetation suggests general information about meteorological and soil characteristics. Collecting this information has been one of the most difficult part of the study. But when phyto-climatic information are linked to the FADN database, it is possible to estimate farming system connections to environmental context. In the following figure is reported map of Italian phyto climatic zones considered for this analysis as described by (Giuliano Vitali et al., 2012).

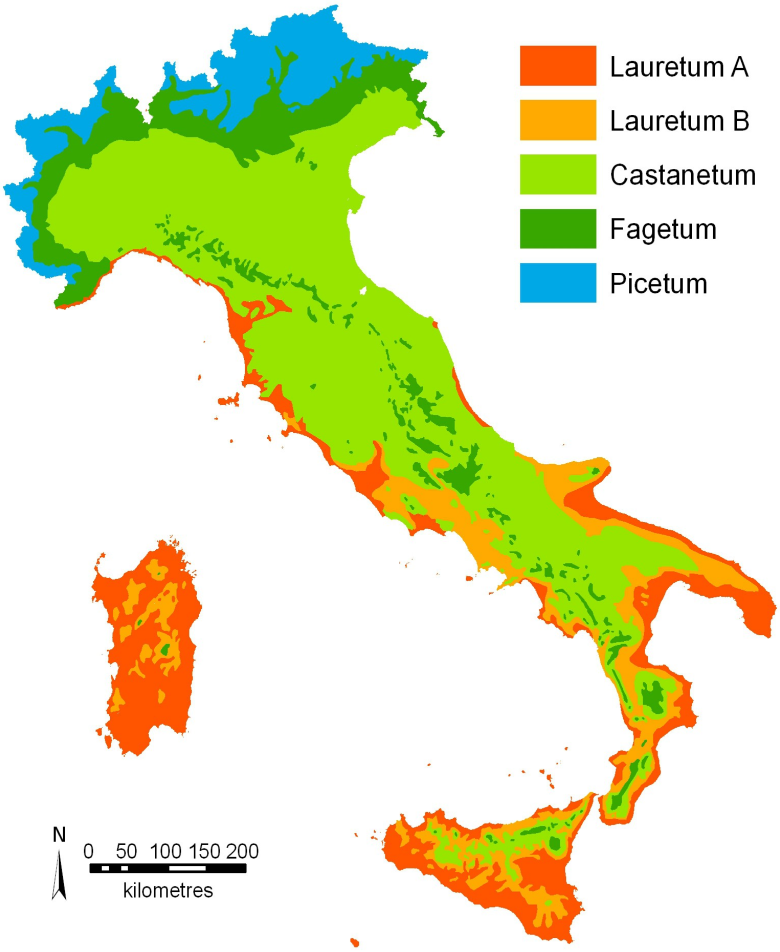


Figure 1.14: the map of phyto climatic zone of Italy (source Giuliano Vitali et al., 2012)

2. Analysis of farm typologies from RICA

2.1 Introduction

The term “classification” means a separate heterogeneous pool split into several groups which are homogeneous for some aspects. Often not all aspects have the same trends therefore they can not be classified easily. In a complex system all aspects can not be easily analysed at the same time. So it is necessary to select certain ones. Results are strongly linked to this selection. For this reason the conceptual view of the system and the aim of the analysis are guidelines to select more suitable aspects to be taken into account for classification definition (see chapter 1).

In this part of the study more common classification types of farms are described. Then new farm classification is suggested and described to improve farming system knowledge.

2.2 The most common farm classifications

Each farm can be classified by a multitude of aspects. Each one of those aspects can be taken into account to develop a specific classification. The major part of aspects consider most of the sustainable areas: environmental, economical and social. The most common farm classifications generally consider size, structural aspects and economical relevance of the farm. FADN database, for example, considers all these aspects.

Classification of farm structure generally considers the main productive processes, but they are affected by other aspects which are usually considered in separate ways. Therefore it is really difficult to describe a farm in the most complete way and without loosing a synthesis approach. Especially if the farm is not a closed entity but it is considered as a farming system connected to the surrounding context.

2.2.1 Size classifications

Surface is one of the most common aspects which describe farm structures. The farm size could report a lot about the agricultural situation. The size of farms can be an indicator of the presence of latifundium. The large areas can support more investment in machinery, but on the other hand when technologies are already present in the large areas, changing can be difficult. Size also depends on social and environmental context.

Figure 2.1 shows the analysis of farm size for conventional and organic holding of EC countries. It is possible to argue that Slovakia and the Czech Republic have a different agricultural assessment to Italy or Spain.

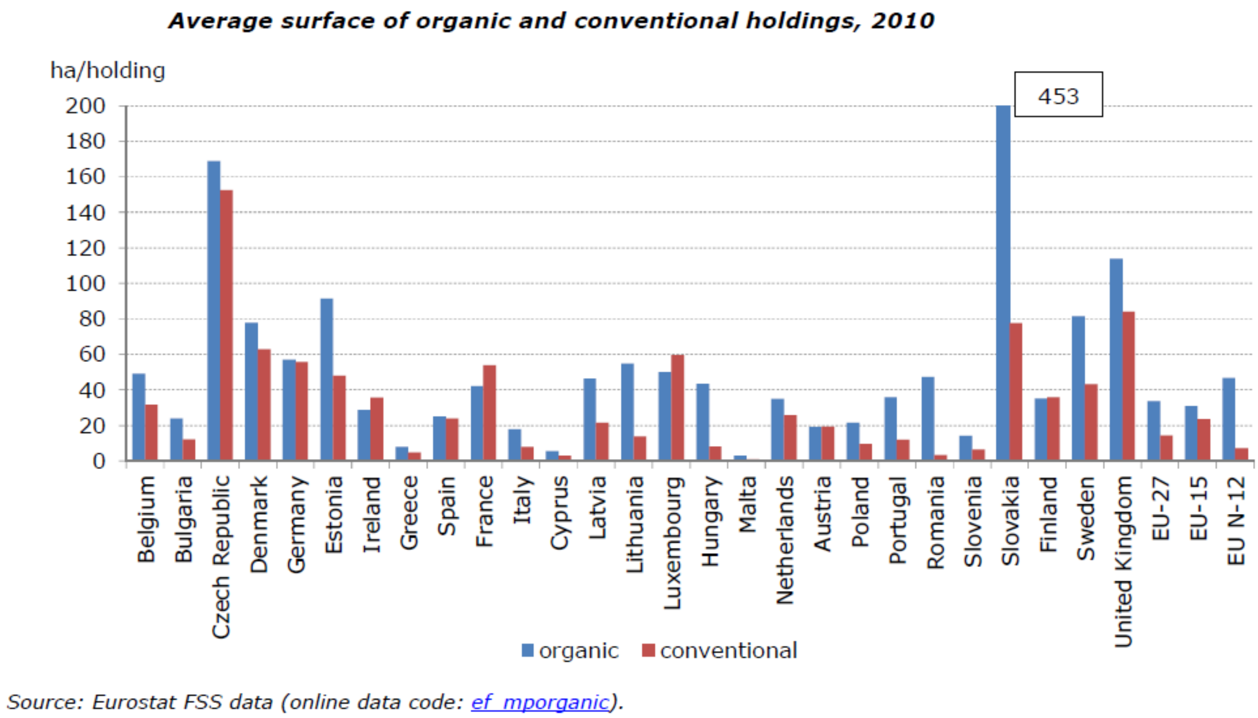


Figure 2.1: histogram of size holdings of EC countries separated into organic and conventional ones (E.C., 2013)

The farms distribution for size is not linear, but it records logarithmic trend. This aspect is taken into account to define the class size. This is an example of how classification could be improved by knowing the phenomenon to classify. In the figure 2.2 the farm distribution by size is reported for each class.

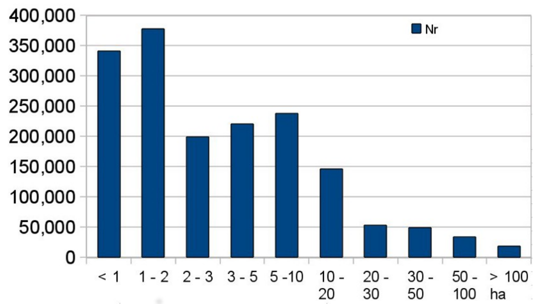


Figure 2.2: histogram of Italian farm distribution by size for 2010 (ISTAT source)

Knowing the size is not enough to analyse the farm structure. For this reason the main productive processes are considered to classify the farm structures. In Italy for example the main processes are cereals, forages, other arable field, olive tree, grassland, vine, horticulture, fruit tree and citrus tree (ISTAT source for year 2010).

Also specialisation of farm practices reports structure information. It records the number of productive processes developed on the farm. Medici analysed the Italian farm structures concerning 1950-1970. He observed trends to simplify practices to increase efficiency. Also abandonment of self consumption and the decline of animal usage in hard agricultural work brought farms to specialise in specific products. For Medici this trend could improve the efficiency of farms. He designed some farm structures to improve farm production (Medici & others, 1974). Recently the SABIO Project investigated the same subject. That investigation showed that only a few numbers of productive processes are present in Italian farms as suggested by Medici (figure 2.3).

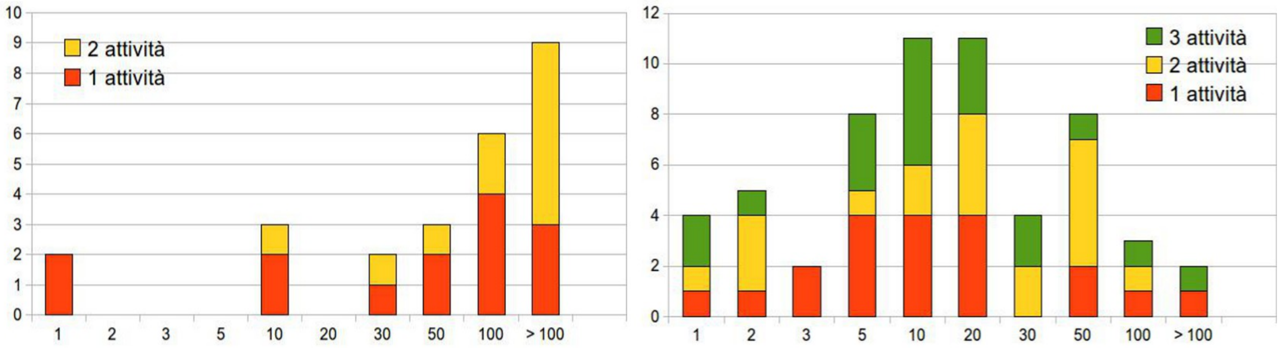


Figure 2.3: the left hand histogram reports Medici structures separated into classes of farm size (ISTAT classes). The right hand histogram shows SABIO farms.

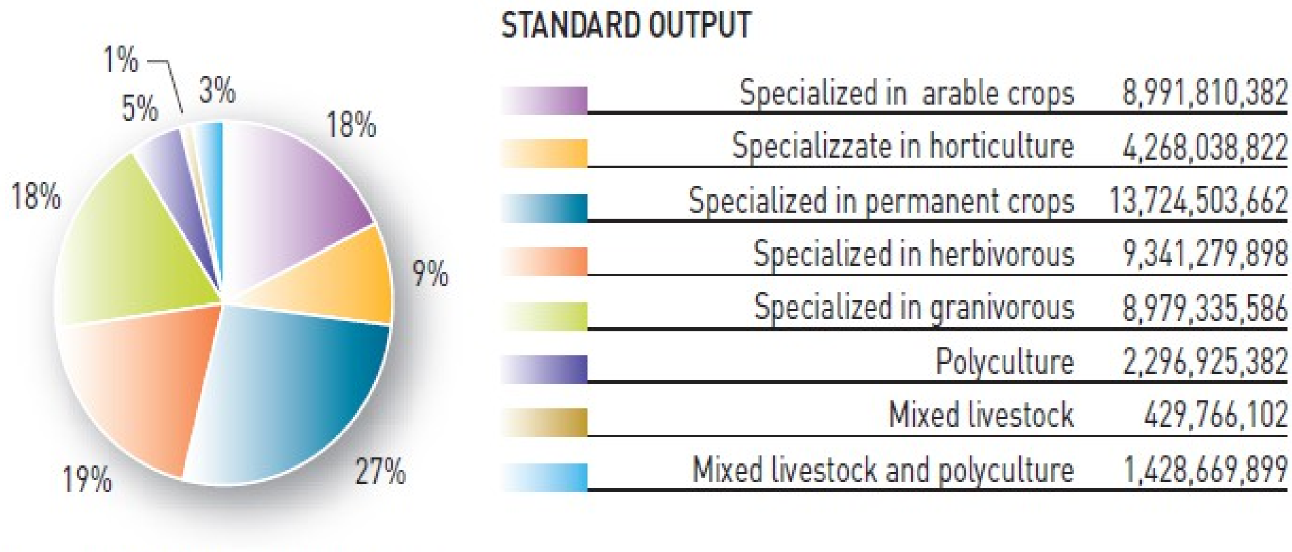
Irrigated areas, potentially irrigated areas and labour can be taken into account to classify the farm structures.

In general the economical dimension is usually based on a few standard aspects such as UDE or standard output. Also OTE is frequently considered to classify farms (see chapter 1.5.2). It mentions only main economical processes.

Usually all these types of information are combined together to evaluate the agricultural situation at national level. This information is useful to develop policies about economical and social topics. An example of this analysis is reported in figure 2.4 where two aspects of the Italian agriculture are described: the main technical orientation (structural aspect) and the amount of standard output (economic aspect) for 2010.

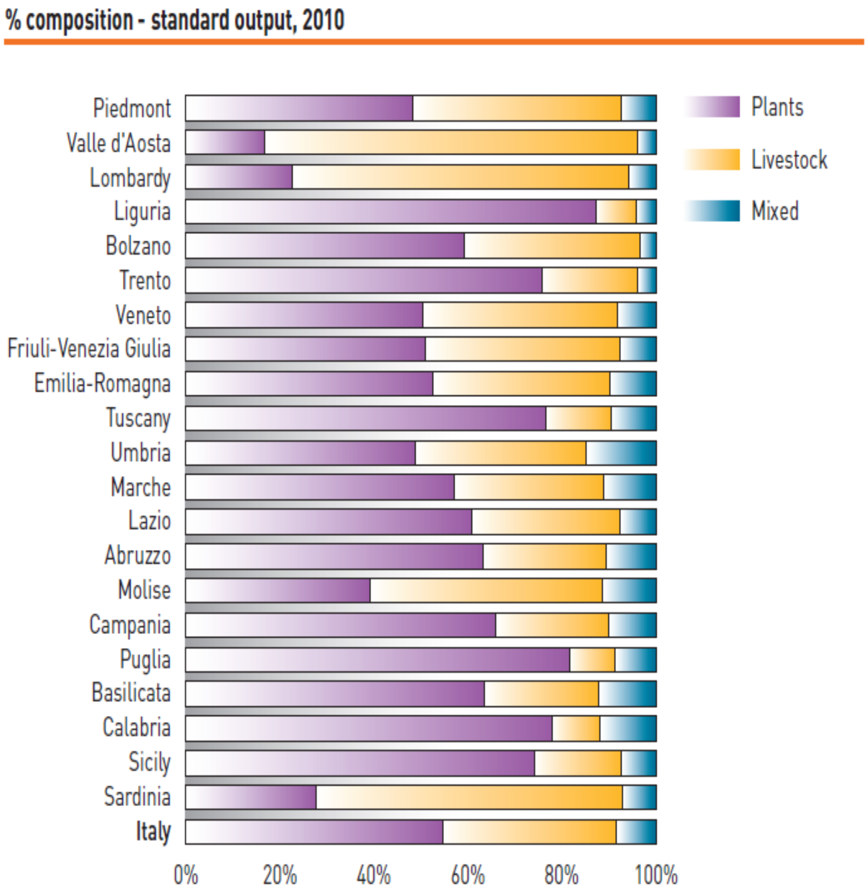
Another important aspect is the geographical location of the farm. This information is usually the only one which directly describes the farm context from an administrative point of view and it is usually associated with other types of classification such as connection to territory as shown in figure 2.5.

Farms have a lot of aspects which are connected with the surrounding context. Some analysis try to indirectly underline these connections. These aspects are the number of natural surfaces and the landscape elements such as hedgerows, lakes and walls. These aspects often describe the farm structure and its practices, because they modify the in and out farm environment.



Source: ISTAT, 6th Agricultural Census.

Figure 2.4: pie chart of distribution of Italian standard output separated into the main technical orientation per year 2010 (INEA, 2014).



Source: ISTAT, 6th Agricultural Census.

Figure 2.5: chart reports general farm structure for each administrative region for the year 2010(INEA, 2014).

Antonietti collected several of the above mentioned information to describe the national situation in 1961. He produced a map which reported both farm and context information. In this analysis is considered the size of farms, but also the types of farmers and their interaction with the social/economical context (figure 2.6). In the map the information about farm surfaces (red and green spots) is collocated in areas described by landscapes: alpine mountains, areas with intensive crops for capitalist agriculture, surface with family farms, ect.

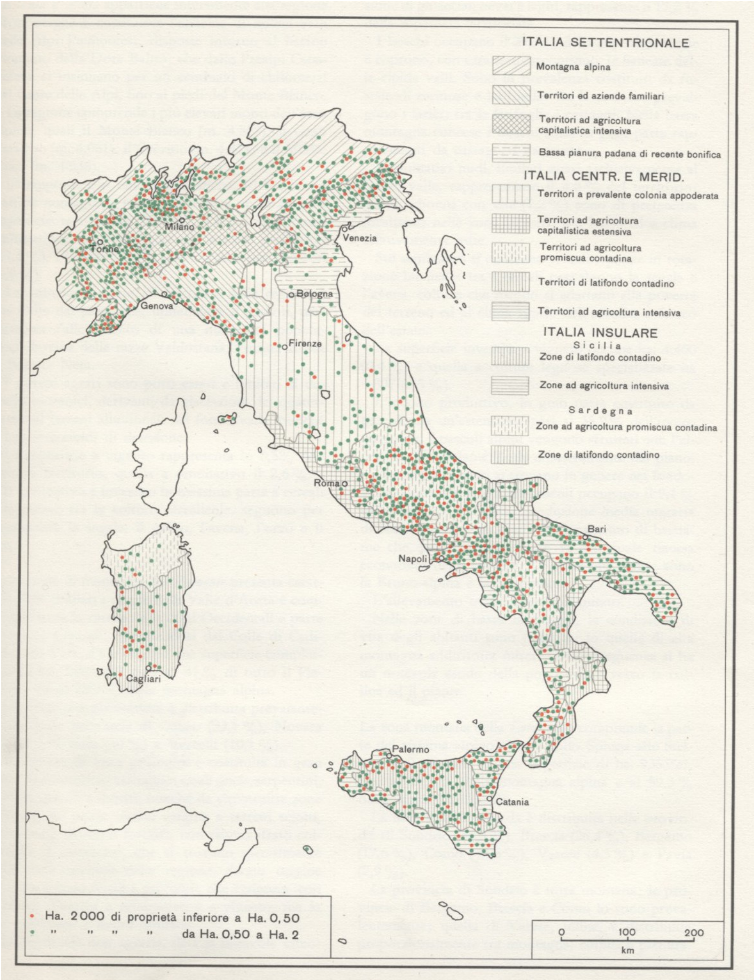


Figure 2.6: Antonietti's map reported the agronomical situation for Italy in 1960. The spots report information about farm size. The red spots represent 2 000 hectares of farms measuring less than half hectare, green ones represent 2 000 hectares of farms measuring between 0.5 and 2 hectares. Area descriptions report farms or crop types in terms of social and economical aspects.

2.3 New farming system classification

In this study a new farming system classification is proposed. It is principally based on specific "farm structure" placed side by side with other information such as regime, geographical location, slope and phyto-climatic zone. This classification approach can also be considered a tool of analysis. Indeed farm structure and geographical location are described at several levels of detail. On the other hand is possible to consider only a subset of all information mentioned. This means that it is possible to group and describe farm typologies in several ways according to the aim of the analysis.

2.4 Materials and method

2.4.1 General overview

This method analyses farm typologies at national level. Structural, geographical, environmental and general information are used to define farm typologies. Each typology can be separated into several farm types according to the considered level of details. The list below reports the general steps to describe farm typologies of a country:

- Building up of a preliminary pool of sampled farms to analyse, which has to be representative of the universe to describe
- Collection of all information to define farm typologies
- Codification and processing of information in useful analysis categories
- Selection of the analysed pool of farms from the preliminary pool, eliminating farms not suitable for analysis or with incomplete information
- Attribution of farm typologies to each farm

In this study the preliminary farms pool is “represented” by the whole RICA sample for years 2007-2011. Several operations have reduced the number of farms for each year. So analysed pool is a subset of RICA farms for years 2007-2011. It describes the major part of the ISTAT universe for the considered period.

The main source of information is RICA database. It is supported by other source for phyto-climatic data.

2.4.2 Building up of preliminary pool of sampled farms to analyse

The Italian agronomical situation is the aim of the study. The ISTAT census data (ISTAT universe) is the best available description of it. RICA database guarantees representativeness of the ISTAT universe as previously mentioned (chapter 1.5.2). The RICA farms for years 2007, 2008, 2009, 2010, 2011 are considered for analysis. At the beginning of this study only 2007 sample was the most recent, during the development study also 2008-2011 samples became available and they are now integrated in the work. Having several years data permits to have a stronger average and suggests evolution trends of analysed phenomenons.

For years selected RICA database refers to the fifth agricultural census data operated by ISTAT in 2000. In table 2.1 the amount of RICA farms and the ISTAT correlated farms are reported for each year. Observing this table it is possible to argue that RICA farms are sampled on average less than 3 times.

	2007	2008	2009	2010	2011	Total Records	Total different RICA farms
RICA farms	15082	11393	11029	11156	11238	59898	23993
ISTAT farms	755022	693918	694469	785920	779757	3709085	-

Table 2.1: for each considered year the number of RICA farms is reported in first line; in the second line, the number of ISTAT farms described by RICA ones is reported. On the right hand side of the table are the total of RICA analysed records, the total of ISTAT described farms and the total of different RICA farms (among 5 years) are reported.

2.4.3 Collection of all information to define farm typologies

Two sorts of information are required to define farm typologies: general information and farm structure. Among general information can be mentioned: geographical farm location, administrative/political assessment, environmental potential, and also farm representativeness and regimes. The farm structure describes the productive processes of farm: the management of surfaces, including natural areas, and the amount of husbandry.

For this study the whole range of information comes from RICA database, except phyto-climatic zones information. The climatic details come from a study on natural potential vegetation. Indeed no pedo-climatic data are available at national levels, especially for soil characteristics and meteorological aspect at the requested details. These aspects present so high variability also in restricted areas, that the general available level of detail does not immediately fit with generic farm location inside each municipality. For these reasons potential vegetation covers described at a general level are taken into account.

Cartographic analysis has been developed with the most recent data available at the beginning of the study. As described by Vitali (Giuliano Vitali et al., 2012), two maps of Italian vegetation are merged. The final result, linkable with FADN data, consists in attributing the most present phyto-climatic zones to each Italian municipality.

2.4.4 Codification and processing of information in categories useful for analysis

No specific software or instruments are required to develop this sort of analysis. Even though simple spreadsheets and their functions are to be used, a powerful computer could be a useful support to take less time to complete the elaboration (it takes a long time when spreadsheet with ten of thousands rows and hundreds of columns is proceeded).

RICA database is available for this study in the form of several spreadsheets. The main spreadsheets considered for this analysis are about 5 (per year): general farm information, crop and product information, husbandry information and farm weight to connect the ISTAT universe.

All spreadsheets always report two key code: year of sample and farm identity code. Using both these fields is possible to match information from every spreadsheet. The protocol to create farm identity code has been changed in the 2008. So a new specific code has been developed to link 2007 year data to 2008-2011 years data.

Also, many of the most important codes have been changed since 2008 when a heavy update was requested because of the usage of the new management data software “GAIA”. First check is about code changes: for all analysis period each code must be linked to its specific meaning, for each of the subjects. Usually to create a new unique code list is necessary to match the two previous series. These are quite simple operations especially for short lists of codes. Support by subject and RICA database experts can make the operation faster. For this reason more details about this step are not discussed, but just slope case is reported as example.

RICA reports three classes of slope for 2007 and five for 2008-2011 (table 2.2). One class has the same meaning, but not the others. Since 2008 the two extreme slope classes have both been divided in two. The class <5% of 2007 considers both of the two classes of 2008-2011 0% and 0%-5% just in a mixed one. To not lose details for period 2008-2011 all classes are maintained.

After this preliminary data organisation, some subject must be codified, grouped and selected in a suitable way for analysis. It is often necessary to generalise original and deeply detailed data, or to reduce the focus of analysis. This step is the most delicate of all method. It influences the codification of original data and it defines range where result will appear at the end of analysis. All the farms information treated in this study are reported by specifying presence and the type of codification operated:

Original 2007 classes	1	2	3				
Meaning	<5%	5%-15%	>15%				
Original 2008-2011 classes	0	1	2	3	4		
Meaning	0	0%-5%	5%-15%	15%-30%	>30%		
Unique slope code	1	2	3	4	5	6	7
Meaning	0	0%-5%	<5%	5%-15%	>15%	15%-30%	>30%
U. s. code presence in 2007			x	x	x		
U. s. code presence in 2008	x	x		x		x	x
U. s. code presence in 2009	x	x		x		x	x
U. s. code presence in 2010	x	x		x		x	x
U. s. code presence in 2011	x	x		x		x	x

Table 2.2: in the upper part of table slope categories for each sampling year and their meaning are reported. In below part of table unique slope code classes and meaning are reported.

• *sample year:* not elaborated, used to create historic dataset

• *identifying farm code:* used to extract identifying farm coding number, necessary to subsequently create a unique identifying farm code. The RICA identifying farm code also reports administrative region, province and municipality for the period 2007-2011, and since 2008 it reports also the sample year. All this information is allocated in different sections of identifying farm code for 2007 and 2008-2011. So it is necessary to extract all single information and than to collect them all together again into a unique code. For this reason identifying numbers for farm, municipality, province and administrative region are required to develop a unique farm identifying code.

During the 5 years of analysis some administrative borders changed: some municipalities were joined together and some provinces changed their administrative region reference. In these cases one or two administrative nut information have been modified according to the first sample year (*). Merely by combining the farm identifying code with the sample year it is possible to describe in a univocal way each record.

• *municipality:* not elaborated*, used to create a unique identifying farm code and to attribute phyto-climatic zones.

• *province:* not elaborated*, used to create unique identifying farm code.

• *administrative region*: not elaborated*, used to create unique identifying farm code and to describe farm geographical localisation at a more general level.

• *adopted regime:* not elaborated, used as a general information.

• *representativeness*: partially elaborated: for some farms are reported numbers of ISTAT farms which are described by RICA ones. Farms without connections with the ISTAT universe are considered representative of themselves. According with this principle, which is shared also by one RICA supervisor who is responsible of the sample, these farms has been arbitrarily attributed weight 1. In the sample year 2007 some farms correlated to the ISTAT universe record weights with a value minor than 1. In these cases the value is converted into 1.

• *phyto-climatic zone:* partially elaborated: 6 phyto-climatic zones are reported for each Italian municipality. One of them describes humid zones near the Po river delta. The difference between this zone and other Po valley zone (Castanetum)) is just a major water availability. But in this study irrigation and water in general are not taken in account, so this class is converted into original one: Castanetum. Just few hundreds of farms are interested by this operation.

• *slope:* partially elaborated: to simplify analysis unique slope code classes 1, 2, 3 are aggregated as "plain", 4 is attributed as "gently slope" and 5, 6, 7 are grouped as "high slope" (see table 2.2)

• *wooden surface:* not elaborated; data used to define natural areas.

• *crop cover:* strongly elaborated: all crops are grouped in several productive processes. There are four hierarchical levels of details describing crop cover. The first is RICA crops/land use detail, the second groups them in "rubriche" (as defined in RICA), which are aggregated in macro activities that are grouped in just three super activities (tabel 2.3in next page).

This classification has been designed to describe farm structure and also to be suitable for MAD computing (the following described model used to estimate indicator levels of farm typologies).
Categories try to group together similar crops/land covers mainly for technical coefficients, but also for similar expected impacts to farm sustainability.

For some arable crop, the destination of production means techniques so different to change surface codification. Because of this, also product information are considered.

• *husbandry:* extended elaborated: just as in the case of crop husbandry, it has been classified in several hierarchical levels. The most detailed of them considers also product orientation in terms of milk, meat or both of them(table 2.4).

super	macro	livestock type
ZOO	BL	dairy cattle
ZOO	BC	meat cattle
ZOO	BM	mixed cattles
ZOO	BU	buffalo
ZOO	EQ	horses
ZOO	OC	meat sheeps
ZOO	OL	milk sheeps
ZOO	OM	mixed sheeps
ZOO	CC	meat goats
ZOO	CL	milk goats
ZOO	CM	mixed goats
ZOO	SU	swines

Table 2.4: in the table from left side super activity, macro activity and production orientation are reported.

S.A.	M.A.	Rubriche	Descrizione rubriche
NAT	BO	BO	Boschi
NAT	PR	F01	Prati e pascoli, esclusi i pascoli magri
NAT	PR	F02	Pascoli magri
SEM	CR	D01	Frumento (grano) tenero e spelta
SEM	CR	D02	Frumento (grano) duro
SEM	CR	D03	Segala
SEM	CR	D04	Orzo
SEM	CR	D08	Altri cerali, Farro
SEM	FO	D05	Avena e miscugli estivi
SEM	FO	D08	Altri cerali, Sorgo
SEM	FO	D18A	Erbai temporanei
SEM	FO	D18B	Altre piante raccolte verdi
SEM	FO	F01	Leguminose
SEM	FO	F01	Mais verde
SEM	FO	F02	Altre piante raccolte verdi non menzionate altrove
SEM	IN	D06	Granturco
SEM	IN	D09	Legumi secchi e colture proteiche per la produzione di granella
SEM	IN	D10	Patate (comprese le patate primaticce e da semina)
SEM	IN	D11	Barbabietole da zucchero (escluse le sementi)
SEM	IN	D12	Piante sarchiate da foraggio (escluse le sementi)
SEM	IN	D14A	Ortaggi da pieno campo
SEM	IN	D14B	Coltivazione in orti stabili: fragola, pomodoro da mensa, altro
SEM	IN	D16	Fiori e piante ornamentali all'aperto
SEM	IN	D19	Piantine per orticole, floricole e altro
SEM	IN	D20	Sementi da prato e altro
SEM	IN	D23	Tabacco
SEM	IN	D24	Luppolo
SEM	IN	D26	Colza e ravizzone
SEM	IN	D27	Girasole
SEM	IN	D28	Soia
SEM	IN	D30	Semi di lino
SEM	IN	D32	Canapa
SEM	IN	D33	Cotone
SEM	IN	D33	Piante aromatiche, medicinali e spezie
SEM	IN	D34	Altre colture industriali, non menzionate altrove
SEM	IN	D35	Canna da zucchero
SEM	RI	D07	Riso
TRE	AB	G01C	Frutta a guscio: mandorlo, nocciolo, castagno, noce, altro
TRE	AB	G02	Agrumeti: arancio, mandarino, clementine, limoni, altri
TRE	AB	G03B	Per la produzione di olive da olio
TRE	AR	G01A	Frutta a nocciolo: pesco, nettarina, albicocco, ciliegio, susino
TRE	AR	G01A	Frutta temperata a semi: melo, pero, fico, altro
TRE	AR	G01B	Frutta di origine subtropicale – actinidia
TRE	AR	G03A	Per la produzione di olive da tavola
TRE	AR	G04C	Uve da tavola e Uva passa
TRE	AR	G05	Vivai: Viti, fruttiferi, ornamentali e altro
TRE	AR	G06	Altre coltivazioni permanenti – bacche, piccoli frutti
TRE	VT	G04A	Vini di qualità
TRE	VT	G04B	Altri vini
OTH	AL	D15	Orticoltura in serra o sotto altre protezioni (accessibili)
OTH	AL	D17	Fiori in serra
OTH	AL	G07	Coltivazioni permanenti in serra
OTH	AL	I02	Funghi

Table 2.3: in the table from left side super activity, macro activity and rubriche are reported.

2.4.5 Selection of the analysed pool of farms from the preliminary pool, eliminating farms not suitable for analysis or with incomplete information

In this phase, the preliminary pool of farms becomes a selected pool of farms by eliminating farms that are not suitable for analysis. To be included in the selected pool, each farm must pass 3 checks. The first is about checking lack of general information, the second is to eliminate farms with not considered general information and the last one is to control structural information.

The lack of information can be identified only when all available data is correlated with preliminary pool of farms. If a farm presents even one lack of information, it is eliminated. After this check all farms have the same set of information. Farms often present just one missing information. When this happens, it is sometimes possible to find the missing information from the same farm in another sampling year.

The second check individuates farms with information aspects that are not suitable for analysis. In this case, farms which report mixed regimes are eliminated. This detail is present only for years 2007.

The last check controls the meaning of structural data. The objective of this last control is to analyse only farms with considered productive processes. Indeed, this analysis takes into account only the main productive processes. On the other hand on RICA sampling, which describes all national agronomical universe, there are also farms which present minor processes not mentioned in this study. To not consider only a part of farm management, which should return false farm structure, the minor processes in husbandry and land management must be really marginal. In the case when minor processes were present more than 5% in surfaces or animal (expressed in UBA) amount, the farm has been eliminated.

Thanks to these controls, farm surface are checked: in some cases there is no surface. It is assumed that farm must have some types of surface. Farm with value 0 for all categories of crop/land use have been eliminated. This could mean error in database which are filled by human been. On the other hand, more probably, these farms have other types of surfaces taken into account by RICA, but not in analysis (for instance: the edge surface).

2.4.6 Attribution of farm typologies to each farm

At this point the attribution of farm type is really simple. The general information (slope, phyto-climatic zone, regions and regime) constitute the first part of farm types. The second part is represented by structural types. This is evaluated at a minor level of detail just with presence absence of each super activities: tree crops, arable crops, natural areas and husbandries. Each super activity must cover more than 5% surface or must count more than 0.5 UBA to be reported in structural types.

Also other detailed structural types could be defined starting from the same data. Super activities can be describe not only by presence/absence but also by the amount percentage of covered surface (not for husbandry). On the other hand structural types could be defined by macro activities. But this last kind of analysis and other ones more detailed become useful only at a small scale of analysis. Indeed at national level so detailed farm types report a lot of results but not easily describable.

2.5 Results of farm analysis

2.5.1 Distribution

In this chapter some analysis about farm structure are reported for both conventional and organic pools. First of all farms structures are analysed in terms of farm number and surface at national levels of RICA sample and ISTAT universe. Also dynamics of farm structures and regimes among 2007-2011 are reported.

Then farm structures are placed side by sidy with other farm information reported by farm typology. The most common of them at national level are described.

Final analyses are about farm structure comparing to yet existing categories like farm size, OTE and UDE.

2.5.1.1 Distribution at national level

In the figure 2.7 are reported the conventional, organic and complete RICA farms (whole preliminary pool) grouped for farm structure. The values are an average of 5 years (2007-2011). First of all farms that are not described by this method are less than 15% of the whole sample. Conventional and organic samples show different distribution for some structures, included the main ones. The farms amount of both the two regimes is heavily different and the organic one counts farms 35 times less than conventional. For this reason organic sample has often a wider standard error than conventional, and the whole RICA sample behaves nearly the same way of conventional ones.

More in detail, the organic sample often counts more farms in structures where TRE is considered, especially for TRE, TRE+ARA and NAT+TRE+ARA. On the other hand the organic sample counts less farms in structures where ARA appears as a unique sort of surface: ARA and ARA+ZOO.

By considering RICA farms the most common structures at national level are TRE, ARA, TRE+ARA and then NAT+ARA+ZOO and ARA+ZOO. In general, the agronomical scenario is less diversified for organic sample because only the 3 major structures describe about more than 55% of organic farms and farms with minor processes are only the 7% of the whole organic sample. This different behaviour respect CON sample could be affected by different farm amount of two samples.

The correlation between weights of RICA farms and the ISTAT universe is used to analyse the Italian agronomical situation (figure 2.8). But it is important to remember that this weights have been attributed basing on different farm classifications. For that reason all the analysis about ISTAT population could be just an indicative general overview, sometimes more and sometimes less useful.

In the ISTAT universe prospective, farms with minor productive processes not considered are less 10%. Ratios among conventional farms, organic ones and the whole universe change reporting quite similar trends for both regimes except for ARA which is sensibly less represented in organic one. Also ratios among structures change from RICA sample: TRE overcomes 25% in each categories (rising nearly to 30% for organic ones), followed by TRE+ARA which considers more than 15% of all universe farms as ARA (for conventional regimes). All other structures are nearly 5% or less.

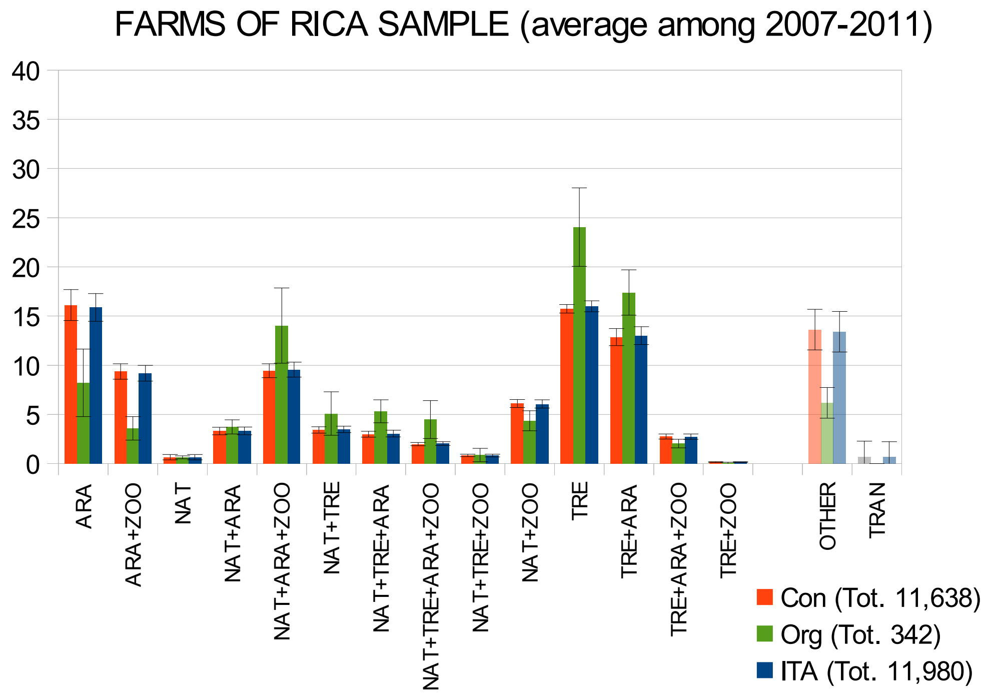


Figure 2.7: chart of RICA farms grouped for structure types. Histogram reports the percentage of each structure for conventional (Con), organic (Org) and whole RICA preliminary pool (ITA) as average of years 2007-2011. Also not analysed farms are reported (OTHER), and farms with regimes transitions during considered period (TRAN) are mentioned too. In the lower right corner there is a legend that reports the total farm amount for each category.

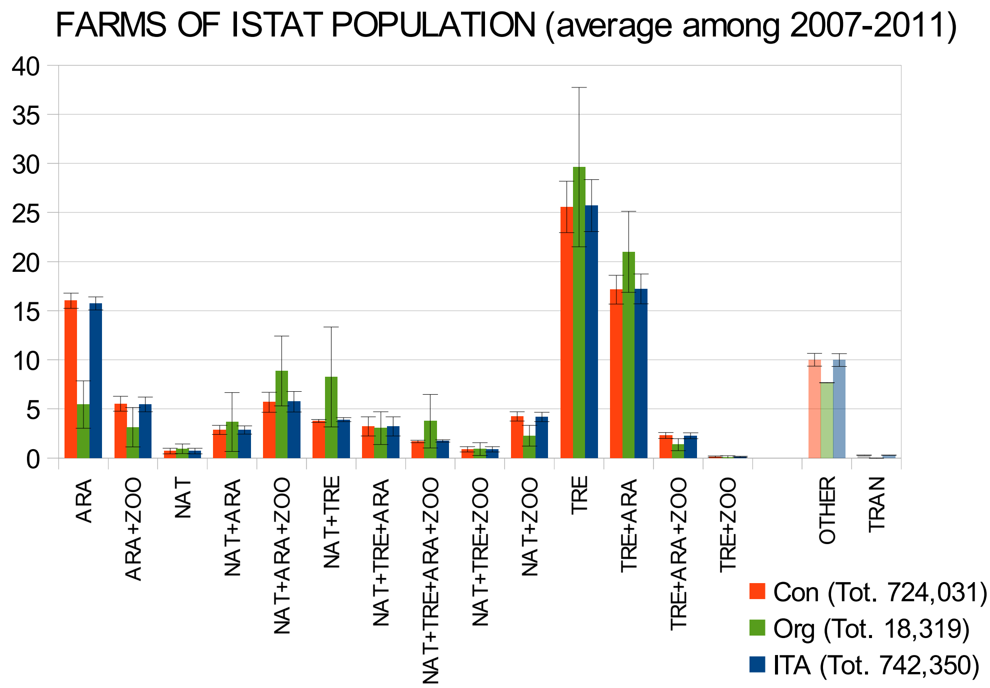


Figure 2.8: chart of ISTAT universe farms grouped for structure types. The histogram reports the average for years 2007-2011 of percentages of each structure in the conventional (Con), organic (Org) and ISTAT universe (ITA) categories. Also not analysed farms are reported (OTHER), and farms with regimes transitions among considered period (TRAN) are mentioned too. In the lower right corner there is a legend that reports total farm amount for each category.

Farms have not the same surface so, to evaluate the extension of the main productive processes, surfaces should be analysed on figure 2.9. Ratios among surfaces population maintain nearly the same trends among the regimes except organic ARA, ARA+ZOO and NAT+ZOO, that are less frequent in terms of percentage than the conventional ones. On the other hand organic TRE covers a little bit more surface than the conventional one. There are also ratios changing among amounts of universe farms and universe covers. Conventional ARA nearly reaches 20% of all agronomical surfaces and NAT+ARA+ZOO overcomes 15%. These second structure type considers few farms with big amount of surface. On the other hand TRE, which counts 25% of farms, covers less than 15% in conventional and 7% in organic describing a lot of farms with small surfaces. Considering cover extension, also NAT+ZOO, TRE+ARA and ARA+ZOO are relevant at national level. Farms with minor productive processes cover less than 5% of surfaces. This underlines how these farms and their processes are not dominant for Italian agronomical situation, especially from viewpoint of surface amount.

This analysis shows how productive processes are not distributed homogeneously among Italian farms and also among regimes.

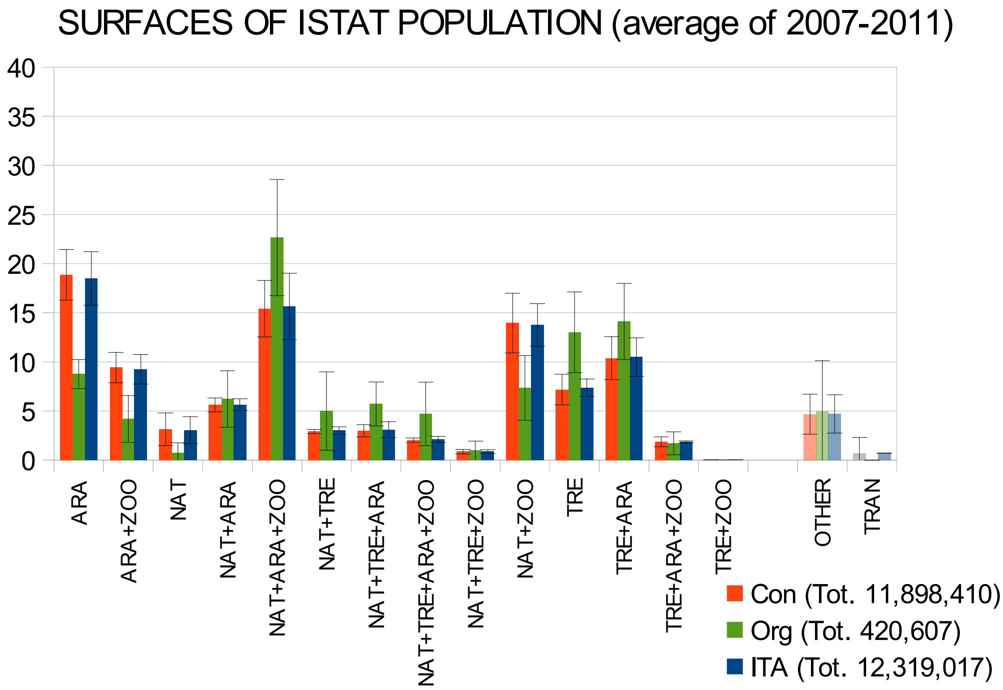


Figure 2.9: chart of the ISTAT surfaces grouped into structure types. The histogram reports the average for years 2007-2011 of percentages of each structure in the conventional (Con), organic (Org) and all universe (ITA) categories. Also, the surfaces of not analysed farms are reported (OTHER), and the surfaces of farms with regimes transitions among considered period (TRAN) are mentioned too. In the lower right corner there is a legend which reports the total surfaces amount for each category (in hectares).

2.5.1.2 Distribution over time

In the previous charts the average behaviour during 5 years (2007-2011) is analysed. The correlated standard error is often wide, this could mean heavy fluctuations among years. For this reason in the following charts (figure 2.10 and 2.11) the structure distributions are reported for each year.

According to the amount of farms, conventional regime shows less variability among years than organic regime. But both of them show several bars outside the owned respective average as in the TRE case: 2007 is outside of average range for conventional, 2008 2009 2011 are outside range for organic. Outsider bars are not always of the same years. This shows a correct RICA sampling connection (and its interpretation made by this methodology) among year 2007 and 2008-2011.

In terms of cover surface, explained in following charts 2.12 and 2.13, variations among years appear more relevant than variations of farm numbers in conventional and in organic too, especially for NAT+ARA+ZOO, NAT+ZOO, ARA and TRE+ARA.

As in previous situation outsider bars are linked to all years and not to specific ones. Also trends among different structures are not immediately individuated and it is not possible to link the decrease of farm structures (in terms of number or cover surface) to the rise of other farm structures.

It shows a quite stable scenario with annual fluctuation which is important in some cases, especially in structures with ARA or NAT.

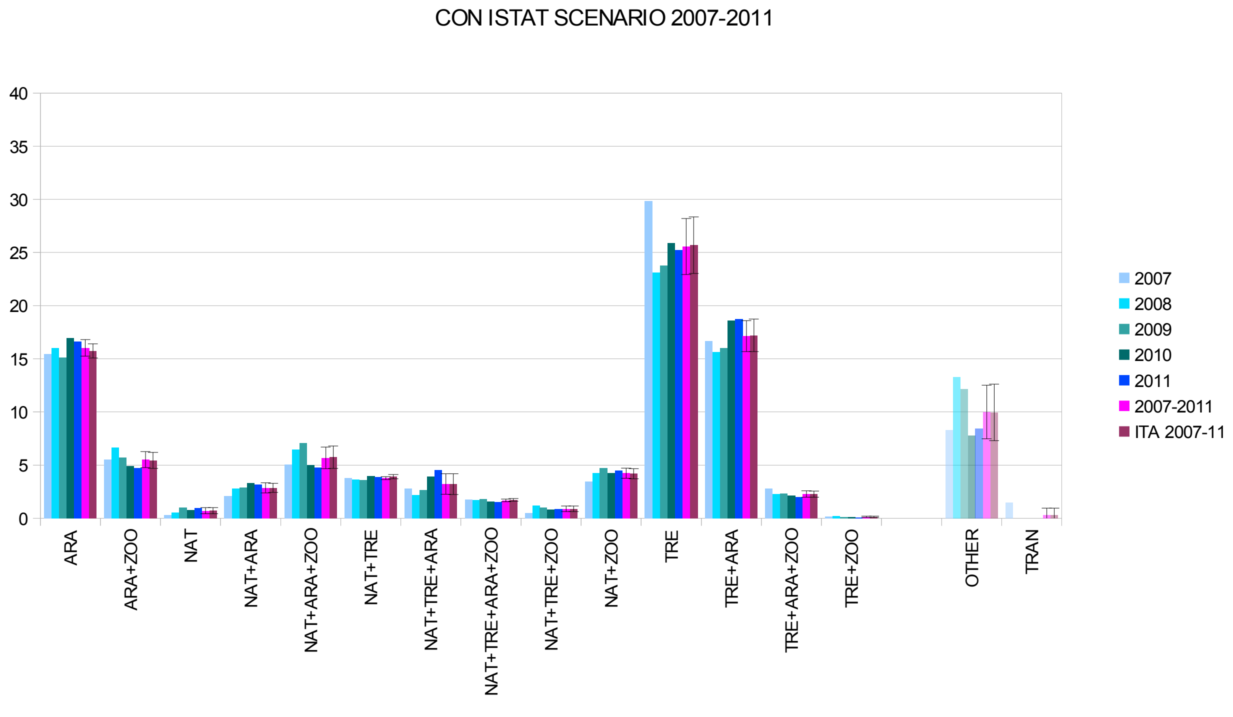


Figure 2.10: chart of ISTAT universe conventional farms grouped into structure types and years. The histogram reports the percentage of each structure for each year in different patterns of blue (2007, 2008, 2009, 2010, 2011), the conventional average among years is in light violet (2007-2011) and the national average among years is in dark violet (ITA 2007-11). For single years standard error is not reported because it is just a count and not an average as in the other two bars.

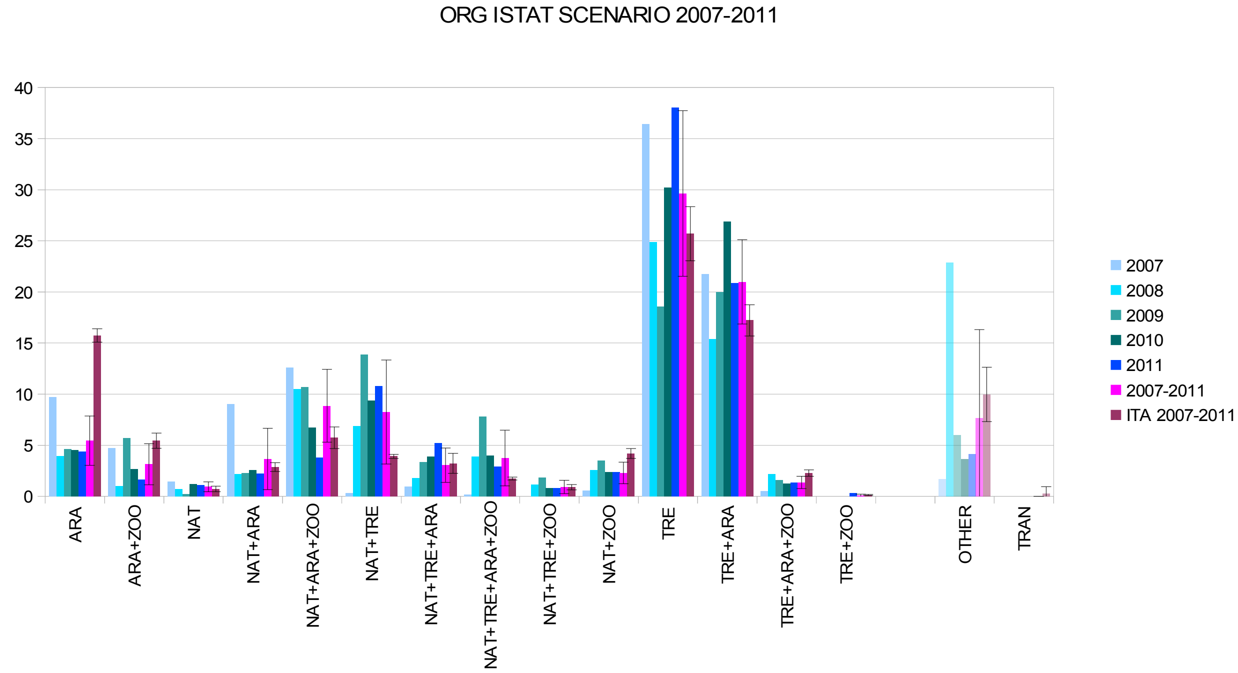


Figure 2.11: chart of ISTAT universe organic farms grouped into structure types and years. The histogram reports the percentage of each structure for each year in different patterns of blue (2007, 2008, 2009, 2010, 2011), the organic average among years is in light violet (2007-2011) and the national average among years is in dark violet (ITA 2007-11). For single years standard error is not reported because it is just a count and not an average as in the other two bars.

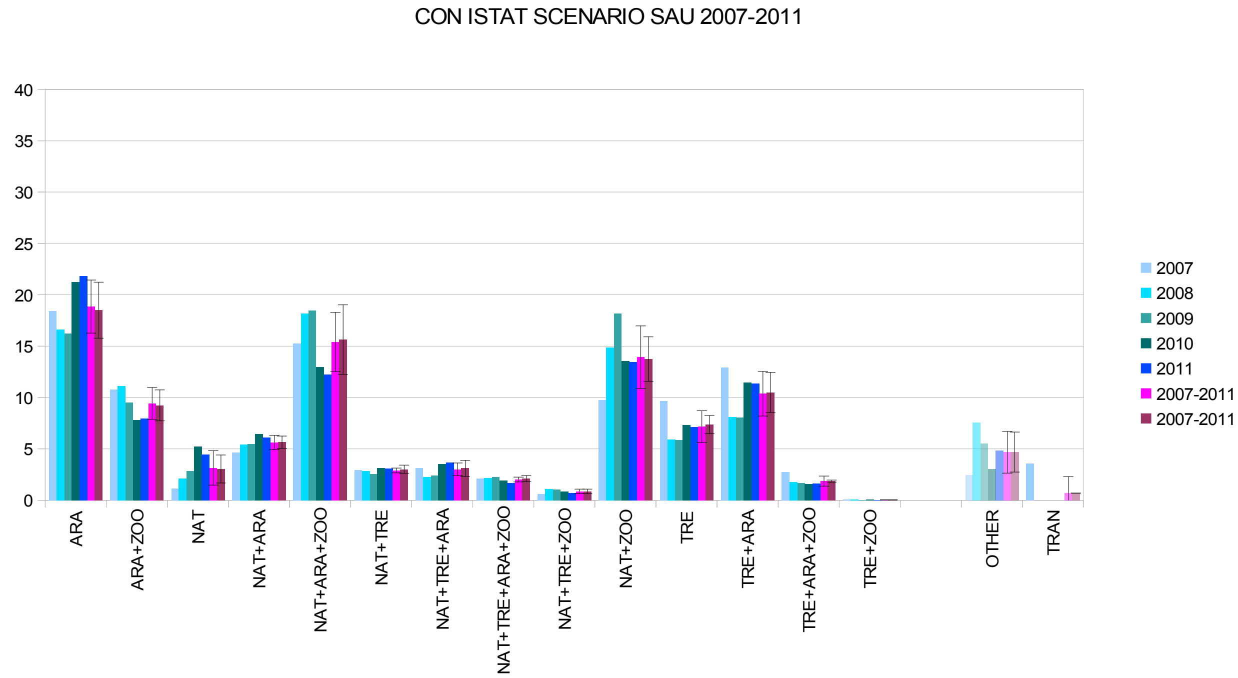


Figure 2.12: chart of conventional ISTAT universe surfaces grouped into structure types and years. The histogram reports the percentage of each structure surfaces for each year in different patterns of blue (2007, 2008, 2009, 2010, 2011), the conventional average among years in light violet (2007-2011) and the national average among years in dark violet (ITA 2007-11). For single years standard error is not reported because it is just a count and not an average as in the other two bars

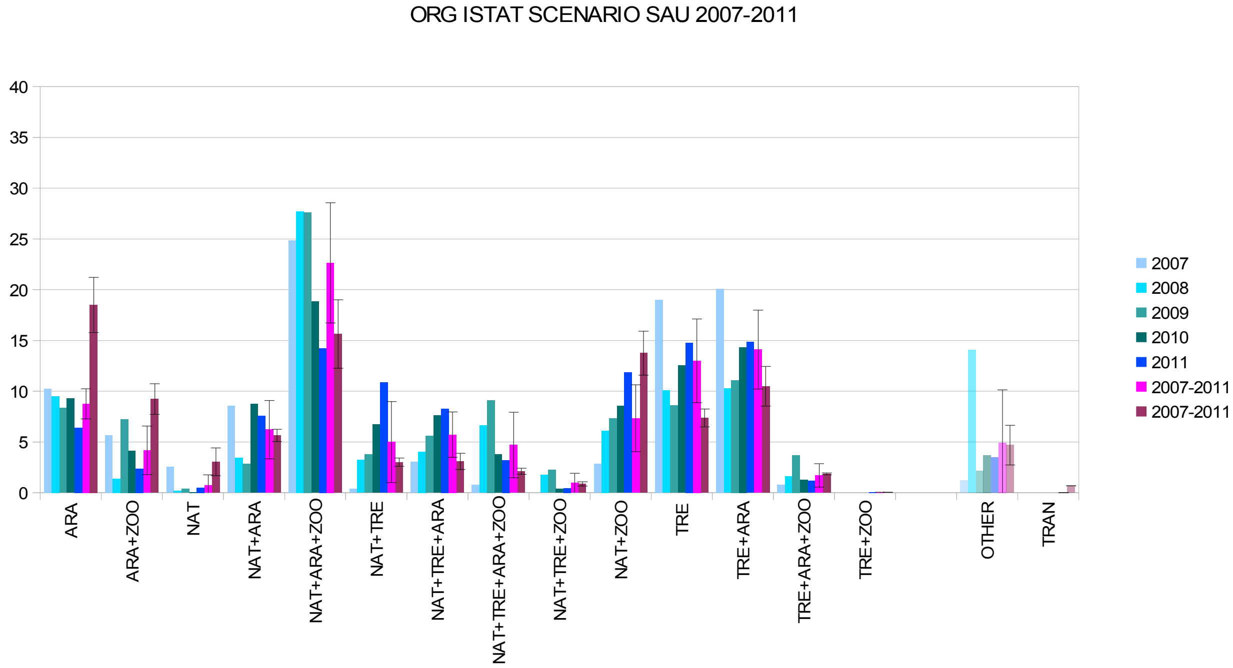


Figure 2.13: chart of ISTAT universe organic surfaces grouped into structure types and years. The histogram reports the percentage of each structure surface for each year in different patterns of blue (2007, 2008, 2009, 2010, 2011), the organic average among years is in light violet (2007-2011) and the national average among years is in dark violet (ITA 2007-11). For single years standard error is not reported because it is just a count and not an average as in the other two bars.

2.5.1.3 Stability of farm structure over time

Only the historical part of selected pool must be taken into account to evaluate the actual stability of farm structure over time. For this reason RICA farms are considered only if they are sampled more than 1 year. Farms with minor processes are not considered. Also, ISTAT universe evaluation is not mentioned because it has not real specific data, but just a general extension of RICA information.

For this analysis RICA farms have been grouped for a wide historical sequence: 2, 3, 4 and a maximum of 5 years (2007-2011). The farm sample sequence covers different years which are usually the following ones, but not always. For these reasons it is defined just a wide sequence without any specific starting or ending year. It is possible that a farm sampled in 2007-2008 and another farm sampled in 2010-2011 have been joined (if they have same structure ad regime). This is acceptable because this analysis tries to investigate which structures are more fixed than others. But it is not possible to individuate the specific year of structure change. Wide time periods are considered to evaluate structure stability in short (2-3 years) and medium time scales (4-5 years).

For this historic analysis also farm regime variations are taken into account because regimes influence farm structures (as the farm structure distributions show). So in the following data farms are grouped into homogeneous regime during the whole period, and a variation regime category is added.

The following table 2.5 and charts 2.14 report data of farms with fixed structure over all the time sequence. Farms with fixed structure might decrease with the increase of time sequence, if farm structures are not fixed and present randomly variations. Farms with fixed structures do not simply decrease when the sample sequence increases. Variations from expected trends are often limited (more fixed farms than shorter sequences), but they are sometimes relevant. For conventional regime, high levels of unexpected farms with fixed structure are always more common in medium time sequences (4 or 5 years). In organic and mixed regimes also short sequences (2-3 year) report unexpected trends.

In general TRE and ARA are the more fixed structures in all the conventional time sequences because they count high percentages of farms with no structure changes. Organic regime records high percentages of farms with fixed structure for NAT+ARA (100% for 2-3-4 sequence years), TRE, NAT+TRE+ARA and NAT+TRE+ARA+ZOO. Organic and mixed regimes often show complete populations of farms with a fixed structure. This should be connected to a little amount of organic farms and not only to a marked stability of farm structure.

Structures that report more variations are NAT (48.8-16.7 % of fixed farm structure) and TRE+ZOO for conventional regime; for organic and mixed ones there are more fluctuations among time sequences as regards to structure typologies.

		CON		ORG		MIX		RICA*	
STRUCTURE	S. Y.	Tot.	Fixed	Tot.	Fixed	Tot.	Fixed	Tot.	Fixed
ARA	2	777	92.8	6	100.0	5	60.0	788	92.8
ARA	3	307	87.0			8	75.0	315	87.0
ARA	4	809	86.7	3	66.7	29	82.8	841	86.6
ARA	5	243	74.5			10	60.0	253	74.5
ARA+ZOO	2	441	81.0	3	100.0	5	80.0	449	81.1
ARA+ZOO	3	167	67.7			5	40.0	172	67.7
ARA+ZOO	4	425	68.2	2	50.0	7	42.9	434	68.1
ARA+ZOO	5	195	59.5			4	0.0	199	59.5
NAT	2	41	48.8	1	100.0	1	0.0	43	50.0
NAT	3	19	21.1					19	21.1
NAT	4	29	24.1			2	0.0	31	24.1
NAT	5	12	16.7					12	16.7
NAT+ARA	2	174	69.5	3	100.0	2	50.0	179	70.1
NAT+ARA	3	92	51.1	5	100.0	2	100.0	99	53.6
NAT+ARA	4	146	44.5	2	100.0	6	33.3	154	45.3
NAT+ARA	5	68	52.9			5	20.0	73	52.9
NAT+ARA+ZOO	2	367	74.7	5	80.0	14	78.6	386	74.7
NAT+ARA+ZOO	3	184	58.7	2	50.0	11	81.8	197	58.6
NAT+ARA+ZOO	4	366	57.1	7	100.0	42	54.8	415	57.9
NAT+ARA+ZOO	5	241	51.5	2	100.0	14	64.3	257	51.9
NAT+TRE	2	145	82.1	9	66.7	7	71.4	161	81.2
NAT+TRE	3	100	67.0	1	100.0	4	100.0	105	67.3
NAT+TRE	4	157	63.7	7	42.9	7	57.1	171	62.8
NAT+TRE	5	80	66.3	1	0.0	7	28.6	88	65.4
NAT+TRE+ARA	2	126	72.2	6	83.3	3	100.0	135	72.7
NAT+TRE+ARA	3	78	50.0	4	100.0	9	44.4	91	52.4
NAT+TRE+ARA	4	128	52.3	3	100.0	12	50.0	143	53.4
NAT+TRE+ARA	5	78	64.1			7		85	64.1
NAT+TRE+ARA+ZOO	2	77	76.6	5	100.0	4	25.0	86	78.0
NAT+TRE+ARA+ZOO	3	50	58.0	4	100.0			54	61.1
NAT+TRE+ARA+ZOO	4	84	60.7	4	50.0	8	37.5	96	60.2
NAT+TRE+ARA+ZOO	5	29	48.3			1	100.0	30	48.3
NAT+TRE+ZOO	2	42	69.0			1	100.0	43	69.0
NAT+TRE+ZOO	3	21	47.6	2	100.0	2	50.0	25	52.2
NAT+TRE+ZOO	4	29	62.1			3	0.0	32	62.1
NAT+TRE+ZOO	5	17	35.3			1	0.0	18	35.3
NAT+ZOO	2	287	79.1	2	50.0	8	75.0	297	78.9
NAT+ZOO	3	157	71.3	1	100.0	5	60.0	163	71.5
NAT+ZOO	4	180	63.9	2	100.0	17	58.8	199	64.3
NAT+ZOO	5	218	69.7			2	50.0	220	69.7
TRE	2	673	93.0	28	100.0	21	100.0	722	93.3
TRE	3	298	85.2	3	100.0	10	80.0	311	85.4
TRE	4	762	88.1	11	81.8	62	88.7	835	88.0
TRE	5	293	86.3	6	50.0	20	65.0	319	85.6
TRE+ARA	2	666	89.0	30	93.3	21	81.0	717	89.2
TRE+ARA	3	231	70.1	4	50.0	10	70.0	245	69.8
TRE+ARA	4	569	69.9	11	72.7	36	72.2	616	70.0
TRE+ARA	5	186	60.8			16	43.8	202	60.8
TRE+ARA+ZOO	2	118	78.0	3	100.0	1	0.0	122	78.5
TRE+ARA+ZOO	3	59	67.8					59	67.8
TRE+ARA+ZOO	4	116	56.0			10	70.0	126	56.0
TRE+ARA+ZOO	5	65	52.3			1	0.0	66	52.3
TRE+ZOO	2	6	50.0			1	100.0	7	50.0
TRE+ZOO	3	3	0.0					3	0.0
TRE+ZOO	4	7	28.6					7	28.6
TRE+ZOO	5	3	33.3					3	33.3

Table 2.5: for each structure is reported a wide sample sequence (in years), the total amount of farms and the percentage of farms which do not change their structure (fixed). Values are reported for conventional, organic, mixed regimes and all joined together (RICA). The farms which are sampled for just one year are not considered (*). Also, farms with regime variations or with minor processes are not mentioned (*).*

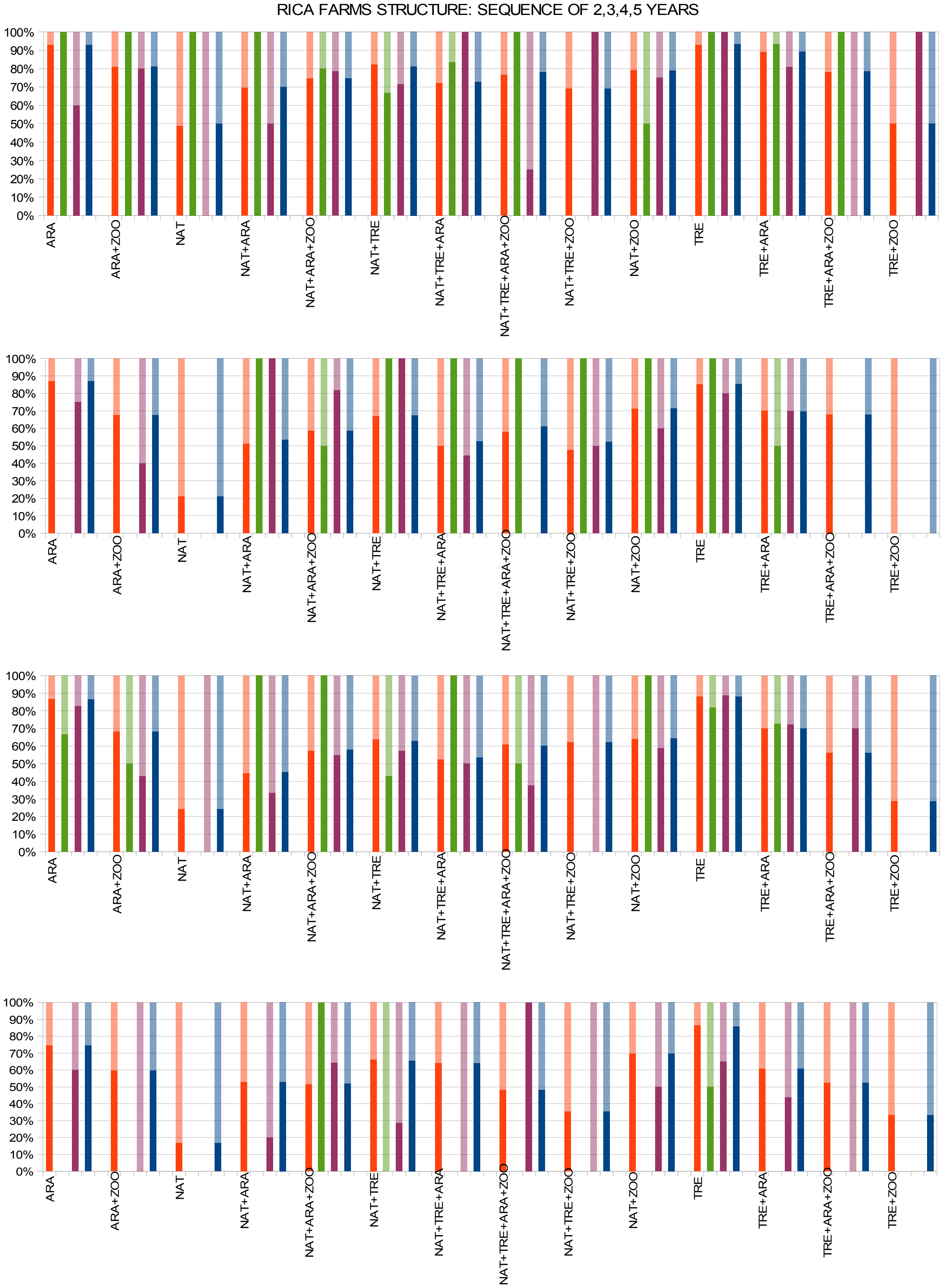


Figure 2.14: histograms of farm structures separated in time sequences. The lower bars sections, the more intensively coloured ones, represent farms which have the same structure during the whole period. The upper bars sections, which are quite transparent, represent farms which have this structure in the first sample and other structures in the following years. Red bars describe

conventional farms, green bars the organic farms, purple bars the farms which change regime and blue bars RICA farms. The farms that are sampled for just one year are not considered (*). Also, farms with regime variations or with minor processes are not mentioned (*).*

2.5.1.3 Details about structure dynamics over time

Farm structure at a most general level, as it has been described until now, count just the main productive processes/land covers that have been developed. Inside these structure types a wide heterogeneity is considered in terms of surface variations and amount of husbandries. Just by checking the surface percentage of super activities ARA NAT TRE and the amount of the whole husbandry, it is possible to infer that there are fluctuations during the time inside the most general description of structure types.

Some structures are more fixed than others by their definition: for example all structures with just one types of land cover (as ARA, NAT and TRE) could describe little fluctuation among 95% to 100% of main processes and for this reason they are not taken into account. But more complex structures could include fluctuation among 5% to 85-90% of farms surface. On the other hand also the presence of husbandry could describe the wide amount of animals: from 0.5 to thousands of UBA.

For this analysis only the RICA farms that are sampled for all 5 years are considered, to be sure that the average counts always the same farms. This should better report fluctuations among time and guarantee homogeneity among groups of farms for every year.

Structure fluctuations are reported in terms of percentage of cover surfaces/amount of husbandry in figure 2.15 only for conventional farms. Indeed only two organic farms are sampled all five years reported and they are not mentioned.

It is possible to show how farm structures are stable over time. Just fluctuation about 5% of surfaces are recorded for ARA and NAT in some structures (NAT+ARA or NAT+ARA+ZOO). The most variable super activities is ZOO which often records a variability among years higher than 300%. This variability is present not only for little amount of animals (as in NAT+TRE+ZOO) but also for farms with hundreds of UBA (as ARA+ZOO and NAT+ARA+ZOO).

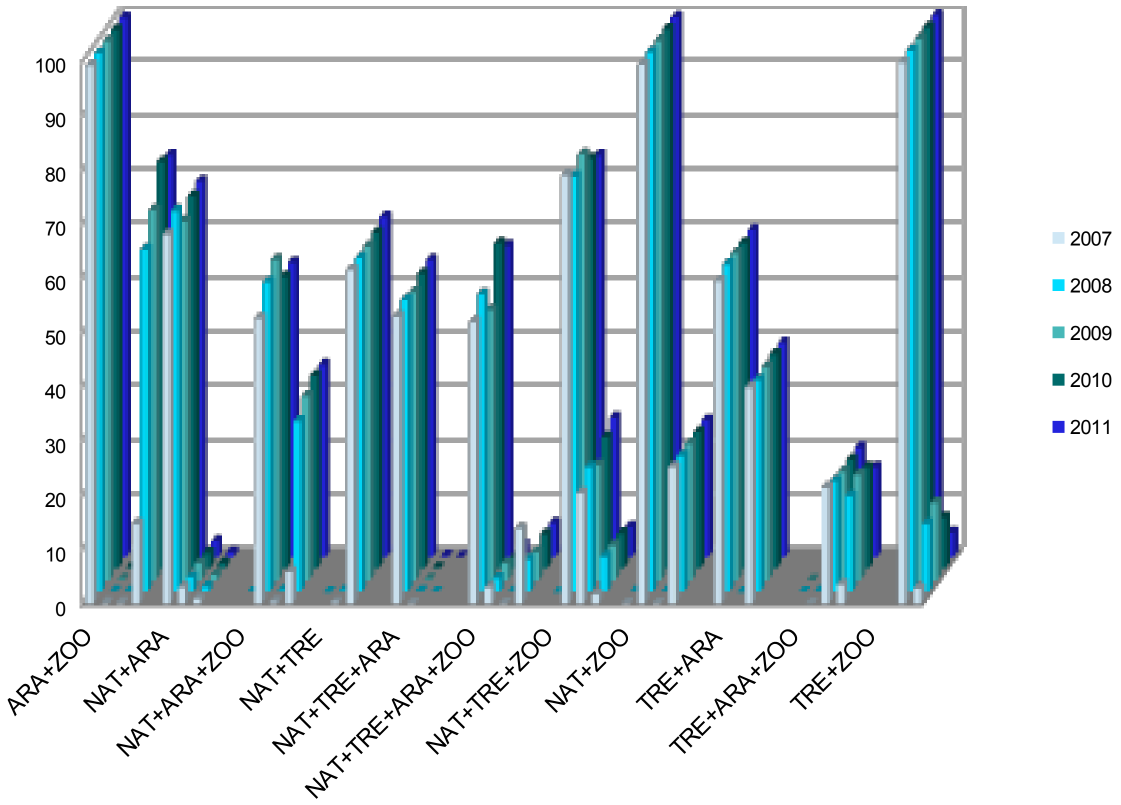


Figure 2.15: histograms of farm structures described for super activities and years. Every farm structure is described by four bars for each year, from the left side percentage of ARA, NAT, TRE and ZOO which is expressed in 10 UBA (so top of the chart for this super activities means 1000 UBA.

2.5.2 Farm structures and other general information

2.5.2.1 Administrative location

The first general information considered side by side with farm structures is the administrative location. Starting from FADN data, several levels of detail are available to describe these aspects. National ones (applied for previous charts), macro areas, administrative regions, provinces and municipalities. In general to better describe national situation it is considered the regional level. Also because a lot of agricultural policies are decided at this level. In the figure 2.16 the chart reports the percentage of every farm structure for conventional and organic farms separated by administrative regions for ISTAT universe.

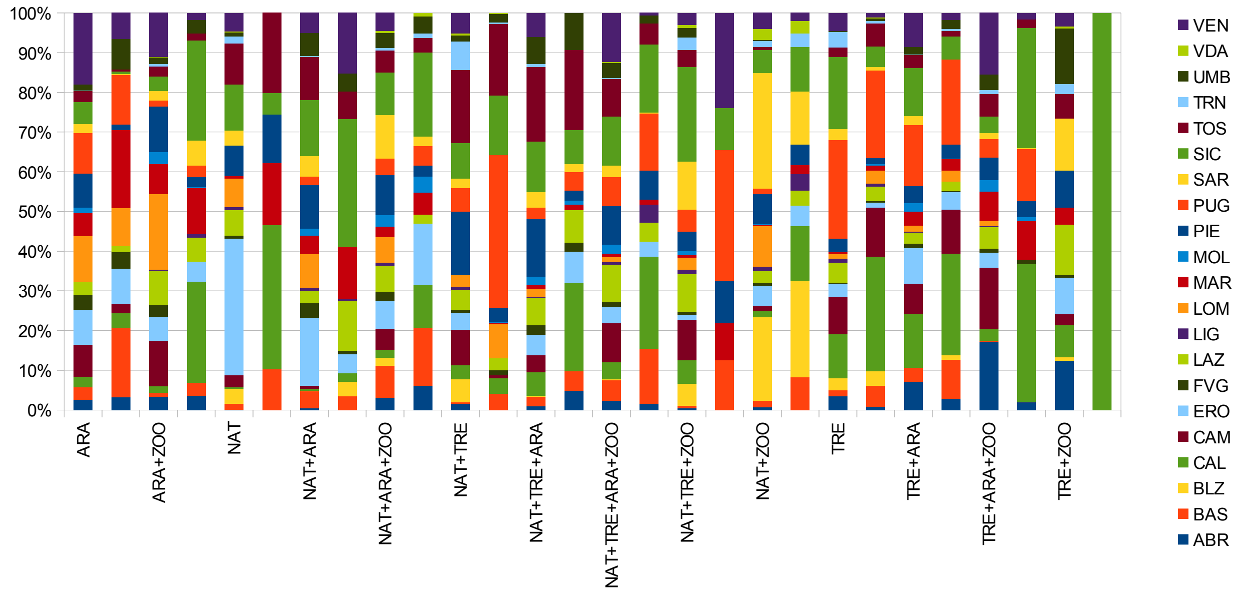


Figure 2.16: histograms of farm structures distribution as average of presence among years 2007-2011 grouped for administrative regions. Each farm structure is reported in two bars, on the left it is reported the distribution of conventional farms and on the right the distribution of organic ones.

The chart reports a large variability among administrative regions. High variability is reported also between conventional and organic farms. Only organic farms with structure TRE+ZOO record no variability, but it is due to sample RICA which counts only one farm.

In general conventional farms report farm structures quite homogeneously distributed among administrative regions. Indeed a single region usually represents at maximum the fifth part of farms with that structure. Excepting for NAT where Emilia Romagna (ERO) counts more than 35% of farms. The same situation for NAT+ZOO is in Sardegna (SAR).

On the other hand organic farms record a less diversified distribution where, for example, Calabria (CAL) and Sicilia (SIC) consider relevant parts of structures ARA+ZOO, NAT+TRE+ARA+ZOO and TRE+ARA+ZOO. Calabria counts also other relevant part of organic farms of NAT, NAT+TRE+ARA, TRE and also TRE+ARA. This shows a concentration of organic farms in these regions and also in Puglia (PUG) Toscana (TOS) and Veneto (VEN).

For both conventional and organic farms the structure NAT+ZOO reports a high concentration of farms in Bolzano (BLZ) and Sardegna.

2.5.2.2 Slope

The second general information analysed is the slope. In the following chart (figure 2.17) the distribution of farm structures for ISTAT universe is reported for each type of slope.

The chart shows a stable trend between conventional and organic farms for no slope (plain surfaces G1). In all farm structures there are more farms in plain in conventional regimes than in organic ones, except for NAT and NAT+TRE+ZOO. This is balanced by the presence of more organic farms in gently slope (G2) and sometimes in high slope (G3). The most frequent farm structures are in high slope (G3) often consider ZOO (ARA+ZOO, NAT+ZOO, TRE+ZOO).

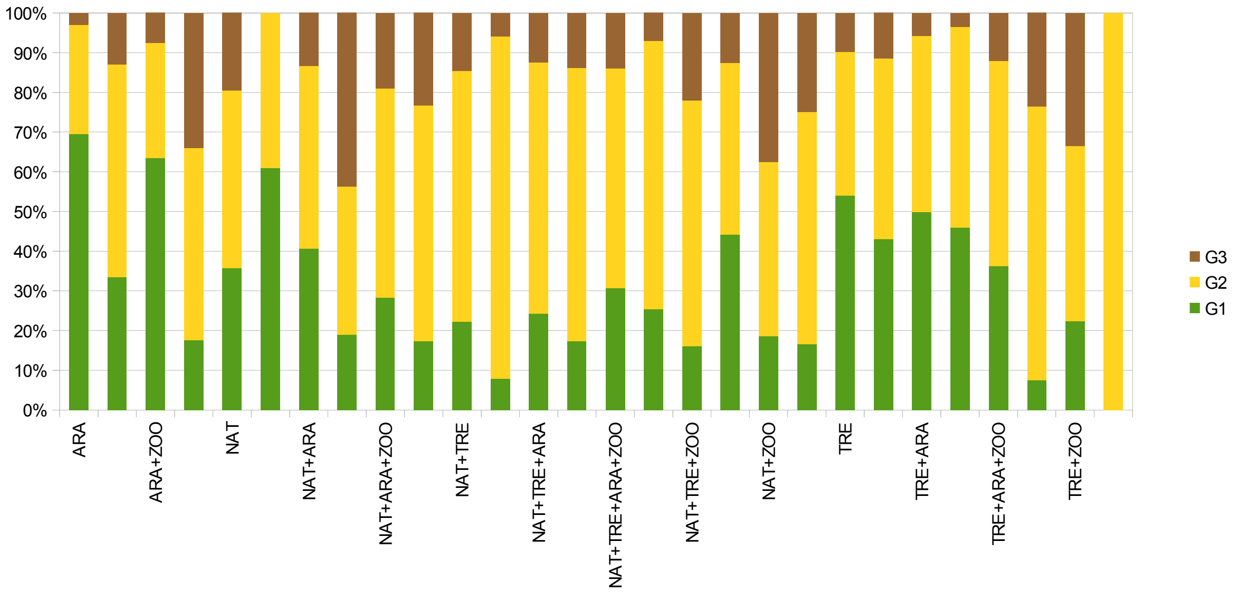


Figure 2.17: histograms of farm structures distribution reports the average presence among years 2007-2011, grouped for types of slope. Each structure is reported in two bars, on the left it is reported the distribution of conventional farms, on the right the distribution of organic ones.

2.5.2.3 Phyto-climatic zones

The third and last general information about farms is phyto-climatic zones. In the chart of figure 2.18 it is reported each phyto-climatic zone distribution of farm structures for ISTAT universe.

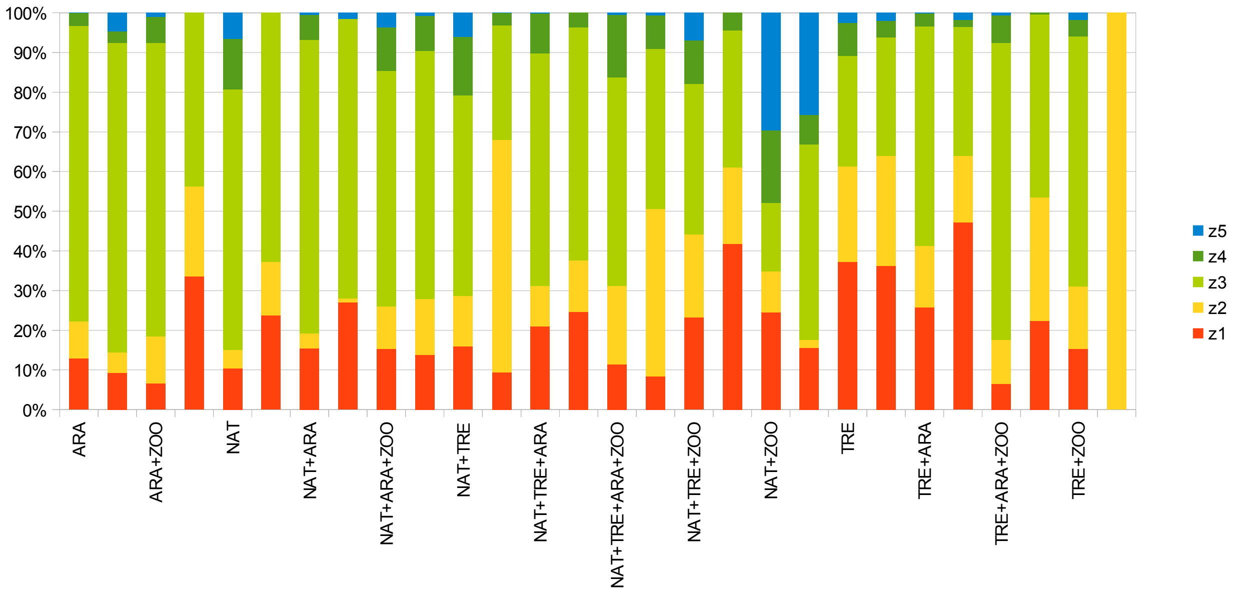


Figure 2.18: histograms of farm structures distribution as average of presence among years 2007-

2011 grouped for types of phyto-climatic zones. There are reported two bars for each structure, on the left the distribution of conventional farms and on the right the distribution of organic ones.

The chart reports variability among structures and regimes. Generally in cold phyto-climatic zones (z4 and z5) conventional farms are more present than in organic ones, especially with structures that consider NAT (NAT+ZOO, NAT+TRE, NAT). On the other hand organic farms are more frequent in warm phyto-climatic zones (z1 and z2) especially for the structures that include TRE (NAT+TRE, TRE+ARA, NAT+TRE+ZOO). As it should have been predicted, the temperate phyto-climatic zone is the most frequent in nearly all structures because it is the most extended category in Italy. It is not verified for some previously mentioned structures, especially for organic but also for conventional farms. The most similar structures between regimes are ARA and TRE and NAT+ARA+ZOO.

2.5.2.4 Complete farm typologies

The complete farm typologies consider farms structure, locations, slopes and phyto-climatic areas. Farm structure is detailed at a super activity level; location at regional level. In the following table 2.6 the farm typologies, which represent more than 1% of conventional or organic ISTAT universes, are reported.

CONVENTIONAL				
structure	%	Ad. region	P.C.Z.	slope
1 TRE	3.0	PUG	z1	G1
2 ARA	3.0	VEN	z3	G1
3 TRE	2.2	PUG	z2	G1
4 TRE	2.1	SIC	z1	G1
5 TRE	1.5	SIC	z1	G2
6 TRE+ARA	1.5	ERO	z3	G1
7 ARA	1.4	ERO	z3	G1
8 TRE+ARA	1.4	VEN	z3	G1
9 TRE+ARA	1.1	PUG	z1	G1
Total >1%	17.2			

ORGANIC				
structure	%	Ad. region	P.C.Z.	slope
1 TRE	3.4	CAL	z2	G2
2 TRE+ARA	3.2	CAL	z1	G2
3 TRE	3.1	CAM	z3	G3
4 TRE	3.0	PUG	z1	G1
5 TRE	2.6	CAL	z1	G2
6 NAT+TRE	2.5	PUG	z2	G2
7 TRE+ARA	2.4	PUG	z1	G1
8 TRE+ARA	1.7	CAL	z1	G1
9 TRE+ARA	1.5	CAL	z2	G2
10 TRE	1.4	TOS	z3	G2
11 TRE+ARA	1.4	CAM	z3	G1
12 NAT+TRE	1.3	TOS	z3	G2
13 TRE	1.1	CAL	z2	G1
14 ARA+ZOO	1.1	SIC	z1	G1
15 TRE+ARA+ZOO	1.1	SIC	z3	G2
16 NAT+ARA	1.1	SIC	z1	G2
Total >1%	31.8			

Tables 2.6: in the table on the left hand side are reported the most frequent conventional farm typologies. In the table on the right hand side are reported the most frequent organic farm typologies. Each one of these is described by the percentage of frequency with respect to ISTAT universe, administrative region, phyto-climatic zone (P.C.Z) and slope.

The conventional situation reports a higher variability than the organic one. Indeed only 9 conventional farm typologies overcome the 1% unlikely 16 of organic ones. On the other hand the most frequent conventional farm typologies report always few structures, regions, phyto-climatic zones and the same slope (except for fifth typology).

Farm structure considers only ARA, TRE and them together. ARA appears in the north regions (VEN and ERO) and in temperate phyto-climatic conditions (z3). TRE is common in south regions (PUG and SIC) with warm phyto-climatic conditions. The only structure that is present in south and north regions (PUG, ERO and VEN) is TRE+ARA.

In general the conventional situation shows that farms, which are oriented to productions (no NAT), are specialised in just one super activity in 2 cases on 3. The super activities report climatic gradient and same structure appears in several regions with same phyto-climatic conditions. It suggest that conventional farms reports variability for different environment, but not high variability for the same context. Indeed the farms is concentrated on the most productive place as plain where there are the best climatic condition.

On the other hand the organic situation is more diversified in terms of local context, but less diversified at a national scale, where 16 farm typologies represent nearly one third of the whole situation. It could be due to few numbers of organic farms at national level. As in conventional the most frequent farm typologies are concentrated in few regions, but they consider several types of environmental conditions: more phyto-climatic zones and slope than conventional ones.

Farm structure nearly always considers at least TRE, suggesting a relevant role of this super activity for the organic situation. The farm structures often consider with relevant presence of NAT and ZOO. On the other hand the same structure appears more times in the same administrative region showing high plasticity: for example TRE+ARA appears 3 time in Calabria (CAL). NAT appears only in gently slope in several situations: island (SIC), south (PUG) and centre of Italy (TOS). ZOO only in Sicilia (SIC) appears always linked with ARA.

All the considered regions are in the south of Italy except for Toscana (TOS), which is in the centre but with mediterranean climatic conditions too. It suggests a concentration of organic farms in the south or, at least, a better defined situation of farm typologies which are relevant here at national level.

The organic farm typologies consider also gently and one high slope situations. It suggests a higher level of environmental adaptations than conventional typologies, which are present only in the plain.

More in general the farm typologies record a climatic trend for both organic and conventional farms which consider more frequent TRE in the warm conditions and ARA in the colder ones. This is in accord to high presence of orchards in the south of Italy where fruits, citrus and olive tree are strongly cultivated. On the other hand regimes are affected by slope, this shows more conventional farms in plain than organic ones which are more common in gently slope.

Organic and conventional regimes interpret climatic potential in the same productive processes as TRE in south Italy, but adapt farm management in different mood according to specific environment. It is suggested by the higher farm structure variability in organic regime.

2.5.3 Comparison of farm classifications

2.5.3.1 Farm structure and size classes

In the following chart (figure 2.19) farm structures referred to ISTAT universe are separated for size classes that are commonly adopted by ISTAT analysis.

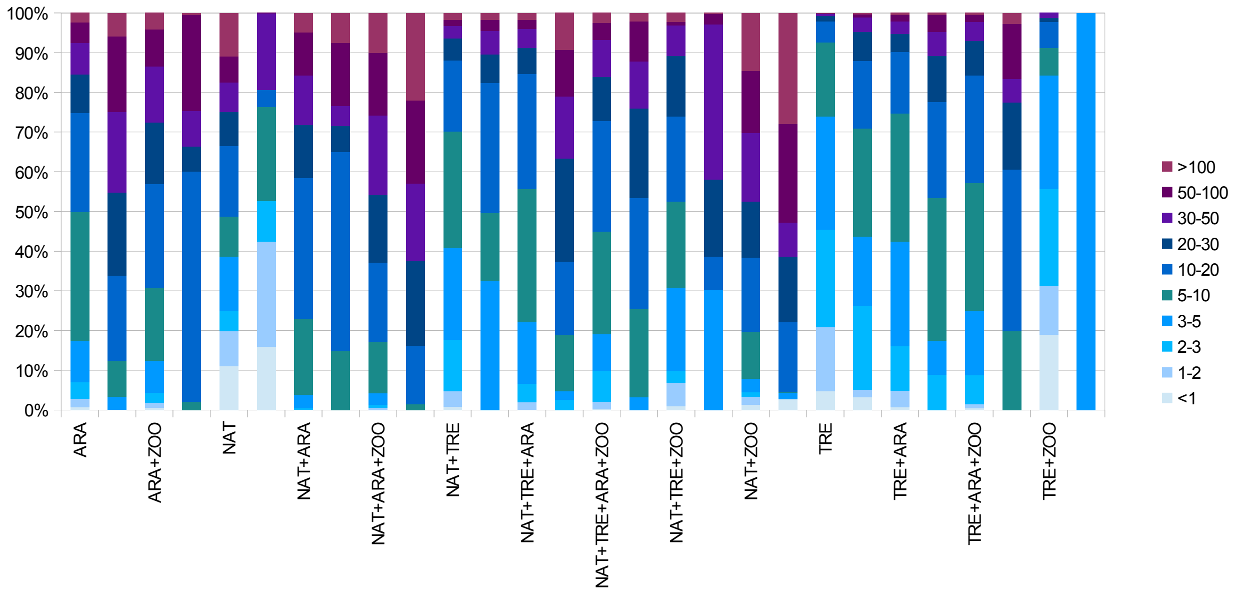


Figure 2.19: histograms of farm structures distribution for years 2007-2011 grouped into size classes. Each structure is reported in two bars, on the left it is reported the conventional farms distribution, on the right the distribution of organic ones.

The chart records variability among size distribution of farm structures and among regimes. Some farm structures as NAT+ZOO, NAT+ARA+ZOO and ARA have a larger size than other farms, especially in organic regimes. On the other hand NAT, TRE and TRE+ZOO are often farms with few surfaces. This is a strange behaviour for farms with only NAT because other structures with NAT have large surfaces. Organic regime generally reports wider farms than conventional.

2.5.3.2 Farm structure and UDE

In the following chart (figure 2.20) farm structures are compared with UDE classification.

This chart reports a high variability inside farm structures but a quite similar behaviours among farm structures. This is because UDE is not directly correlated with farm structure, but more with holding size. Structures with ZOO are associated to high class of UDE but no other trends are clearly recorded. Also in this case some variabilities among organic and conventional situations are reported, especially for TRE+ARA+ZOO, NAT+TRE and NAT+ZOO.

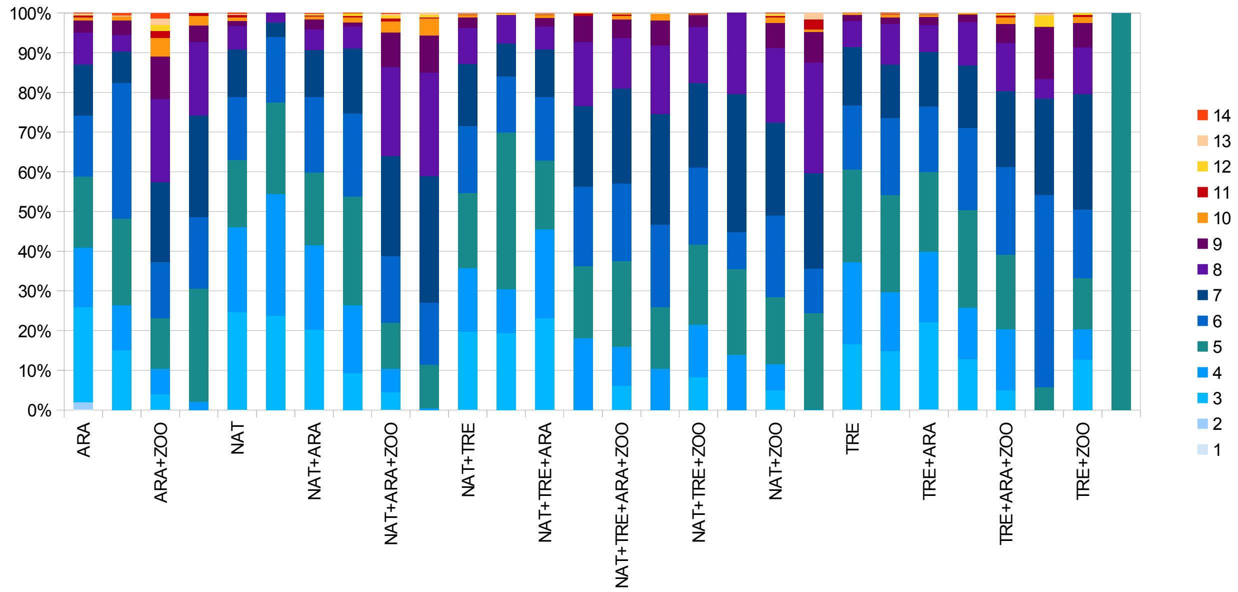


Figure 2.20: histograms of farm structures distribution for years 2007-2011 grouped for UDE. Each structure is reported in two bars, on the left it is reported the conventional farms distribution, on the right the distribution of organic ones.

2.5.3.3 Farm structure and OTE

In the following chart (figure 2.21) farm structures are compared with OTE classification.

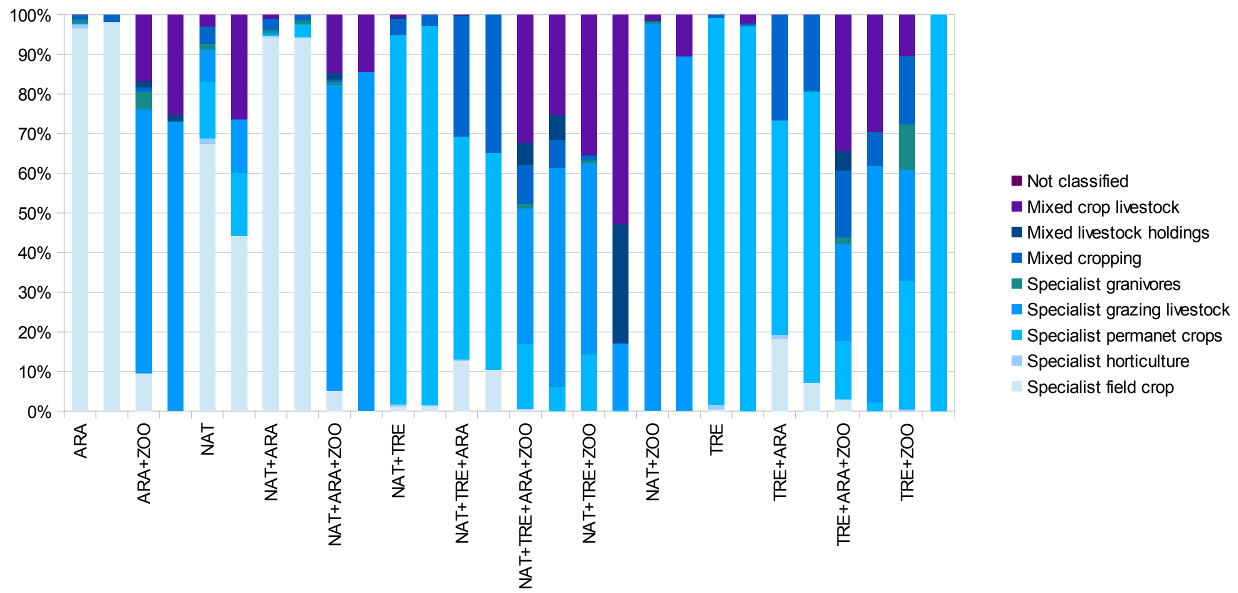


Figure 2.21: histograms of farm structures distribution for years 2007-2011 grouped into OTE. Each structure is reported in two bars, on the left it is reported the conventional farms distribution, on the right the distribution of organic ones.

The chart shows less variability of the previous ones. However for some farm structures there is no a univocal correlation. Indeed for NAT+TRE+ZOO, NAT+TRE+ARA+ZOO and TRE+ARA+ZOO the same structure can be described by three or more OTE. This is clear as OTE is more similar to farm structure when there is a simple structure. But when farm reports several super activities, OTE and farm structure report different classifications. Organic farms especially report this phenomenon (NAT+TRE+ZOO). It could be due to OTE consideration of only relevant processes from an economical viewpoints, farm structure considers all surfaces and husbandries.

3. Analysis of farm indicators

3.1 Introduction

As for farm classifications, a lot of farm indicators have been developed in multitude of studies. In this one 14 indicators are estimate for each farm. They are selected to cover several areas of sustainability, but they describe principally environmental and economical aspects.

The main data source is FADN database side by side with general environmental data (phyto climatic zones). This choice considers two aspects: on one hand some indicator levels are general and not detailed, but in other hand all this indicators should be estimate for each FADN database with just a little support of environmental and agronomical data.

All information are managed by MAD model which returns indicator estimations. This model has been designed specifically to analyse farms described by FADN information during BIOSUS Project (G Vitali et al., 2012). In this work MAD will be shortly described because all aspects about the model structure and the procedure to estimate indicators will be described in the publication "The BIOSUS Project, Final reports" which will be concluded before summer of 2014.

3.2 Selection and indicator list

The most common areas of interest about farm sustainability indicators are water, environment and atmosphere, biodiversity, ecosystem aspects, soil and energy. Large bibliography about them has been developed. But often to estimate indicators level experimental data is required, so their estimations could be applied just for limited areas.

In other hand also social and economical indicators might be considered according with a whole concept of farm surrounding context described in chapter 1. In this study 14 indicators try to describe environmental and economical aspects of sustainability. Also social area is taken into account with one indicator which describe amount of labour.

Some indicators can describe more than one sustainability areas as indicator of labour amount. High level of it could be interpreted in a positive way from social view point (high level of employment). In other hand in an economical view point, high level of labour could be interpreted in a negative way because means high costs for businessman. For this reason in this study each single indicator level is reported and multi criteria analysis is not developed to find the best regime or structure.

The 14 indicators selected are reported in the follower list. Their names are reported in capitol letters if at high values generally correspond a positive trend; the contrary situation is described by minus letters. In this analysis indicator of labour amount is considered from an economical viewpoint, so is reported in minus letters. But to underline its double meaning it is the first indicator mentioned separated by other indicators reported in minus letters.

- **ilab (hour / hectare year):** amount of human labour request from surface unit. All labour is considered, also amount refered to husbandry. All farm surfaces are considered, also natural ones.
- **INAT (%):** ratio of farm natural surfaces toward total amount of farm surface. The natural areas consider woods and pasture.
- **IBDL (/ha)**: habitat diversity indicator. A specific count of each specie is not available. So at each land cover is attributed a class of potential biodiversity. This value is multiplied for

amount of cover surface. Natural covers are considered with the most potential biodiversity, in other hand intensive crops with less biodiversity. Also few intermediate classes are considered.

- **INVI (euro / hectare year):** net revenue for unit surface. Net revenue considers profits (from crops, husbandry and subsidies before CAP 14) and costs (from crops, husbandry, and fixed ones). Labour is not considered inside net revenue.
- **EFF (euro / hour):** efficiency indicator. It is estimated by considering ratio among gross margin (from crops and husbandry) and amount of labour (ilab).
- **ighg (ton C / hectare year)**: green house gases emission index. It estimates basic carbon fluxes inside farm boundaries. The carbon sink are wooden tissues (in woods and orchards) and soil organic matter (estimated applying isohumic coefficient at manure, natural and crop residues). Sources of carbon are animal metabolism, manure maturation, fossil fuel used for machinery, burning of straw).
- **ilai (ton C / hectare year):** green house gases emission outside farm indicator. It considers energy (in terms of carbon emission) required for fossil fuel and synthesis fertilisers production.
- **iccs (/ ha)**: sensibility at climate change indicator. Considering extreme meteorological events as results of climate change, indicator estimate sensibility of crops at these phenomenons. High levels of sensibility are attributed at tree crops, intermediate levels at major part of field crops and low level at natural covers. Class of sensibility is multiplied for amount of cover surface and weighted by total amount of farm surface.
- **iint (/ha)**: crop intensity indicator. According with technical coefficients a class of intensity is attributed at each crops. High classes are associated at intensive crops and orchards; intermediated ones at extensive orchards cereals and forages; low classes are associated with natural covers.
- **iler (/ha):** soil erosion indicator. At each crop is correlated a class of soil cover. Low classes of erosion are attributed at structured and denser covers. Class of erosion is multiplied for cover surfaces and pondered for type of farm slope.
- **ipcl (euro / hectare):** phytopharmacy usage indicator. Farm amount of phytopharmacy usage is recorded by FADN database in economical terms. Indicator considers economical aspects to suggest a quantitative amount of phytopharmacies dispersed on field. But information about nature of phytophamarmacies are not taken into account. It mean a not easy comparison among organic and conventional regimes because they must use different products. However indicator is useful inside regimes, especially for conventional one.
- **ipfl (litre / hectare):** amount of fossil fuel usage index. Indicator considers amount of fossil fuel necessary for machinery labour on field and for husbandry. It is related with total farm surfaces.
- **isdz (%):** animal feeding self sufficiency indicator. It consider amount of feeds (proteins and forage unit) required by husbandry and how much of them come from inside farm (as forages). This indicator suggests level of dependence of farm from context for feed.
- **ipnl (%):** fertiliser self-sufficiency indicator. It considers amount of nitrogen required by crops and how much of this nitrogen comes from inside farm (as manure or crops with no N requires). This indicator suggests level of dependence of farm from context for fertiliser in terms of nutrients and market price.

All together, the indicators consider several areas of sustainability and farm connection with surrounding context. *ighg ilai* and *iccs* describe relation among farm and climate change. *INAT iint* and *IBDL* analyse natural level of farms. *ipcl* and *iler* consider connection among farm and inside/surrounding context in terms of air pollution and soil erosion. *IVNI* and *EFF* evaluate farm efficiency. *ipnl ipfl* and *isdz* estimate self-sufficiency of farm and its dependence from market.

3.3 Material and method: the MAD model

The MAD model has been designed to analyse the farms which are described by FADN data. MAD requires all farm information reported in the farm typologies previous described. Farm structure is required at the finest level of details: crops and animal types and their orientation (milk, meat, mixed). Phyto-climatic zone, slope, administrative region and regime are the other information required for each input farm.

All previous information allows to MAD to define farm as described by FADN database. The original purpose of MAD is to optimise farm structure and their practices to obtain the highest level of net revenue. MAD can change arable crop and it manages fertiliser and animal feed purchase. To optimise some part of farm structure is a way to investigate hypothetical policy impacts towards farms at Italian agriculture level.

For this analysis it is selected MAD modality which does not change surfaces but only estimates indicators considering specific technical coefficients related with crops and animal types. The major part of them comes from FADN database detailed for regime, administrative region and crop/animal type. They are yield, amount of phytopharmacies required, products price at farm-gate, hour of machinery required, ect. So indicators which come from farm structures, are directly based on FADN data. Other ones, correlated to economical aspects, also use elaborated information from FADN. Only environmental coefficients and some agricultural coefficients come from other bibliography sources.

3.4 Results of indicator analysis

In this chapter farm indicator levels are reported, firstly separated by farm structures, regimes and sample years. It suggests the stability or the variability level for each indicator over time. Then farm structures are compared for all indicators between both regimes.

3.4.1 Indicators behaviour among farm structures and time

The behaviour of *ilab* is reported in figure 3.1. The indicator level is reported for each farm structure as average of farms sampled during years 2007-2011.

By looking the chart, it is clear as *ilab* shows deep variability among the major part of farm structures and someones with ZOO. TRE+ZOO, ARA+ZOO and less marked TRE+ARA+ZOO report a huge standard deviations respect other structure. Also other farm structures with ZOO (as NAT+TRE+ZOO, NAT+TRE+ARA+ZOO and NAT+ARA+ZOO) record high level of standard deviation but with average amount of labour more similar to other structures than previous one with ZOO.

All these structure record this types of trend only for CON. ORG structures are more similar to other structure without ZOO. On one hand it could be due to less number of organic farms, but on other hand could be a signal that animal density and/or labour required in organic husbandry is really different than conventional one.

In the following pictures (figure 3.2 and 3.3) *INAT* and *IBDL* behaviours are reported.

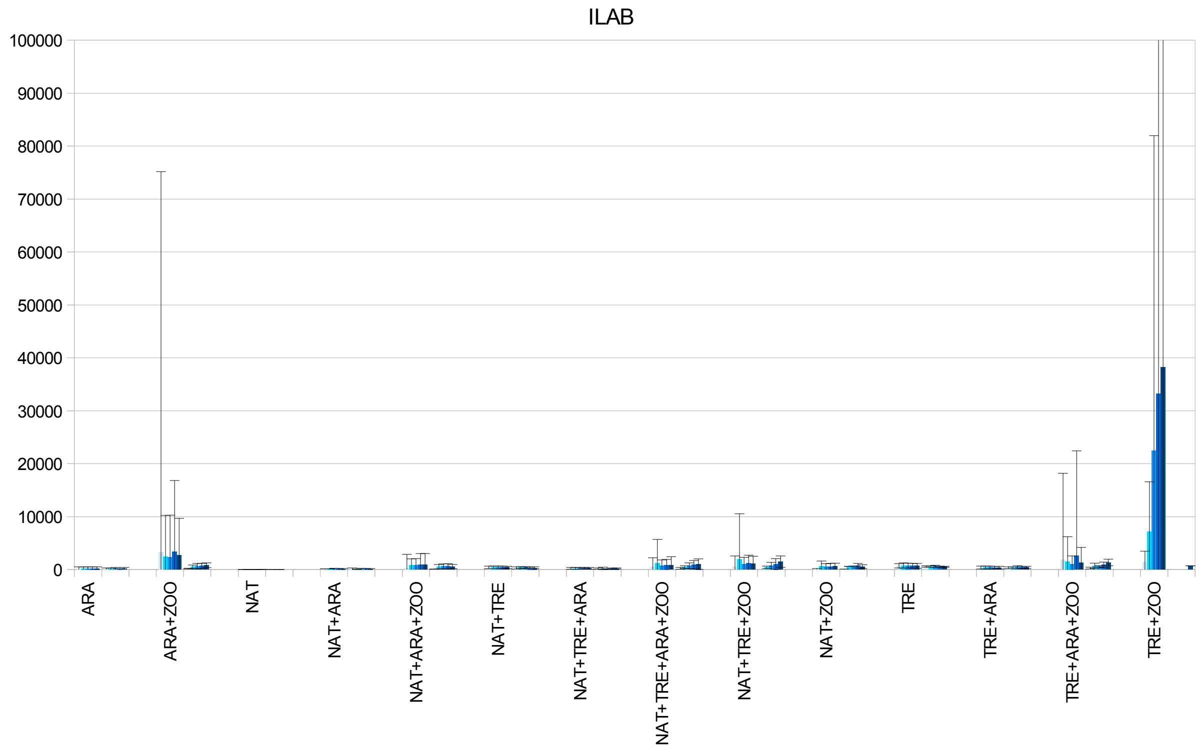


Figure 3.1: the histogram reports average of indicator level for ilab (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

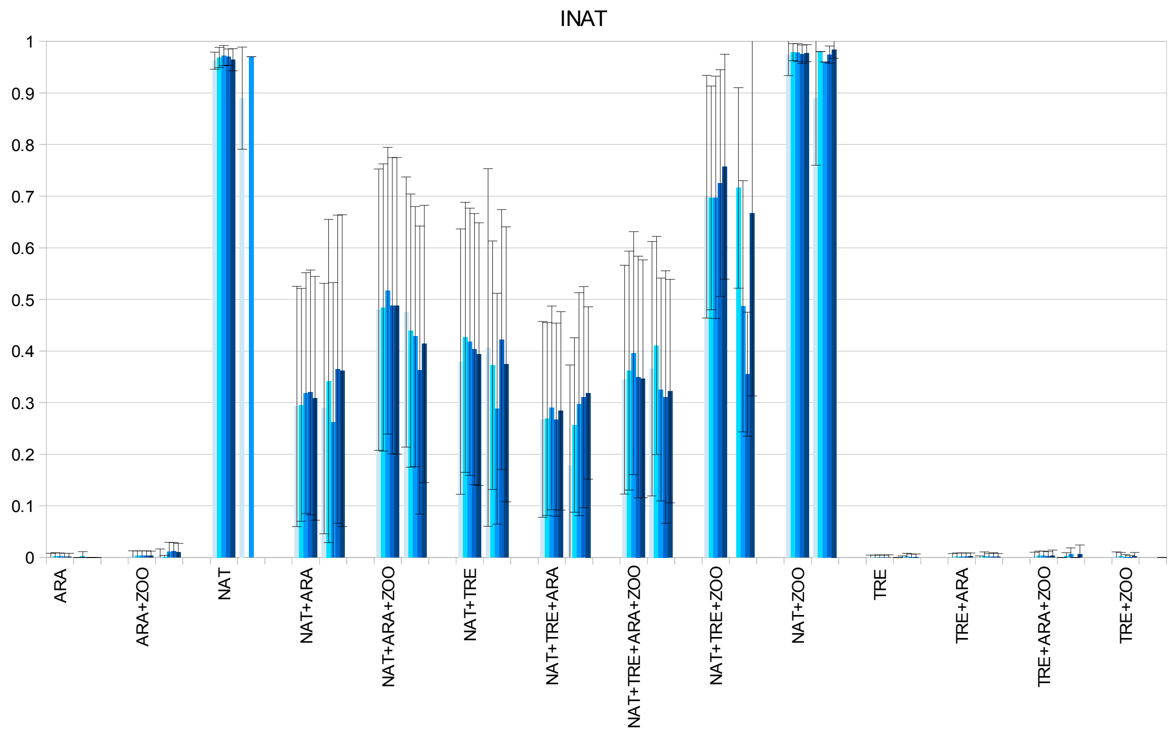


Figure 3.2: the histogram reports average of indicator level for INAT (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

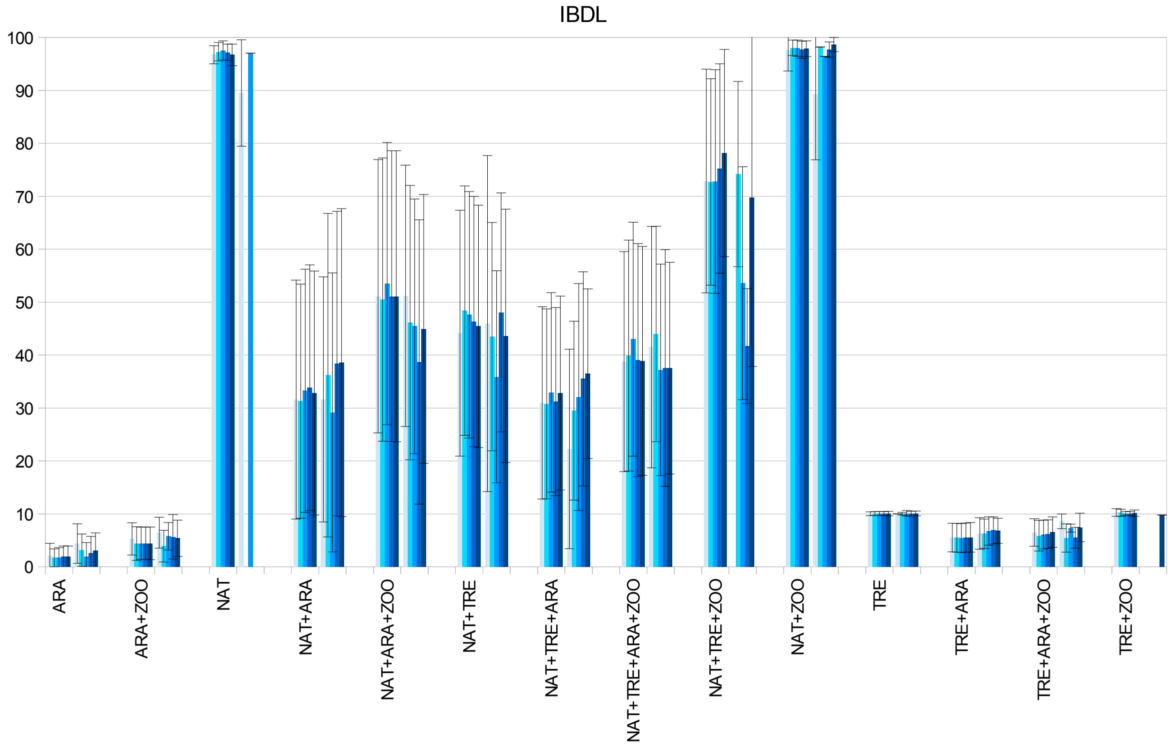


Figure 3.3: the histogram reports average of indicator level for IBDL (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

These two indicators are strictly correlated with farm structure. Their variability among structures is less than previous indicator, but it is also dues to nature of indicators. Both indicators report few variability for structures with only *NAT* or without it. For other structures a larger variability is recorded with surface fluctuation among the same year usually over than 40% of complete range. It means high variability among farms with the same structure, but it is not possible to identify any trends among years or among regimes.

In the following charts 3.4 and 3.5, the behaviours of *IVNI* and *EFF* are reported.
Especially *IVNI*, but also *EFF*, shows huge variability for the same farm structures such as ARA, TRE, TRE+ARA and NAT+ARA. It is normal because TRE and ARA are the surfaces which product gross, on the other hand NAT does not produce and does not affected indicator levels. It is interesting as other structures more complex do not show the same variability as NAT+TRE+ARA+ZOO, NAT+TRE+ZOO, NAT+ZOO and NAT+ARA. It could mean that these structures, despite a high potential variability dued to multitude of combinations, are more similar than farms with just one super activity.

This results could be affected by different number of farms for each structure, but it is a clear suggestion of variability of crops adopted in Italy and/or the variability of regional market and/or variability of techniques. It is easy to agree with this idea by considering the high variations of habitat and micro climatic conditions present in Italy which usually are exploited in regional production (often certified). Similar variability is not reported for husbandry or ORG structures.

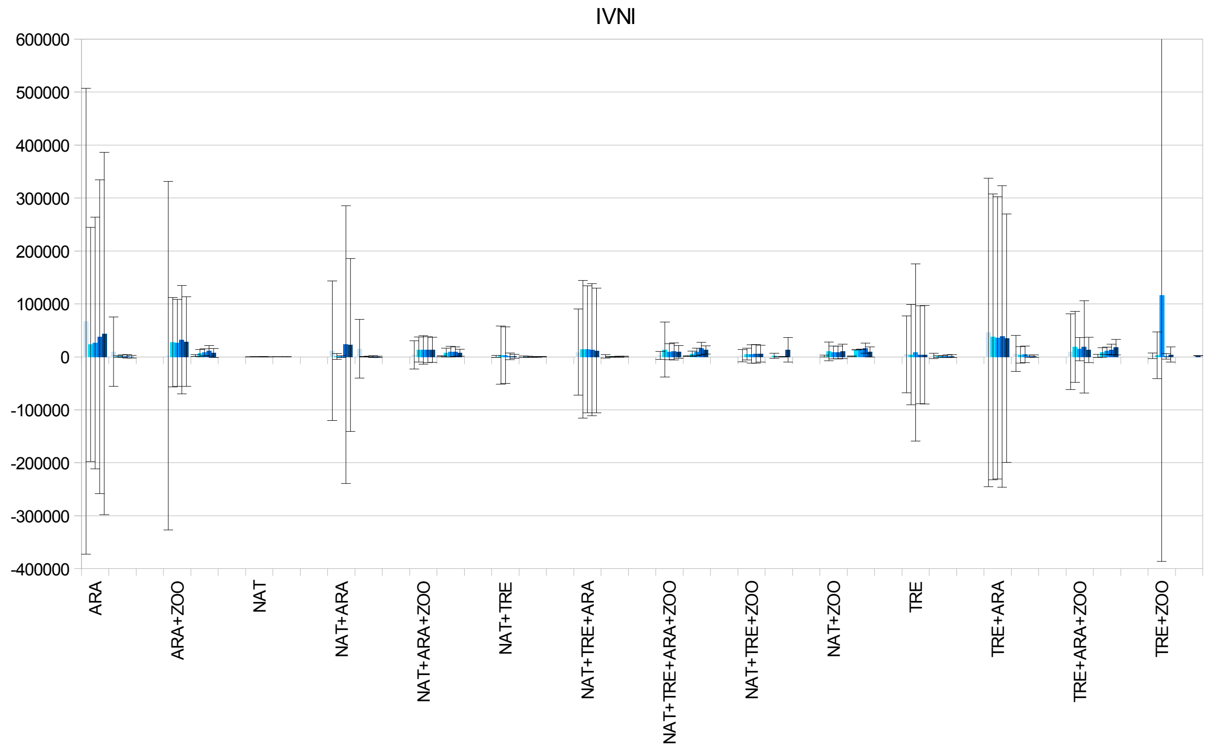


Figure 3.4: the histogram reports average of indicator level for IVNI (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

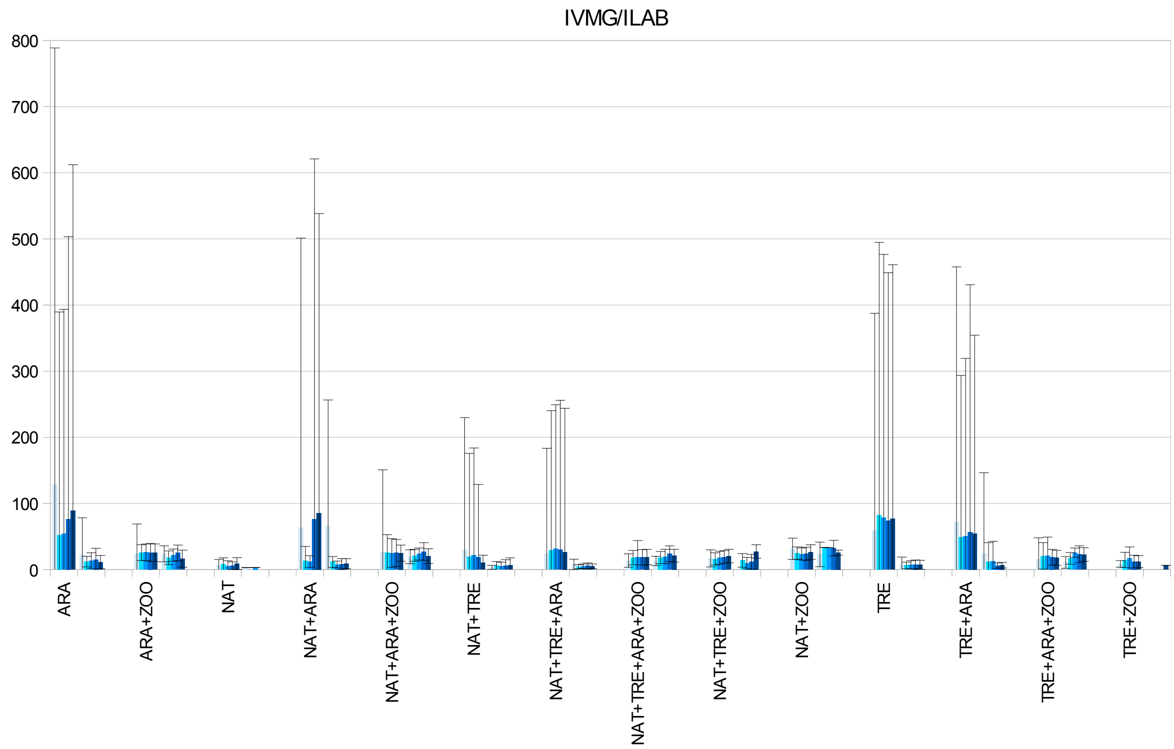


Figure 3.5: the histogram reports average of indicator level for EFF (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

Other interesting phenomenon is the correlation between high level of efficiency of ARA, NAT+ARA e TRE+ARA and the highest but also the lowest level of net revenue reported by standard deviation for the same structure. It could be affected by presence of really small farms which return high level of efficiency, but how legitimise negative net revenue is not clear. A possibility could be market price. Indeed MAD model considers a unique value of price deducted by analysis of period 2007-20011, and it does not reproduce market price fluctuations. To register negative net revenue could be possible for farm with crops which in MAD have a fixed price lower than real market price for that year. But in other hand farmers follow these trends and FADN records them towards crops which farmers have been decided to plant. Probably all these phenomenons contribute to behaviours of these indicators which show variability also among years, especially for NAT+ARA in both regimes.

In terms of efficiency ORG is similar to CON in half of structures which have less variability. Same trend is reported also for net revenue.

In the following figures 3.6 and 3.7, the behaviours of *ighg* and *ilai* are reported.

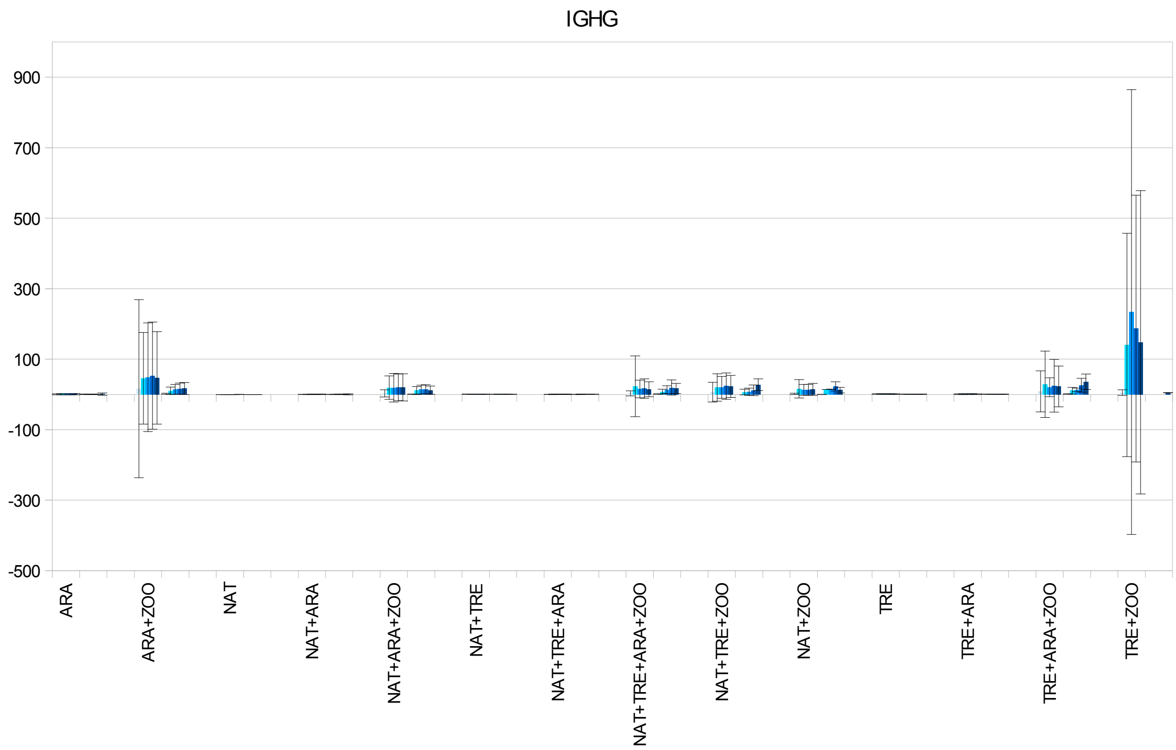


Figure 3.6: the histogram reports average of indicator level for ighg (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

In the figure 3.6 is clear as ZOO is the most influential super activity correlated with green house gases emission. Especially for ARA+ZOO and TRE+ZOO, but also in other structures with ZOO, CON records higher level of emission than ORG in terms of average and also standard deviation.

In figure 3.7 different situation is reported. All structures register quite similar level of out farm GHG emission. It is quite strange that out farm GHG emission levels do not decrease also in structure with NAT where no fertilisers and fuels are applied.

ORG regime shows out farm GHG emission level a little bit less than CON, except for some years or the structure with ARA (as ARA+ZOO or NAT+ARA).

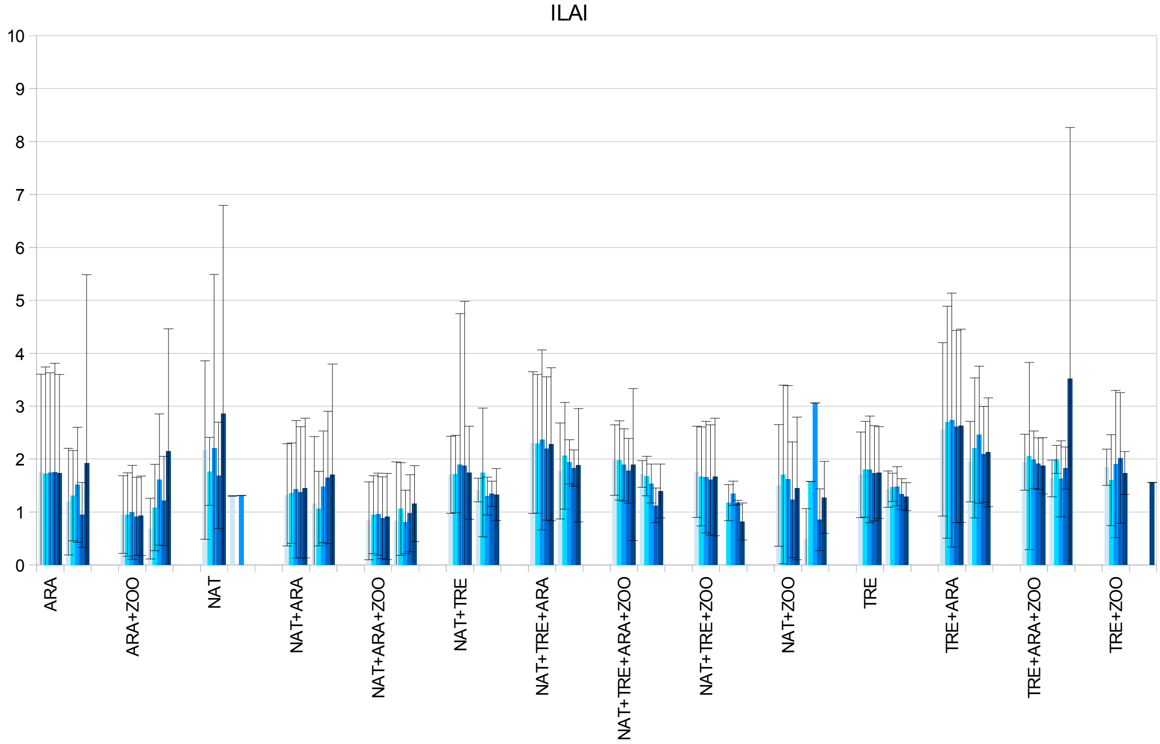


Figure 3.7: the histogram reports average of indicator level for ilai (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

In the following figures 3.8 and 3.9, the behaviours of *iccs* and *iint* are reported.
The trends of *iccs* are strictly linked with farm structure. But it is possible to individuate a different trend among regimes. For structures with ARA (ARA, ARA+ZOO, NAT+ARA, NAT+ARA+ZOO) ORG shows less level of sensibility at climate change than CON. For structures with TRE is the contrary. *iint* levels always record ORG with low crop intensity than CON.

This two indicators, as *NAT* and *IBDL*, have fixed variation boundaries, however in the *iint* case it is possible to argue something more about types of crops. ORG might considers more forages than CON which have less value in terms of crop intensity as the figure 3.9 reports. Similar approach could be taken into account also for ORG orchards which can considers olive and citrus trees, but with less difference among regimes.

In the figure 3.10 *iler* behaviour is reported. This indicator considers also farm slope and this aspect must be taken into account analysing chart.

ORG reports worse performance than CON for structures with ARA as ARA, ARA+ZOO and NAT+ARA. As farm structures reported, the ORG farms are more common in gently slope (G2), so worse performance is correlated with farm location and not with real worse practices from a view point of soil conservation. This indicator shows importance of farm context and environmental conditions to develop rational comparisons among farms.

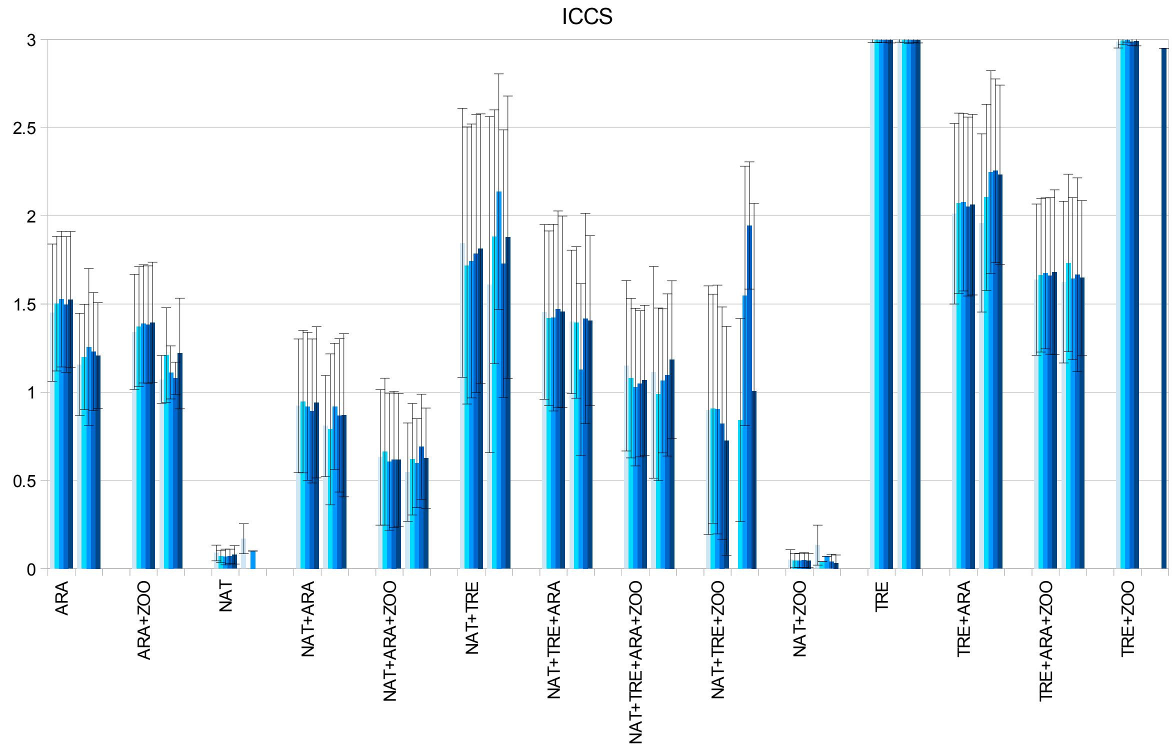


Figure 3.8: the histogram reports average of indicator level for iccs (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

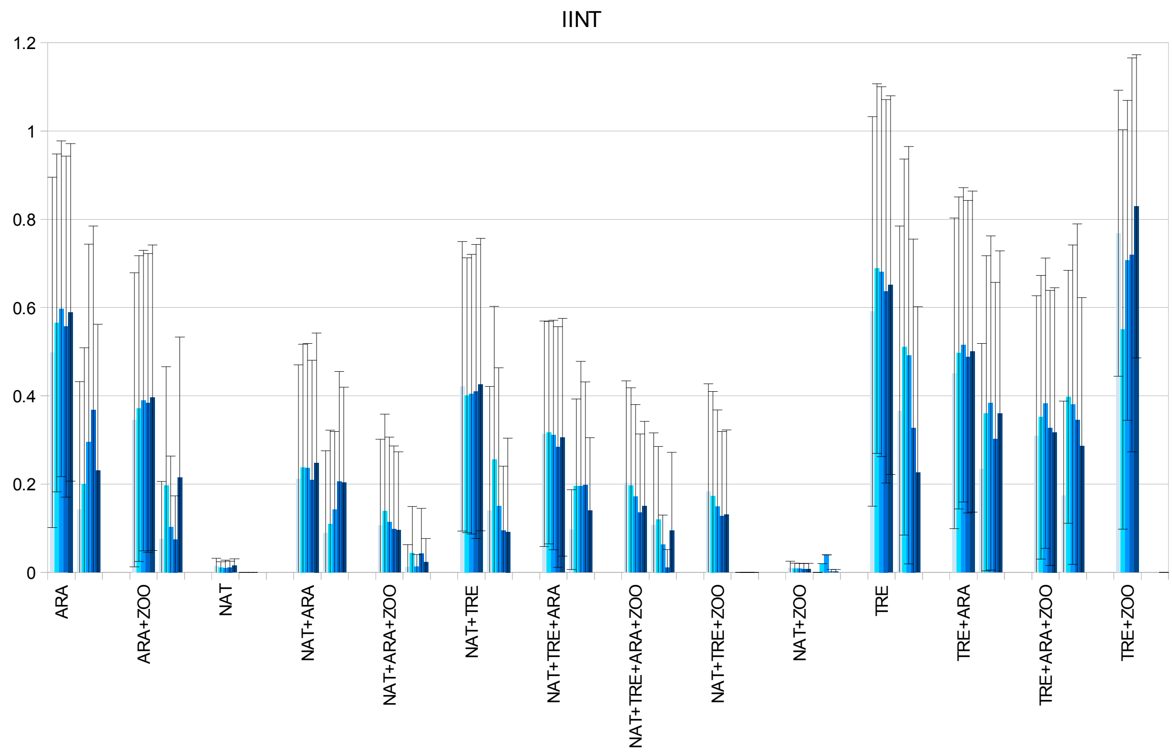


Figure 3.9: the histogram reports average of indicator level for iint (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

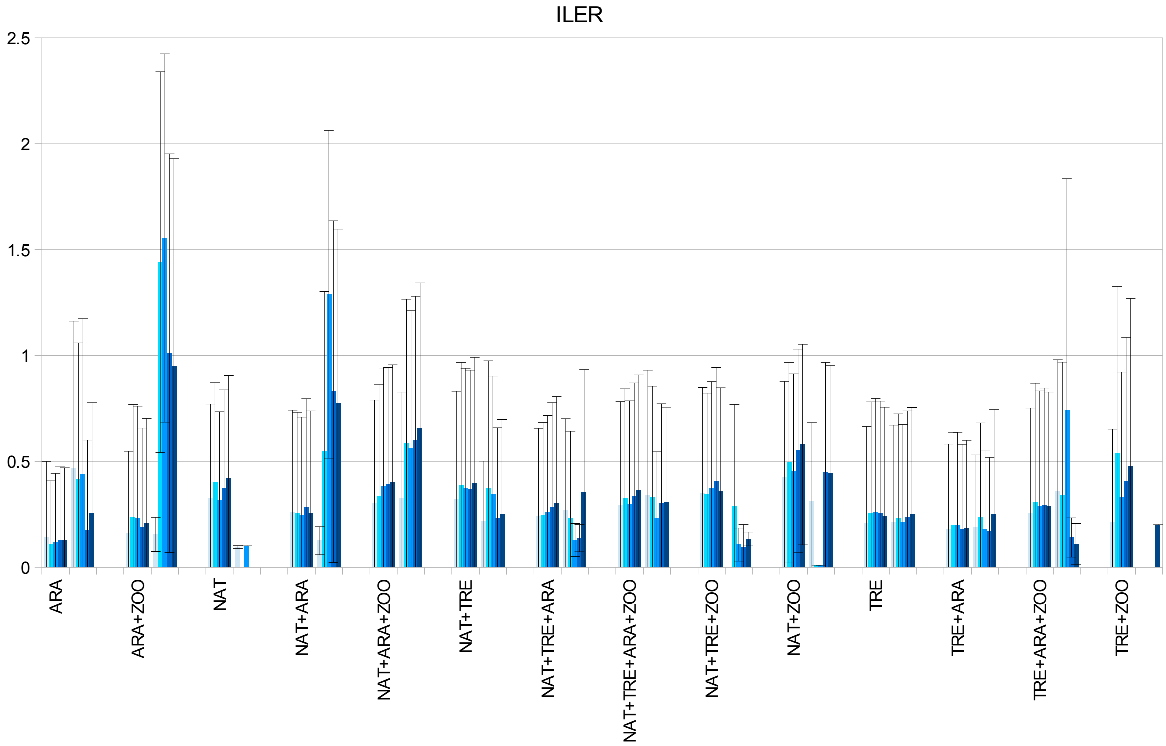


Figure 3.10: the histogram reports average of indicator level for iler (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

In the following charts 3.11 and 3.12, *ipcl* and *ipfl* behaviours show defined trends.

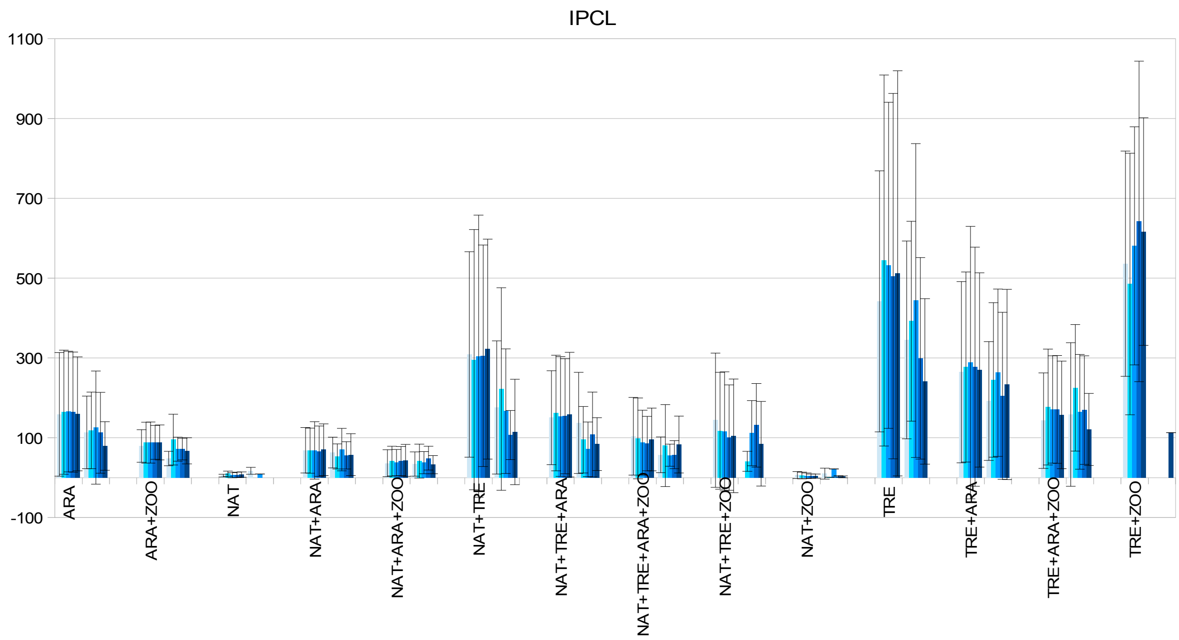


Figure 3.11: the histogram reports average of indicator level for ipcl (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

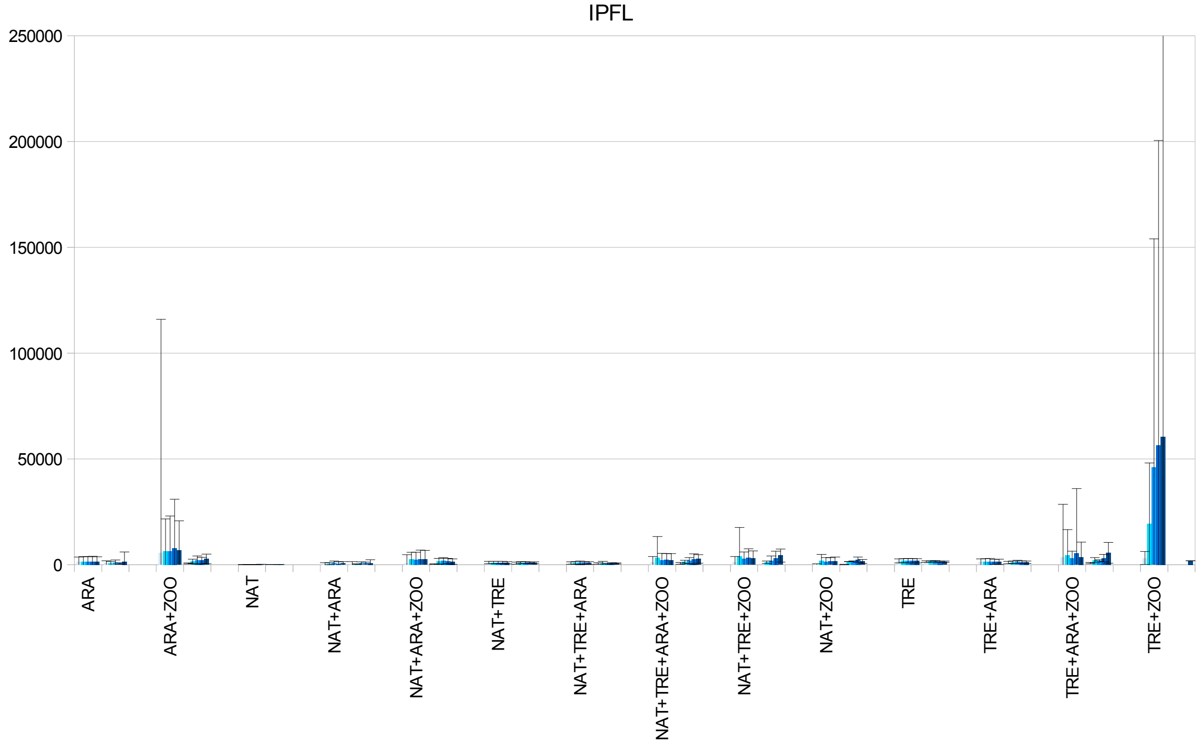


Figure 3.12: the histogram reports average of indicator level for ipfl (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

ipcl records a strong trend among macro activities. TRE is one that required more fertiliser expenses. Relations among regimes are not so evident except for TRE+ZOO where number of sampled farms deeply affected comparison.

On other hand, *ipfl* reports huge variability among structures with high level in farms with husbandry as ARA+ZOO, TRE+ZOO and TRE+ARA+ZOO. The same trend is records by *ilab* and also in this case ORG does not report this huge amount of fuel consumption. Also other CON structures as NAT+ARA+ZOO or NAT+ZOO record levels of fossil fuel consumption similar to other structures. It could means that intensive husbandry, which is present only in CON farms, interest only structures with high variability in terms of *ilab* and *ipfl*.

In the following two charts (figure 3.13 and 3.14) last indicators are reported. *inpl* is dependent from presence of husbandry for manure and *isdz* could be calculated only for structures with ZOO. *isdz* reports a potential connection among presence of ARA and ZOO where a part of feeding is always produced in farm (if it is possible, not for NAT+ZOO and NAT+TRE+ZOO). Indeed this is a MAD optimisation of animal feeding with fixed crops described by FADN database. So this could be a realistic simulation. In other hand MAD does not taken into account pasture as source of feeding.

At this level of details these indicators do not report variability among structures or regimes, but sometimes towards years.

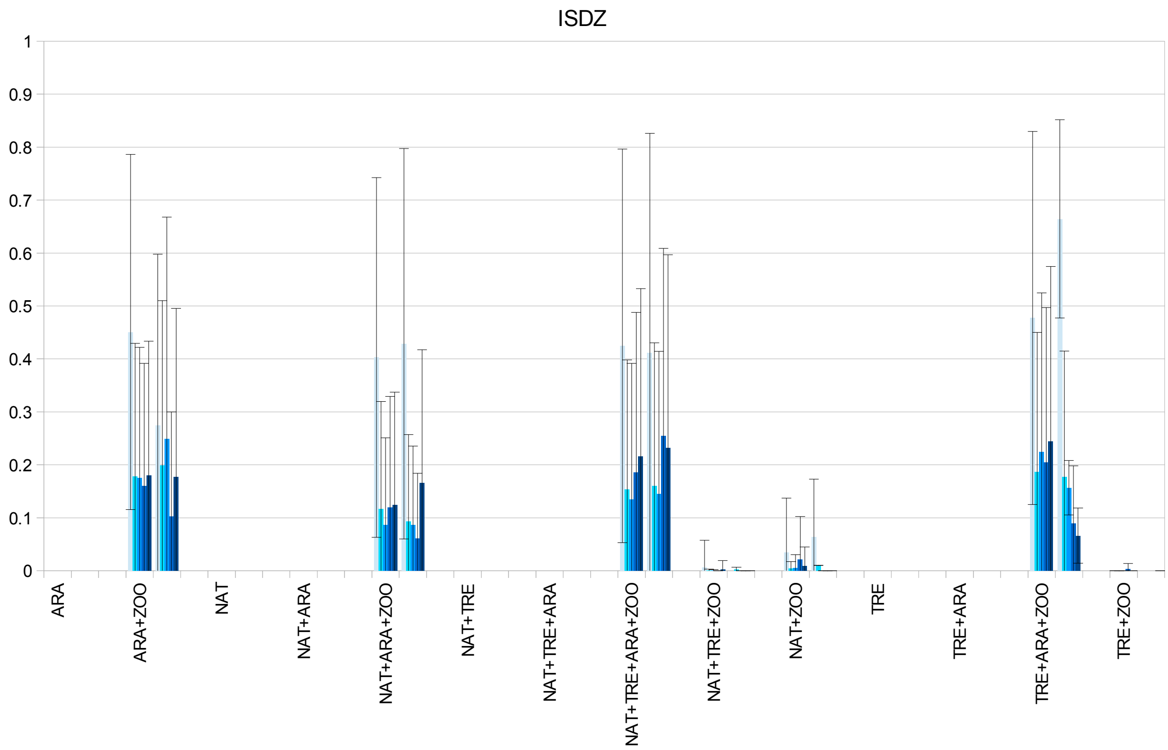


Figure 3.13: the histogram reports average of indicator level for isdz (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

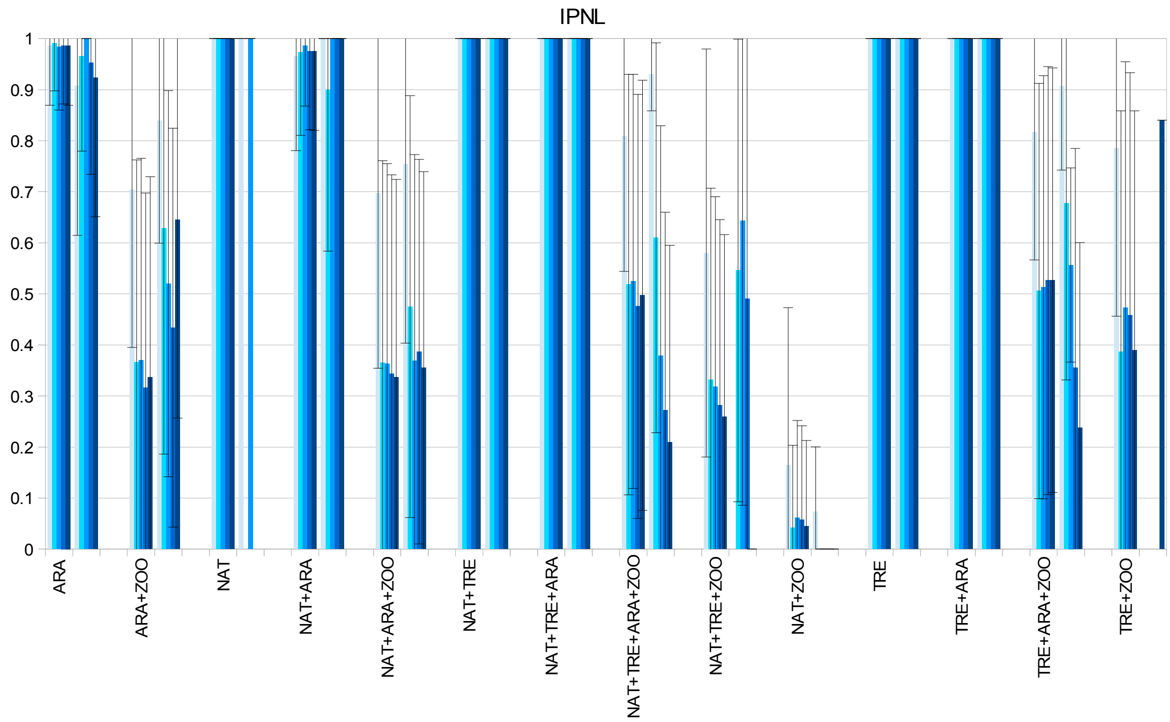
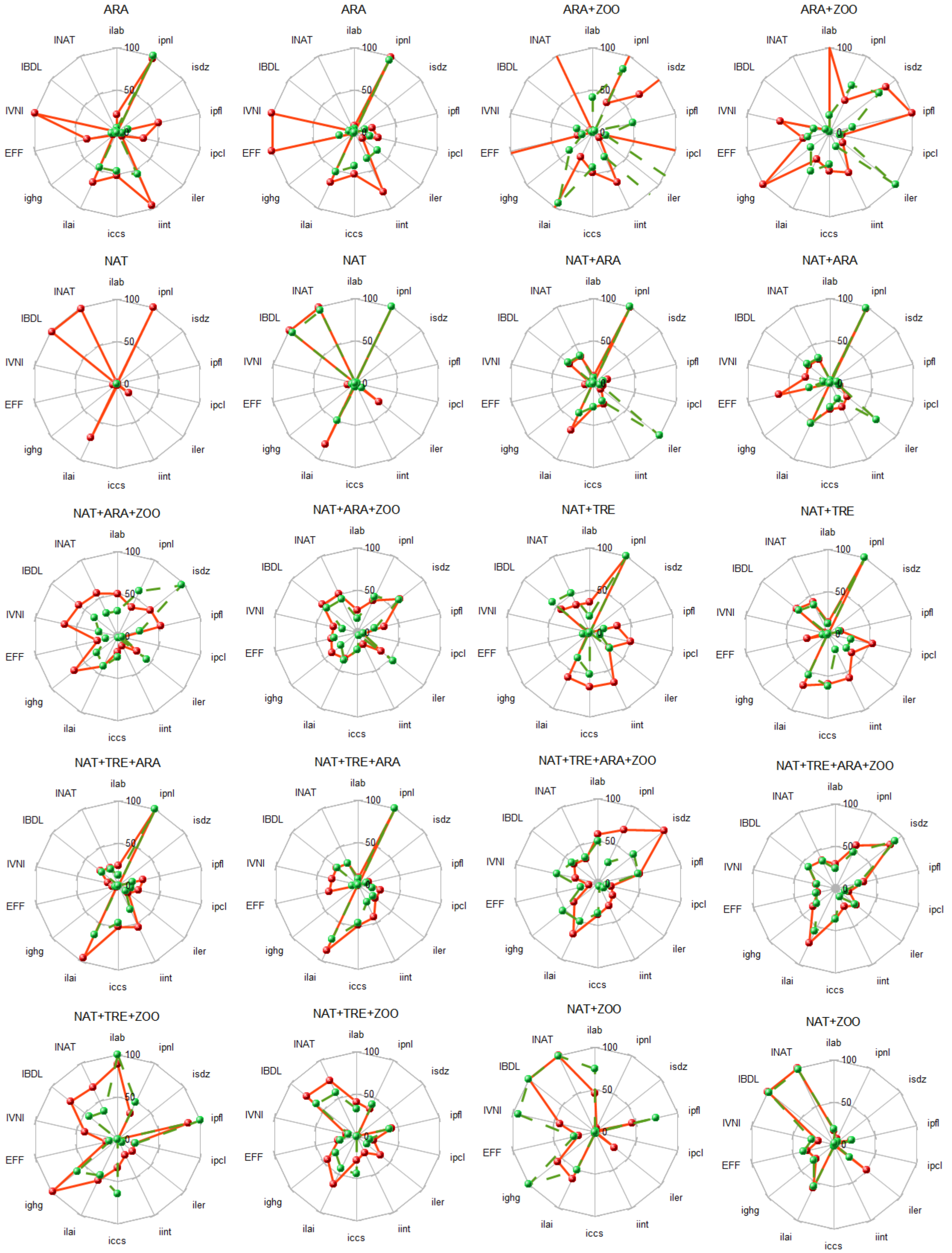


Figure 3.14: the histogram reports average of indicator level for ipnl (and standard deviation) in each year and structure. Each structure is described by two groups of bars: on the left side there are bars related to CON structures, on the right side there are bars related with ORG ones.

3.4.2 Farm structure and complete indicator performance

In the following figure (3.15 a) the performances of all farm structures are reported separated by regimes.



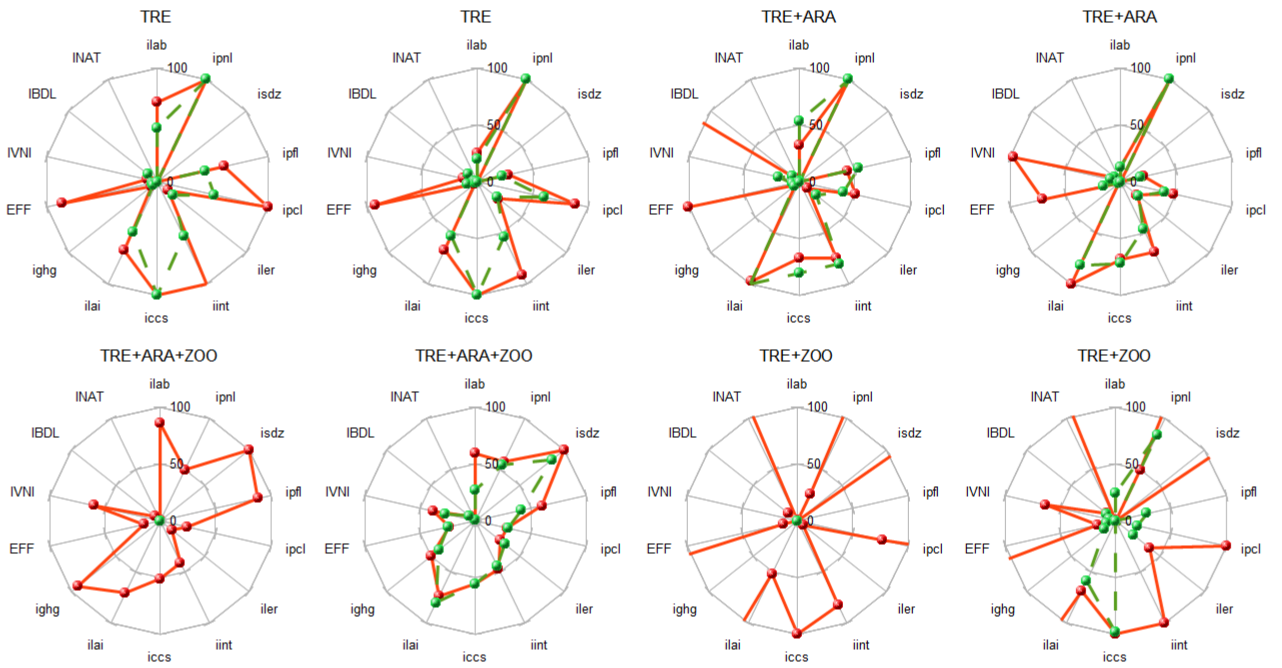


Figure 3.15: each farm structure performance is reported in the radar charts. Each chart shows CON in red and ORG in green. The values of each indicators are reported in terms of percentage. Each structure is described by two charts, in the left one only stable farms are considered; in the right one all farms of that structure are considered.

It is not easy to report all indicator behaviours in the same chart because some of them present huge variability among structures as previous described. For each structures are reported two charts. On the left side are reported only farms with stable structure sampled 5 and for 4 years (2008-2011). It means to always consider the same farm pool each year (except for 2007) with purpose to reduce variability among farm sampling inside and between years. But ORG samples, which are less numerous than CON ones, sometimes count only few farms or also nones. For this reason in the right side charts all recorded farms are considered.

In the figures 3.15 all axis of the same indicator and the same farm pool (stable or all farms) have the same value range. But value ranges are different for each indicator. So it is possible to compare on one hand all charts which refer to stable farms to them-self, in other hand all charts which refer to all farms to them-self.

Extreme values are not considered to better describe major part of structures. They are recorded for several indicators in both farm pools (*ilab, IVNI, ighg, iler, ipfl*). They are attributed in general in CON structures with ZOO, only *iler* refers to ORG ARA+ZOO. It is possible to recognise these extreme values because the spots are not inside chart and line is broken.

Starting to describe this data, farm structures performance are really dependent from presence or absence of super activity as also previous charts have shown. The performances with extreme or high values are reported for specialised structures with only one super activity as TRE, NAT and ARA. This trend is reinforced in structures with just one type of land cover plus ZOO (as TRE+ZOO, ARA+ZOO).

On the other hand, the presence of ZOO does not mean high or extreme values in no specialised structures as NAT+ARA+ZOO or NAT+TRE+ARA+ZOO and, less evident, also in

NAT+TRE+ZOO or TRE+ARA+ZOO. For these structures major part of indicators records intermediate levels.

Comparing fixed farm pools with whole farm pools, few differences emerge. All farm structures report only one or two indicators really different (except for ARA+ZOO). This suggests high variability inside also stable farms (in terms of regime and structure) which affects comparisons among structures at national level.

Maybe also for this reason differences among regimes are not so evident. In a general overview a specific trend is not recognisable. In some farm structures ORG shows better performance than CON for environmental aspects as in TRE+ZOO and TRE. But in other farm structures some indicators record worse performance in ORG regime as TRE+ARA.

Also economical areas does not record unilateral trend. TRE, TRE+ARA and ARA show better performances in terms of *INVI* and *EFF* in CON than ORG. In other hand NAT+ZOO and NAT+TRE+ARA+ZOO record the contrary. In the other structures the performances are quite similar ot each regime.

3.5 Specific comparisons among regimes

The two previous analysis underline the presence of high variability inside farm structure. Sometimes it is higher than variability among structures for some indicators. To reduce this variability farm typologies have been analysed at more detail levels. Slope, phyto-climatic zone and regime preset only one level of detail, but farm structure and location could be described by some levels of detail.

Farm location is considered at municipality level to reduce variability among farm context. Farm structures are detailed at macro activity level. Specific selected comparisons count more than 2 farm sample for each regimes. It is possible that one comparison counts only one farm in a regime because that farm has been sampled three or more times during the years. Each sample is considered as replica or different farm. These farms are described by the same municipality, slope, phyto-climatic zone and by the same exact presence/absence of macro activities.

Moreover also amount of surface is considered and must be similar among farms of the same comparison. Indeed small farms with less than 1 hectare return misrepresented values. ISTAT classes of surfaces are considered as described in chapter 2.2.1.

42 comparisons are selected which describe only 2 farm structures: ARA and TRE are reported in figure 3.16. Also results of this analysis show variability which does not permit to identify a specific trend among regimes.

In the charts the differences among ORG and CON indicator levels are reported in terms of percentage respect CON level. The bars above 0 on y axis describe higher indicator level in ORG regime; the bars under 0 on y axis describe higher indicator level in CON regime.

These results try to investigate if high general variability, observed in previous analysis, is most relevant inside or among regimes and structures. Some indicators (*INAT*, *iler*, *iccs*, *ipnl*) do not report difference among regimes in any case or just in one two of them. For this reason they are not reported in figure 3.16.

Also for other indicators several comparisons do not report difference among regimes. Moreover farm pools of comparison usually do not overcome 10 farms for both regimes. It means that calculated average is not so stable and each farm could be strongly affected final value. However charts suggest soft trend in some cases.

ARA structure reports best performance in ORG regime in 4 comparisons to 5 for *ighg, ipcl* and *ipfl.* Especially for first two mentioned indicators, ORG regime records sensible difference in terms of 10-30% of reduction of GHG emission and phytopharmacy expense. Differences are not described for *iint* and also *IVNI* reports similar level of net revenue. It is interesting because *EFF* behaviour is really variable among ARA comparisons. This suggests a potential economical similarity between the two regimes achieved in different way.

TRE structures report more variability among comparisons than ARA. However also in this case some soft trends could be suggested. In contrary respect ARA, GHG emission on TRE is higher in ORG regime of 5-15% two times on three. Also efficiency is lower in ORG than CON regime in the same proportion. Moreover *iint* indicator quite always shows best performances in CON.

Other indicators do not record clear trends. Geographical, environmental, and farm size gradients are considered, but nones of them show more clear trends.

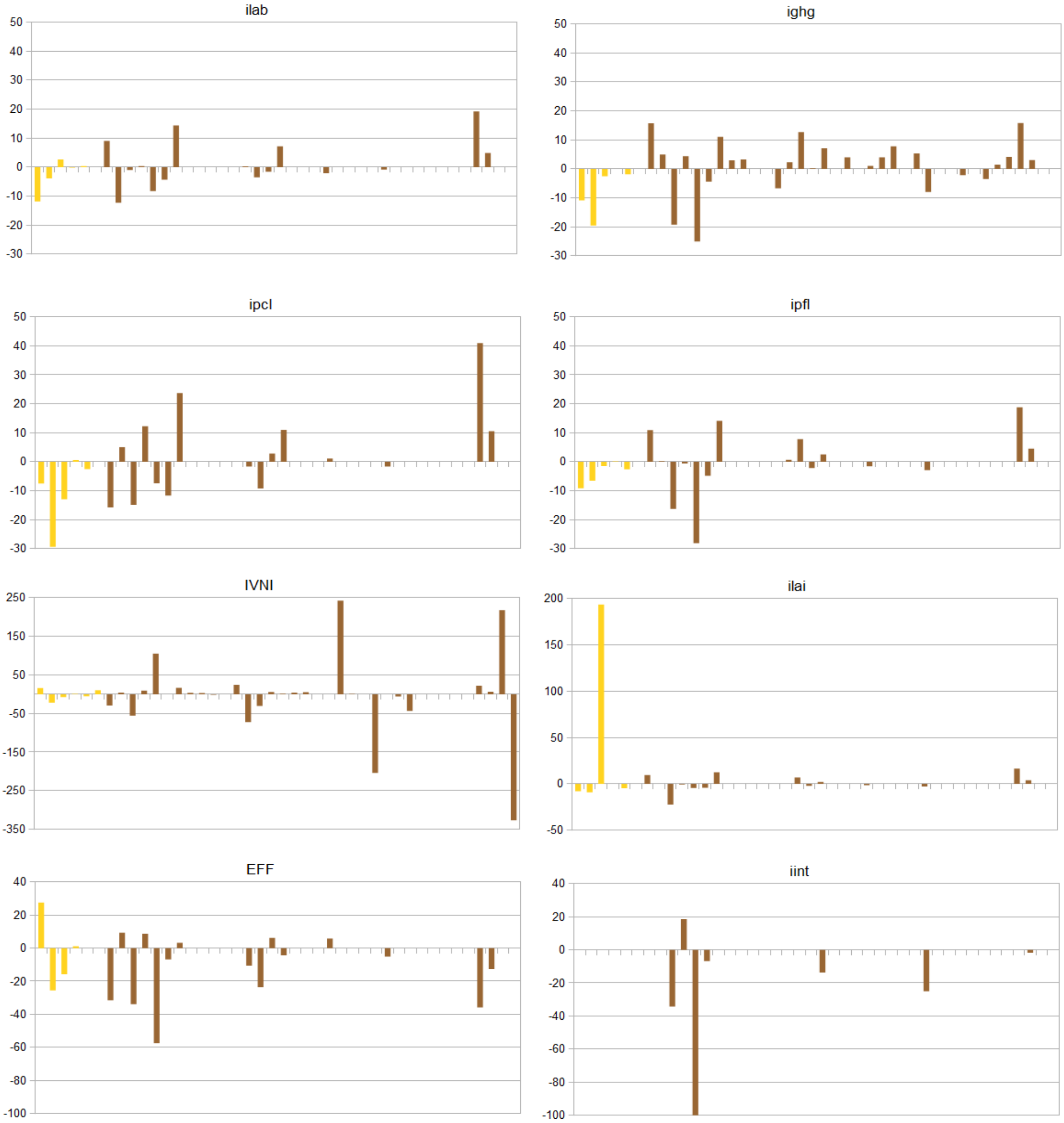


Figure 3.16: each chart reports behaviour of one indicator for ARA (yellow) and TRE (brown). Each bar represents one of the 42 comparisons. Values report difference between ORG and CON indicator level in term of percentage referred to CON value. The order of indicators considers value ranges of y axis.

4. Analysis of arable fields

4.1 Introduction

Arable lands are an interesting part of farms. They are the agricultural practice most malleable on farm respect orchards, natural areas or husbandry. Indeed each year farmer can operate changes on fields. For this reason arable lands and their management might be taken into account especially in short time prospective to develop more sustainable agriculture than nowadays one.

In the past, manure and crop rotations are the key to maintenance of soil fertility. Nowadays the out farm inputs allows to maintain high level of production in other ways.

These changes have consequence in terms of surrounding farm context quality, sustainability aspects and market dependence (as described in previous chapters).

The organic regime establishes several restrictions for usage of these out farm inputs. So it is necessary to take again into account crop rotations or other practices which preserve and increase soil fertility correlated with level of soil organic matter. Moreover, a crop alternation contrasts weeds and crop diseases which are not promoted by environmental changes.

For all these aspects crop rotations are an interesting topic especially for agronomist. However few materials about them are available. A lot of studies describe experimental crop rotations to evaluate crop yield, nutrient balance and organic matter level in the soil. But analysis at territorial scale are not abundant, especially for Italian case study. The main reason is lack of data. For these reasons large source of FADN information could be a way to investigate crop rotations using real field data at national level. On the other hand could be possible to correlate crop rotations with other information collected by FADN as farm structure, context information, amount of husbandry, ect.

But FADN does not immediately reveal crop rotations and data must be interpreted. FADN data reports amount of each crop surface, but no geographical location. So it is impossible create temporal relation among crops if more than one are present in the same farm.

Indeed is not a coincidence that other methods to analyse crop rotation or land cover dynamics consider other sort of data. In France Teruti data is used to analyse land cover dynamics since several years. Teruti data is a national grid of geo referenced points sampled all years since 1980s which describe land covers. So Teruti data is an historical database. From this source crop successions could be analysed in time and space. One example of this method is described by Mari (Mari & Benoit, 2010).

On the other hand, type of land covers, considered by Teruti data, are generally less detailed than FADN. Moreover farm boundaries are not considered. So crop alternation in time is just a succession and not a specific crop rotation developed by farmer on defined surface.

Land cadastre parcels, which receive Common Agricultural Policy (CAP) subsidies, are another data source to analyse crop rotations (Inan et al., 2010). In this case an agronomical entity is considered: the parcel. Also historic path is available for several years. This type of data is more similar to FADN information, but it reports more detailed. The parcels are geo referenced and at each farm many parcels could be attributed.

But also in this case historical path for each parcel is not guaranteed. Indeed one parcel can consider several crops because to create a new parcel one physical element of separation is required as a street, a river or a tree row. But if this physical separation does not exist all crops are collected together with the same problem of crop succession uncertainty which FADN presents. In the figure 4.1 are reported several spatial concepts linked with arable lands.

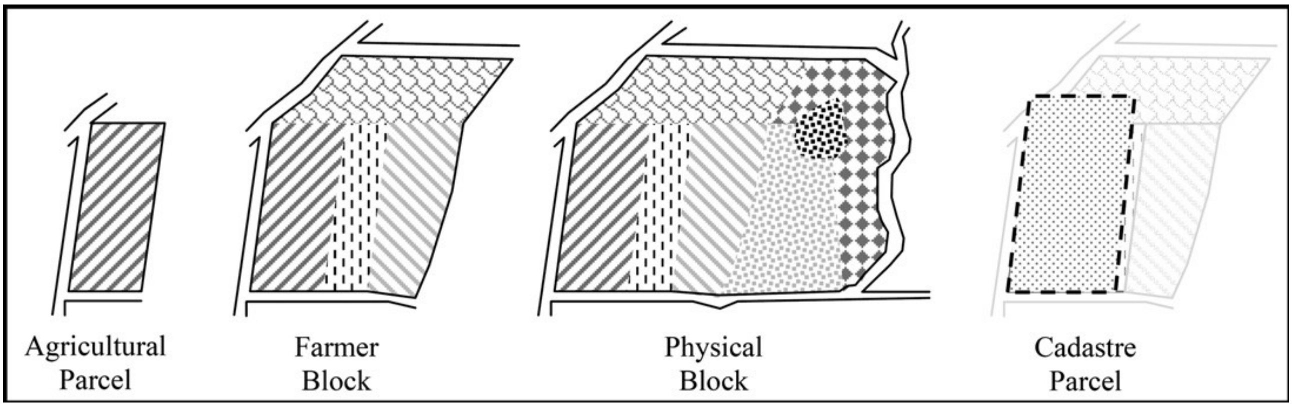


Figure 4.1: several types of land unit are reported (Inan et al., 2010).

One approach has been developed to create the historical crop succession. Only parcels with one crop at starting time of analysis are considered. So, if during the analysed period, parcel counts several crops first succession is defined. But defining this succession become more difficult at each new crop pattern change. Also amount of surfaces and satellite pictures are taken into account to try to geo reference crops. But often it is not possible to be sure of crop successions.

4.2 Spatial approach

To overcome previous mentioned complexities a spatial approach has been developed. This approach is based on some aspects:

- All arable lands of farm are managed in a unique way
- Spatial ratio among crops correspond at temporal ratio among crops in a crop succession
- Crop rotations could be grouped in rotational schemes
- Farm might show the same rotational scheme at least for number of year equal to class ratio.

This approach solves uncertainty of crop sequences considering whole amount of surfaces as a unique rotational scheme. So historical path connects rotational scheme and not single crops. It is based on the assumption that all arable surfaces are connected by the same rotational scheme. This first hypothesis is supported by farmer choices which manage all farm surfaces. So it is credible that farmer adopts only one arable land management, especially for farms with small or medium amount of surfaces.

This hypothesis converts classic crop rotation conception from time to space. In the classic historical approach whole surface is covered by one crop which in the following years are replaced by other crop. In this approach only one crop is grown each year. In spatial approach all crops are present at the same time, but they cover different amount of surfaces.

This approach allows to farmer to diversified crops on field. It is a useful aspect from economical and environmental viewpoints. A classic crop rotation considers one or more years where entire field is planted with no remunerative crop which, on the other hand, restores soil fertility. It means that only some years farmer can plant remunerative crops and it is a risk, especially in a global market so affected by price fluctuations. With a spatial approach a fixed part of surface is destined at each crop of rotation, so farm production is stable in time.

On other hand if all production is based on one crop, the weakness of crop is the weakness of all production. If extreme events appear during sensible phase of crop develop, all production is potentially compromised. But if production is based on several crops, their weaknesses do not coincide in the same time. So it is difficult that whole production are destroyed by few extreme phenomenons.

The third hypothesis suggests presence of crop rotation groups denominated rotational schemes. Rotational schemes are a simple ratio among class of crops which describe quite homogeneous pool of crop rotations. Rotational schemes could be interpreted with both temporal and spatial approaches. For this study classes of crops describe groups of crops which are similar in terms of nutrient demand and soil disturbance.

In the figure 4.2 an example of FADN data, its codification in rotational schemes and temporal and spatial approaches are reported.

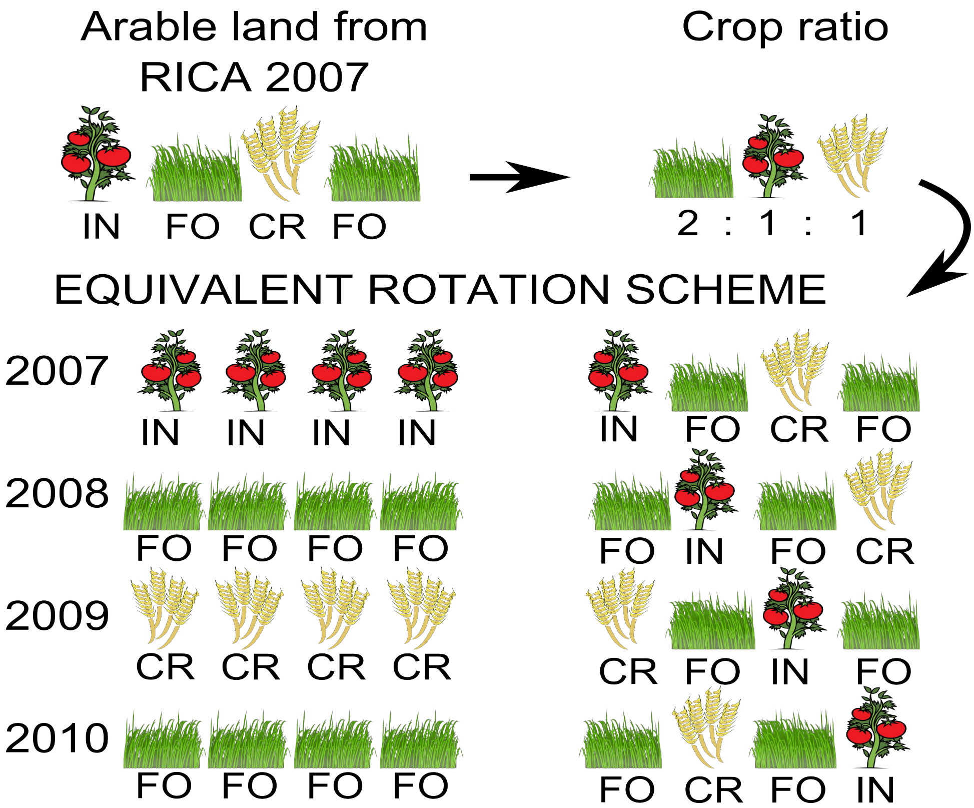


Figure 4.2: in the figure explanation of approaches to crop rotations are illustrated. In the upper part of the figure an example of FADN data is reported and how it is interpreted in a rotational schemes. In the below part of the figure in the left side rotational scheme is developed with temporal approach, in the right side it is developed with spatial approach (Albertazzi et al., 2012).

As figure 4.2 shows, spatial approach and its hypothesis are verified if rotational scheme is sampled at least for a time period defined by sum of crop ratio. Considering example of the figure 4.2, if this rotational scheme with ratio 2:1:1 is recorded less than 4 years (2+1+1=4) spatial approach is not valid. The reason is that rotational scheme has not enough time to be completely developed. If this case will be recorded it could mean an incorrect interpretation of rotational scheme or no validity of spatial approach for that arable land.

4.3 Materials and method

Also for this analysis RICA data for years 2007-2011 are considered. Arable crops are separated in the same classes described in table 2.3 which are used to develop farm structures. Only one extension is considered: set a side surfaces (TR) are added as macro activities of arable lands.

A simple selection of farms is operated. Only farms with arable surfaces are considered without more selection. Arable surfaces with more than 5% of area covers by crops not considered have been classified as arable lands not analysed (OTHER). In this chapter the term "farm" will be used to define only RICA farms with arable land surfaces since here.

To define rotational scheme these crop classes are used. The ration among classes considers only macro activities which cover more than 10% of whole arable surfaces. With this constraint maximum rotational scheme considers a ratio of 1:10 with spatial approaches and 10 years long rotation with temporal approach. To maintain conformity between spatial and temporal approaches class ratio has been forced to consider only integer numbers which correspond at entire period of one year.

Using unique farm identity code historical path of each arable land is created, where FADN samples allow it. Also farm structure, phyto-climatic zone and slope information is added for the last analysis. Only for this pool of arable lands, farms without this information are neglected.

4.4 Results of arable field analysis

In this chapter several types of results are reported. A preliminary analysis describes amount of arable lands considered for the follower analysis and also the distributions of some farm aspects are described. Then the most common rotational schemes will be reported at national level. After that, the historical analysis investigates several aspects of spatial approach to compare it to temporal one. Finally, the arable land records will be analysed separated by farm structures and types of environmental farm context.

4.4.1 Descriptions and distributions

4.4.1.1 Distribution of arable lands among years

In figure 4.3 the distributions of arable lands are reported for each year and regime. Data is referred to each single arable land sampled by RICA database so historical aspect is not taken into account.

As shown in the above figure, this analysis considers the major part of arable land for each regime and year. Only arable lands of MIX regime, which describe farms with intermediate level of organic practices, are completely neglected. A number of arable lands neglected so little supports crop classification adopted for analysis of arable surfaces and farm structures. Indeed other crops are never relevant presence at national level.

The histogram also shows high differences in terms of arable land number among CON and ORG which could affected result comparisons.

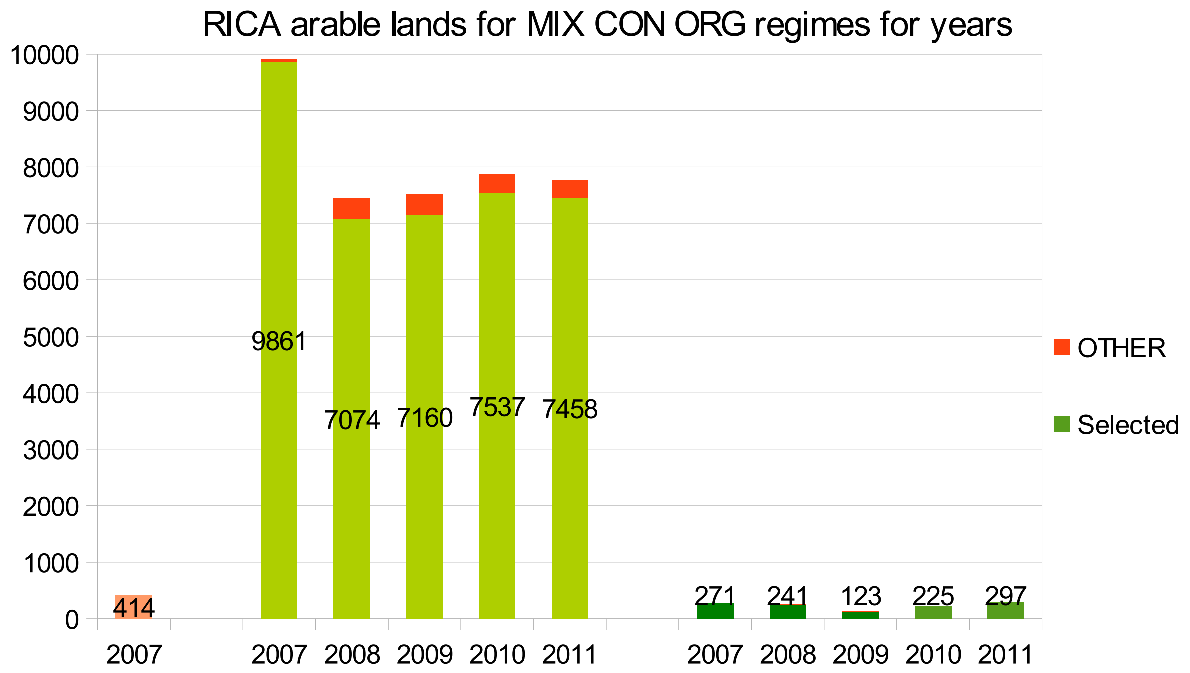


Figure 4.3: distributions of arable lands in terms of number of arable lands. The bars are grouped in 3 regimes, on the left side MIX is reported (only for year 2007); in the middle CON and in the right side ORG is shown. Each bar is divided in 2 parts: the lower one describes arable lands considered for analysis; the upper part reports arable lands covered by other crops (MIX has only this types of arable lands).

4.4.1.2 Descriptions of farms with arable lands

The previous analysis reports 40247 selected arable lands for a total amount of 15330 farms. In this part that farms are described to individuate which ones can be analysed by historical viewpoint. The first step is to create sequence of sampled arable lands for each farm and recording wide of sample period (from 1 to 5 years).

Then farms with a sample period wider than 1 year, must be respect some constraints to not altered final results. Indeed farms with no homogeneous regime for whole period are not considered because regime transition might affected farmer crop selection. Also farms with variability of arable land surfaces among years are neglected. The reason is that these variations should affected rotational scheme identification.

The wide sample period, regime variability and arable surfaces variability are reported for each farms in figure 4.4.

The first pie chart shows that 1 farm on 3 is sampled just once. The other farms are distributed among sample period with a trend which gently decrease wih wide of sample period. However the period of 5 years records the largest number of farms among multi-year periods.

The second pie chart records high level of regime stability. More than 97% of farms reports the same regime for all sample period. This result should be affected by high presence of farms sampled one year which have forcedly a homogeneous regime. But also not considering them the farms with homogeneous regime for all sample period are more than 95%. It suggests high farm stability in terms of adopted regime.

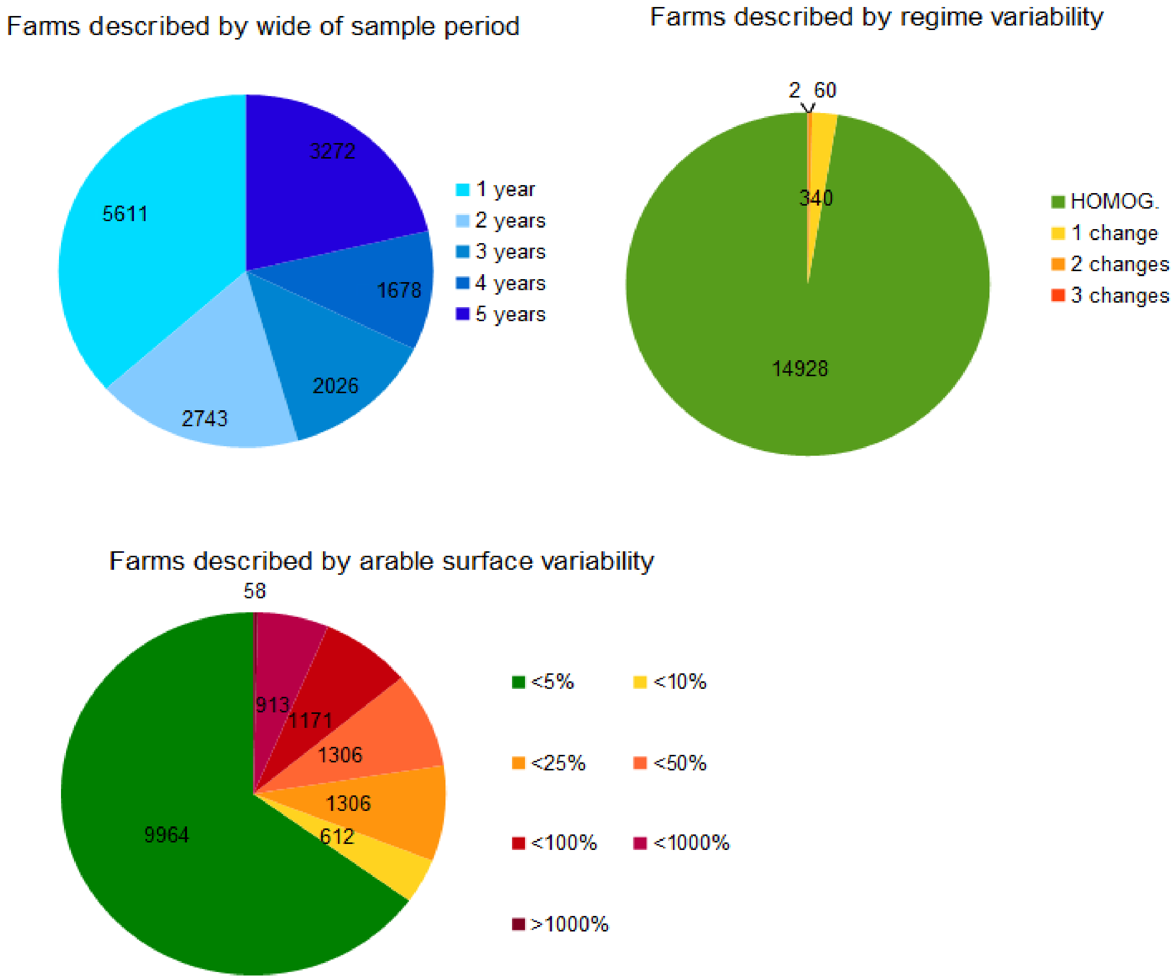
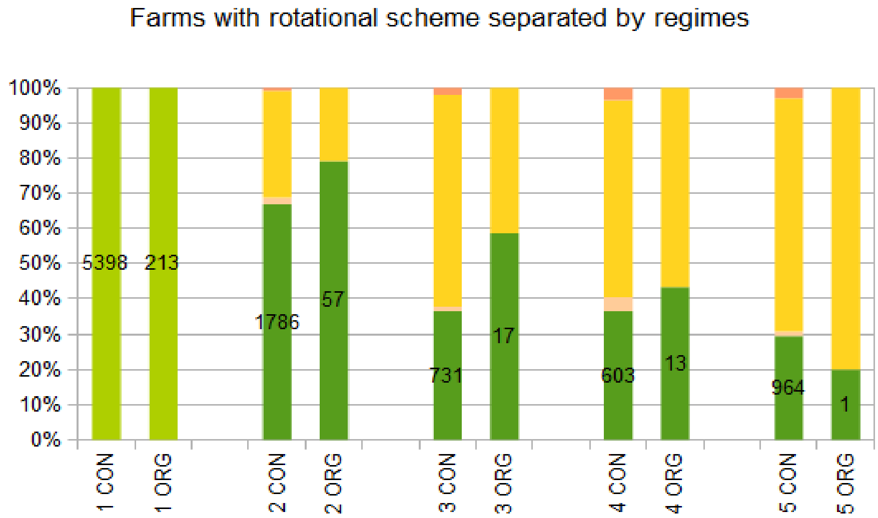


Figure 4.4: wide of sample period, regime variability and arable surfaces variability distributions are reported in terms of farm numbers (farms with other crops are not considered.) The legends are next respective pie chart.

The third pie chart reports distribution of arable surface variability classes in terms of percentage. The arable surfaces of the same farm have been compared in all chances in terms of percentage value. The highest recorded percentage has been used to describe arable surface variability of each farm. A variability under 5% is not considered to affected in relevant way the identification of rotational schemes. The farms with higher levels of variability are neglected. They are 1 farm on 3 in general. However if only farms with multi-year periods are taken into account, the farms with stable amount of arable surface are near 45%. This unexpected phenomenon halves suitable farm number for historical analysis, with consequence in terms of result representativeness (especially for ORG regime).

4.4.1.3 Farms and arable lands selected for analysis

By combining all previous mentioned aspects, it is possible to define two farm pools. The first one counts farms sampled 1 year and it has been used to individuate the most common rotational schemes (R.S. analysis). The second farm pool considers farms sampled more than once which are stable in terms of arable surface and regime for all period. In the figure 4.5 both farm pools are described in terms of farm and arable land numbers.



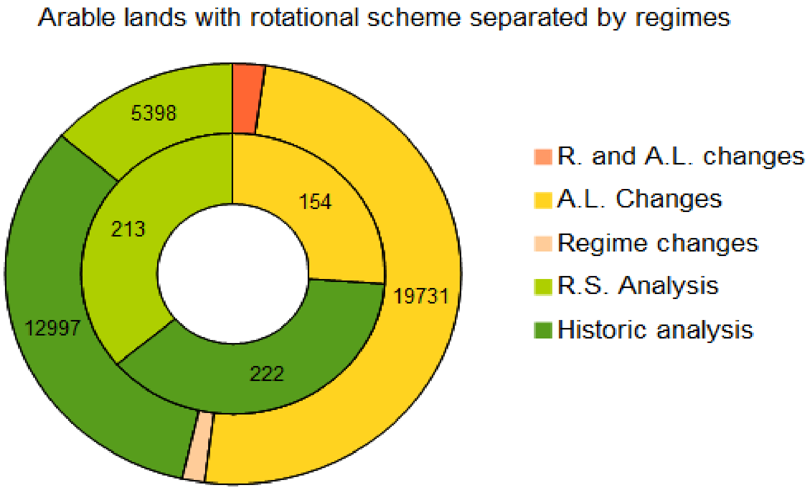


Figure 4.5: in the histogram distribution and description of farms are reported separated by regime and wide of sample period. In the pie chart total amount of arable field with a rotational scheme is reported. Arable field are separated by regime (CON is circle external, ORG is inner circle) and farm description. The same legend, which is in the lower right side, describes both chart.

In the histogram it is possible to define a decrease of selected farms at increase of sample period wide. The major part of neglected farms record arable land variability, as previous analysis might suggest. In the pie chart ORG reports high percentage of arable lands selected for analysis. Indeed only 1 arable land on 3 is neglected. In CON this ratio rise at 1 neglected farm on 2. It suggests a high stability of ORG arable fields.

4.4.2 Rotational scheme results

All farms sampled once have been considered to individuate the most common rotational schemes. Indeed if spatial approach is correct, all sample reports rotational scheme applied on field for several year (as spatial approach definition explains). The analysed arable fields record 216 rotational schemes for CON regime and 36 for ORG one. Each rotational scheme has been described by an average of 25 arable lands for CON regime and 6 arable lands for ORG one. The figure 4.6 reports all Italian rotational schemes in term of arable land number.

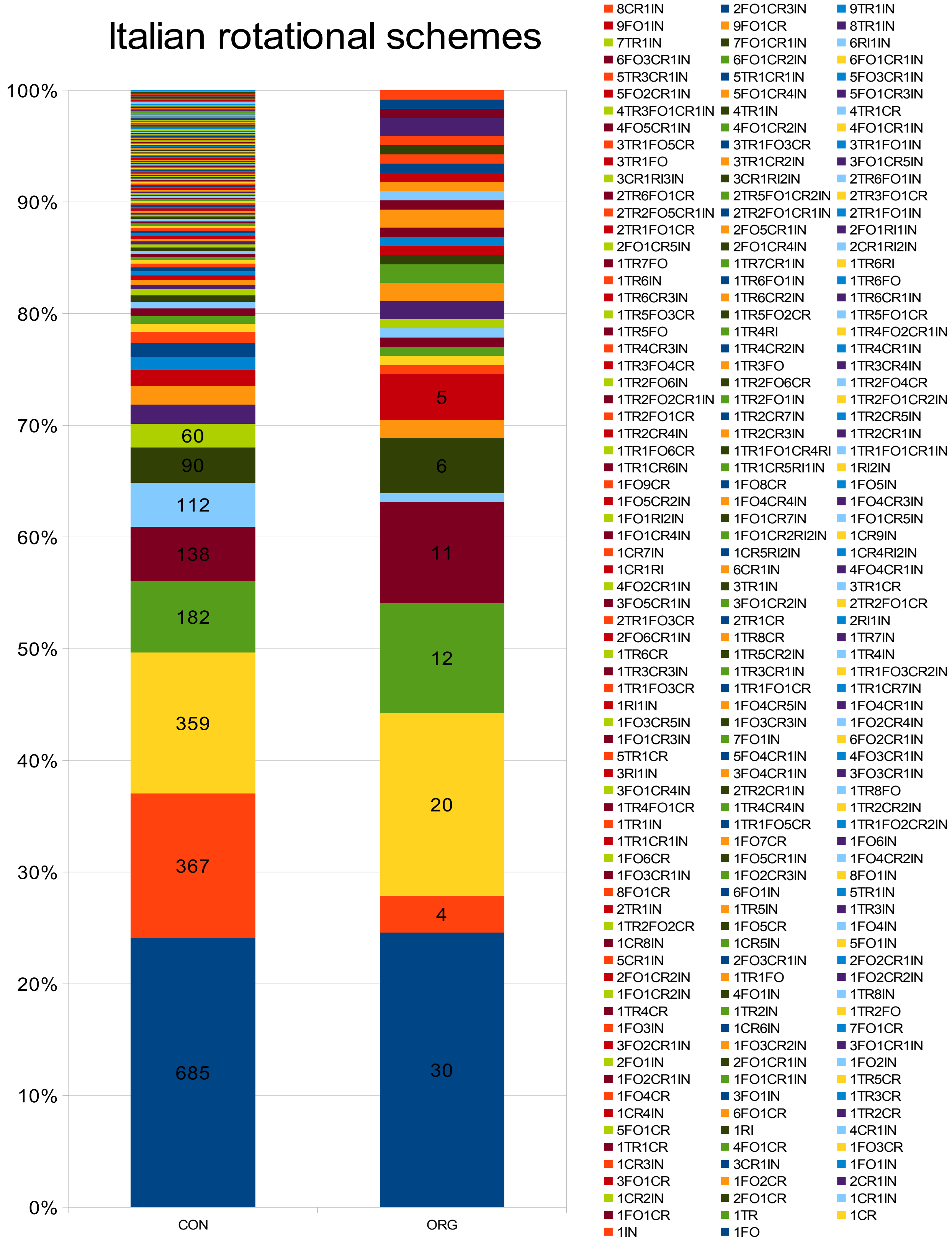


Figure 4.6: all rotational schemes are reported in term of percentage separated by regime.

The histogram reports strongly similar distribution for CON and ORG regimes. The 4 most common rotational schemes are 4 continuous crops (FO, IN, CR and TR) and they describe near 55% of arable lands for both regimes. Considering the next 4 most common rotational schemes, described arable lands are near 70% for both regimes. They are 4 simple rotational schemes which consider only two macro activities with low values of ratio: 1FO1CR, 1CR1IN, 2FO1CR 1CR2IN for CON and also 3FO1CR for ORG.

These results underline two aspects. On one hand rotational scheme identification coul be considered successful because it is able to describe arable lands in synthetic way. Indeed only 8 rotational schemes describe more than 70% of all arable lands.

On other hand, the most frequent rotational schemes are not similar to a classic crop rotation because they present only one crop. This could be a signal that farmers do not manage arable field with spatial approach. More over rotational schemes which describe continuous crops, are frequent also in ORG regime where excepted results should show rotation schemes similar to classic crop rotations with FO or set a side (TR). At more detailed analysis, ORG regimes records higher level of TR and rotational schemes with FO than CON, and continuous crops of IN are really less frequent than in CON regimes. This trend are in according with organic practices which limit out farm inputs.

4.4.3 Historical analysis

4.4.3.1 Analysis of unique arable land management on farm

The first hypothesis about spatial approach is that all arable surfaces of the same farm are managed in a unique rotational scheme. To investigate this aspects only ratio among crop classes is taken into account. If farmers manage the arable surfaces in different way for each field or parcel, it is probable that crop class ratio is not fixed in time. Otherwise, if crop class ratio remains stable in time first hypothesis of spatial approach is verified.

In this analysis crop classes are not considered. Indeed considering crop presence and ratio together means to add other level of uncertainty. If also crop presence are taken into account, a specific fixed rotational scheme have been investigated. But it is not the core of this analysis. For example it is possible to image an arable land which reports the rotational scheme 2FO1CR the first year and 2TR1IN the follower one. If only ratio is considered, the arable land is stable in time; indeed farmer manages all surfaces together changing all crops in the same time. In other hand if crop presence is considered, the same arable land is not stable in time, because rotational scheme stability is analysed and not found.

Previous aspect introduces another phenomenon which can affect stability of data sequences: the farm dynamics. In the previous mentioned example it is reported a variable data sequence. By considering sum of ratios each rotational scheme might be recorded for 3 consequentially years. For this reason at first sight it is not possible to apply spatial approach at this variable sequence. However it is not possible to establish when rotation scheme has been applied for the first time. It is possible that the 2 years before first sample describe the same rotational scheme (1FO2TR and 1FO2TR). From this viewpoint the variable sequence is not a case where spatial approach is not verified, but it is a record of a change of the arable land management.

For this reason the farm sequences are separated in 3 categories. The first category considers sequences with homogeneous ratio in time. The second one describes variable sequences which could record a change of arable land management. They are the sequences with only one change of ratio for all period. The sequences with more ratio changes are collected in the third category as variable ones. Indeed two or more ratio changes can not be considered management dynamics in these so short time sequences (from 2 to maximum 5 years).

In the following figure 4.7 distribution of these farm sequence categories is reported.

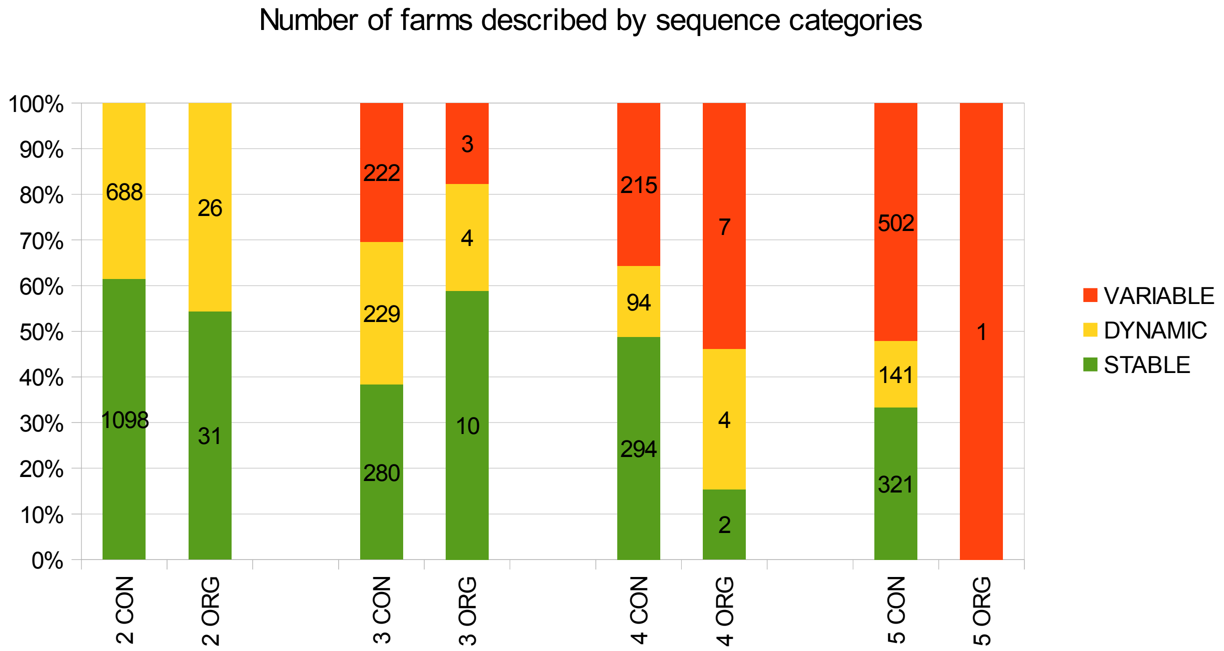


Figure 4.7: the histogram reports distributions of sequence categories separated by regime and wide of sample period.

The homogeneous sequences represent near 40-60% of all sequences of 2 and 3 years. The sequences of 4 and 5 years record respectively near 50% and 30% of CON stable sequences. For these sample periods levels of ORG stable sequences are lower than 15%.

From a general viewpoint unique management of arable land could be suggested for 1 to 2 farms on 3. Considering also dynamic sequences unique management could be suggested for half to whole pool of sample sequences (except for ORG in sampled period of 5 years).

4.4.3.2 Analysis of spatial versus temporal approach

In this part comparison among spatial versus temporal approach is investigated. The most common rotation schemes, which are individuated by previous analysis, are taken into account. The rotational schemes with only 1 crop class are neglected. So only the rotational schemes, which are interpreted in different way by spatial and temporal approaches, are considered. For each of them all sequences which describe 1 of the 2 approaches, are counted.

The sequences which describe spatial approach report the specific rotational scheme for all period. The sequences which describe temporal approach report whole arable surface covered by only one crop class mentioned in rotational schemes. Also crop sequence among years must be accorded with rotational scheme. In the table 4.1 an example is reported.

As table shows, potential sequences for temporal approach are more than for spatial one. Especially sequences which could be also interpreted as continuous crops (1FO, 1FO) are really frequent and could misrepresent comparison. For this reason these specific sequences are separated by other temporal ones.

	Sample period	SEQUENCE 1st Year	2nd Year	3rd Year	4th Year	5th Year	6th Year
SPATIAL APPROACH	2 whole sequences	**2FO1CR**	**2FO1CR**	**2FO1CR**	**2FO1CR**	**2FO1CR**	**2FO1CR**
	1	2FO1CR					
	2	2FO1CR	2FO1CR				
	3	2FO1CR	2FO1CR	2FO1CR			
	4	2FO1CR	2FO1CR	2FO1CR	2FO1CR		
	5	2FO1CR	2FO1CR	2FO1CR	2FO1CR	2FO1CR	
TEMPORAL APPROACH	2 whole sequences	**1FO**	**1FO**	**1CR**	**1FO**	**1FO**	**1CR**
	1	**1CR** **1FO**					
	2	1CR 1FO 1FO	1FO 1CR 1FO				
	3	1CR 1FO 1FO	1FO 1CR 1FO	1FO 1FO 1CR			
	4	1CR 1FO 1FO	1FO 1CR 1FO	1FO 1FO 1CR	1CR 1FO 1FO		
	5	1CR 1FO 1FO	1FO 1CR 1FO	1FO 1FO 1CR	1CR 1FO 1FO	1FO 1CR 1FO	

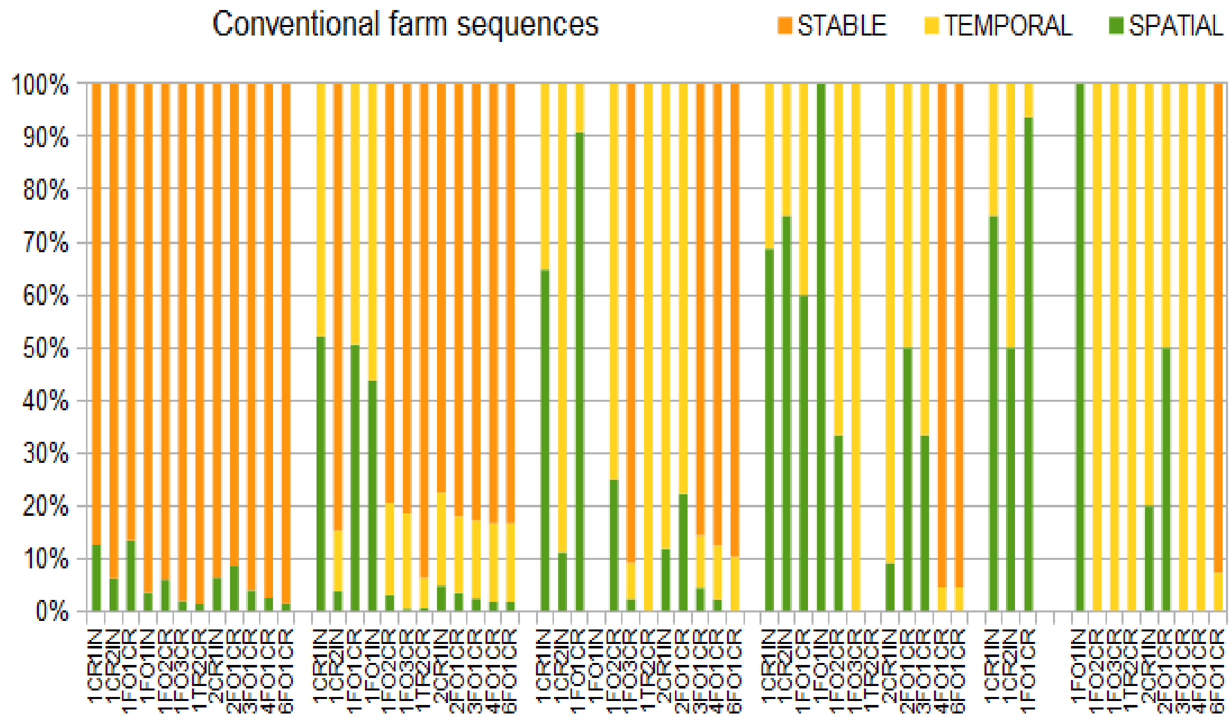
Table 4.1: spatial and temporal approaches are reported for rotational scheme 2FO1CR. In columns 6 years are reported which means two complete rotational scheme cycles. For each approach the first row represents theoretical crop pattern on field, the following ones represent all the possible sequences for each sample period.

In the figure 4.8 results of analysis are reported. In both regimes spatial approach is not relevant for sample period of one year. It is due at presence of stable sequences which are really more frequent. In CON regime, which is described by more farms, spatial approach becomes relevant for sample periods of 2 and 4 years and for some rotational schemes as 1CR1IN, 1FO1CR and 1FO1IN.

If the sequences which describe spatial approach are result of stochastic variability, they might decrease in multi-years sample periods. But this trend is not so clear on histogram (ORG is not considered because counts too few farms). On other hand temporal sequences, without considering stable ones, are really frequent for some rotational schemes.

The results do not show clear situation. Some short rotational schemes (2-3 years) could be alternated with other and this possibility could affect number of spatial approach sequences in long sample periods (4-5 years). The spatial approach could be more suitable than temporal one only for some rotational schemes. Finally, also sequences here considered described by spatial approach, could be also report several continuous crops grown in different fields. This could be an explanation of high frequency of rotational scheme 1FO1CR. This could not be a crop rotation among two crops, but two separated areas which always consider one crop. Indeed separated continuous crops of FO and CR are more frequent than rotational scheme 1FO1CR.

For all these reasons, it is more probable that rotational schemes describe only crop patterns at the moment of sampling and not an agronomic linkage among crops which are present on field.



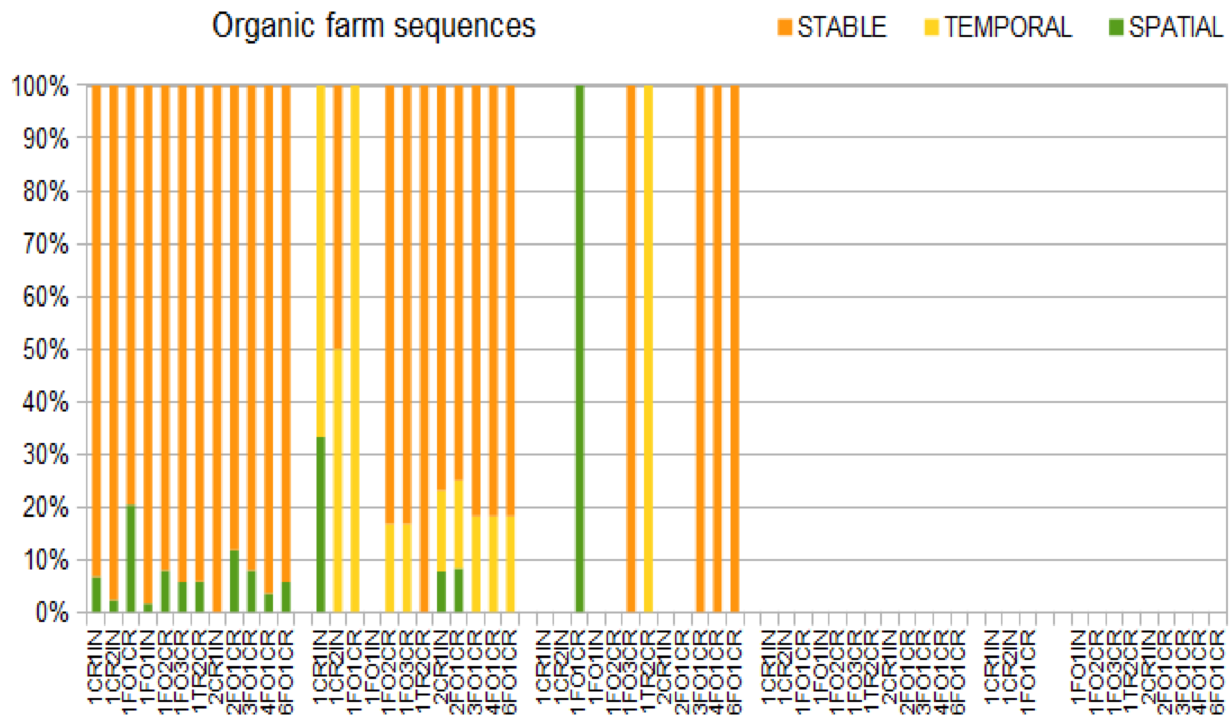


Figure 4.8: the 2 histograms report percentages of sequences for spatial and temporal approaches. The sequences which could also describe continuous crops (stable) are separated by other temporal sequences. The bars of each chart are separated in five groups: one for each sample period. The upper histogram reports CON sequences, the lower one ORG sequences.

4.4.4 Analysis of rotational schemes versus environments and farm structures

In this part rotational schemes are described for homogeneous environmental conditions and farm structures. To develop this analysis farms with arable lands are linked with some farm information by unique farm identity code. All farms suitable for arable land analysis are not also suitable for farm structure analysis. For this reason connection among two farm pool is not always possible. This means that number of farm sequences considered for this analysis are less than all farm sequences considered in previous steps.

In the following figure 4.9 rotational schemes, described by farm sequences, are reported for phyto-climatic zones and types of slope.

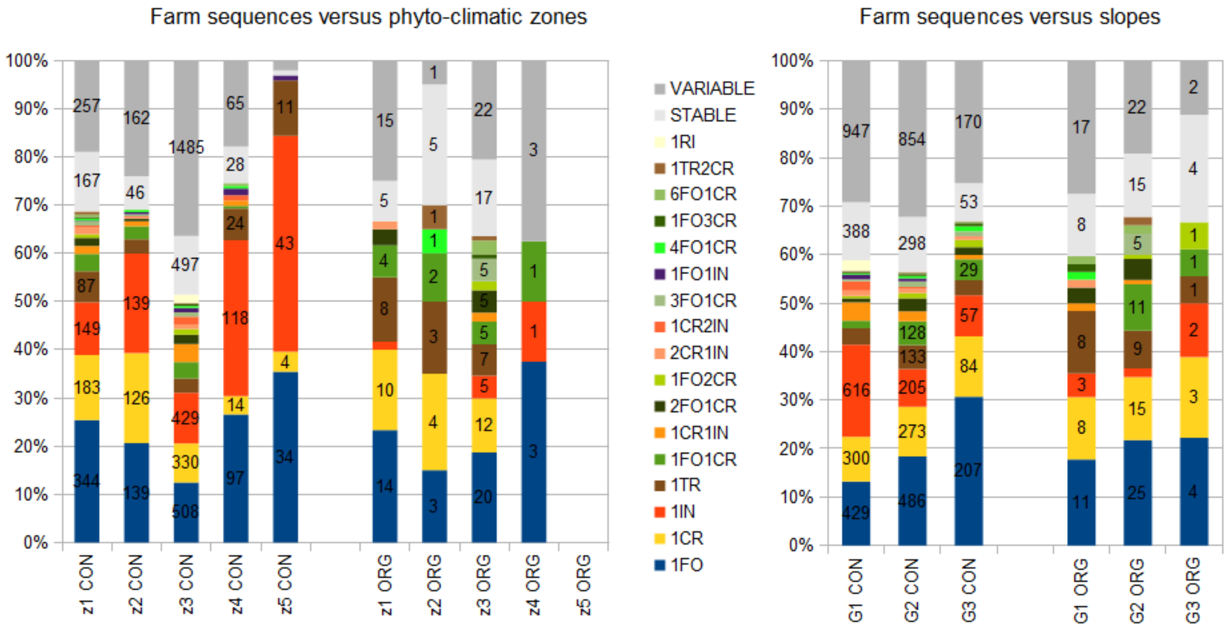


Figure 4.9: the two histograms report farm sequences for phyto climatic zones (on the left side) and types of slope (on the right side). All sequences record stable rotational schemes, except for the upper part of bars (in dark grey) which described variable sequences. Also regimes are reported (on x axis).

Some differences among phyto climatic zones and regimes can be find on left side chart. The CON sequences of z1 and z2 show similar distributions, except for 1IN which is more common in z2 where describes 20% of all sequences. Also the CON sequences of z4 and z5 record quite similar distribution, except for STABLE and VARIABLE sequences not detailed which are more common in z4. In z3 there are the most numerous pool of farms because this is the most extended phyto climatic zone. For this reason it shows more variability than other and higher level of frequency for sequences not detailed (STABLE or VARIABLE). The ORG regime reports similar distributions for z1 and z2, and some difference for z3 and z4; z5 does not count ORG farms.

In both regimes 1CR is more frequent on warm climates. On the other hand 1IN is more common on cold zones. In ORG regime arable land managements which support soil fertility are more frequent as set aside (TR) or rotational schemes (1FO1CR, 3FO1CR and 2FO1CR).

The types of slope show farm sequence distributions quite similar. 1CR does not reports trends among types of slope. 1IN is more common in CON plain. In ORG plain situation also TR is relevant. 1FO is the most important rotational scheme which increase its presence with increase of slope, especially for CON sequences.

In the following figure 4.10 farm sequences are reported for each farm structure.

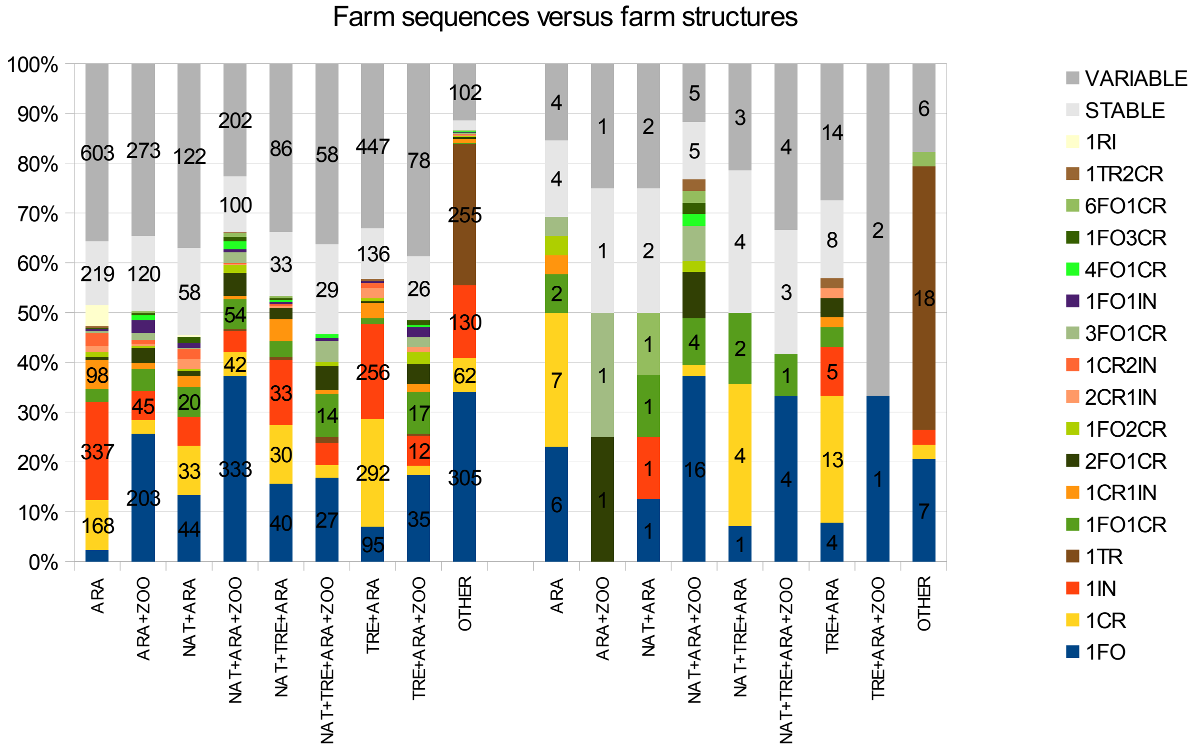


Figure 4.10: the histogram reports farm sequences for farm structures. All sequences record stable rotational schemes, except for the upper part of bars (in dark grey) which described variable sequences. The CON sequences are on the left side of chart, the ORG ones are on right side. With term OTHER are considered all other farms structures where ARA is less than 5% of total farm areas.

A large variability in terms of number of sampled sequences is recorded between regimes. It could be emphasise differences wich appear among CON and ORG farms. CON ARA records the lower level of 1FO and the highest level of IN of all structures and regimes. On other side ORG ARA records high level of 1CR and 1FO.

CON ARA+ZOO and NAT+ARA+ZOO record high level of 1FO. But for other structures with husbandry, like NAT+TRE+ARA+ZOO and TRE+ARA+ZOO, the presence of 1FO is not so relevant. On other side, all ORG structures with ZOO report the highest level of 1FO for all farm structures and regimes. Only ORG ARA+ZOO (described only by 4 farms) does not record 1FO, however rotational schemes with forages are considered as 2FO1CR and 3FO1CR.

ORG NAT+ARA records different distribution of the most frequent rotational schemes, but it is described only by 8 farms. For both regimes TRE+ARA records high level of 1CR and 1IN. Finally for OTHER structures 1TR is really relevant, according with subordinate role which these surfaces have in these types of farms.

The last analysis tries to organise all previous information in only one table for each regimes. In these following tables 4.2 and 4.3, farm structure, slope and phyto climatic zone are considered to investigate rotational scheme distribution.

	A	A+Z	N+A	N+A+Z	N+T+A	N+T+A+Z	T+A	T+A+Z	OTHER
z1_G1	STA.	1FO	VAR.	1FO	STA.	1FO	1CR	1FO	1TR
	1IN	1FO1CR	STA.	STA.	1IN	VAR.	VAR.	2CR1IN	1FO
	VAR.	STA.	1FO1CR	VAR.	1FO	2FO1CR	1IN	3FO1CR	VAR.
z1_G2	VAR.	1FO	VAR.	1FO	1CR	VAR.	1CR	VAR.	1FO
	1CR	VAR.	STA.	VAR.	VAR.	1FO	VAR.	1FO1CR	1TR
	STA.	3FO1CR	1FO1CR	2FO1CR	STA.	1FO1CR	1IN		VAR.
z1_G3	1CR	1CR	1FO1CR	1FO	1CR	VAR.	1CR		1FO
	1FO1CR	1FO	VAR.	VAR.	1FO	1FO1CR	1FO		1IN
	1FO			1FO1CR	VAR.		1FO1CR		VAR.
z2_G1	1IN	1FO	1FO	1FO	1CR	VAR.	1CR	1FO	1TR
	VAR.	VAR.		VAR.		STA.	VAR.	VAR.	1FO
	1CR	1FO1CR		STA.			1IN		VAR.
z2_G2	VAR.	1FO	1FO1CR	1FO	1CR	VAR.	1CR	1FO	1FO
	1CR	STA.	VAR.	VAR.	VAR.	1FO	VAR.	1FO1CR	VAR.
	STA.	VAR.	1CR	STA.	1IN	1FO1CR	1IN	STA.	1TR
z2_G3	1CR	VAR.	1FO1CR	1FO	VAR.	VAR.	VAR.	1FO	1FO
	1FO	1CR	VAR.	VAR.		1FO	1IN	STA.	VAR.
	STA.			1CR		3FO1CR	STA.		1IN
z3_G1	VAR.	VAR.	VAR.	VAR.	VAR.	STA.	VAR.	VAR.	1TR
	1IN	STA.	STA.	STA.	1IN	VAR.	1IN	STA.	1IN
	STA.	1FO	1CR	1FO	1CR	1FO	1CR	1FO	1CR
z3_G2	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	VAR.	1TR
	1CR	1FO	1FO	1FO	STA.	STA.	1CR	1FO	1FO
	STA.	STA.	STA.	STA.	1FO	1FO	STA.	STA.	1IN
z3_G3	VAR.	VAR.	1CR	1FO	1FO	VAR.	VAR.	VAR.	1FO
	1CR	1FO	STA.	VAR.	VAR.	1CR	1CR	1IN	1TR
	STA.	STA.	VAR.	STA.	1CR	1FO	1FO	1FO	VAR.
z4_G1	1IN	VAR.	VAR.	1FO	1FO	1IN	1IN	1IN	1FO
	STA.	1IN	1IN	VAR.	VAR.	STA.	VAR.	VAR.	1IN
	VAR.	1FO	STA.	STA.	1IN	VAR.	1FO		1TR
z4_G2	1IN	1FO	1IN	1FO	1IN	1TR	1IN	1FO	1FO
	STA.	VAR.	STA.	1IN	1FO	1IN	VAR.	1FO1IN	1IN
	VAR.		1FO	VAR.	VAR.	STA.	1FO	1IN	1TR
z4_G3		1FO	1CR1IN	1FO	1CR		1IN		1FO
			1IN	1IN	1FO				1IN
				1CR	1IN				1TR
z5_G1	1IN			1FO	1FO	1FO	1IN		1IN
	VAR.			1IN					1FO
									1CR
z5_G2	1IN	1FO		1IN	1IN	1IN	1IN	1TR	1TR
		1IN		1FO					1IN
				1FO1IN					1FO
z5_G3		1IN	1IN	1FO		1IN			1IN
				1IN					1CR
				STA.					1FO

Table 4.2: in the table the 3 most frequent rotational schemes are reported for each environment and farm structure. Only CON sequences are taken into account. Rotational schemes shows the same legend of previous chart, except for other STABLE sequences (STA.) and VARIABLE ones (VAR.). The super activities which describe farm structures are so abbreviated: ARA = A, NAT = N, TRE = T, ZOO = Z.

	A	A+Z	N+A	N+A+Z	N+T+A	N+T+A+Z	T+A	T+A+Z	OTHER
z1_G1		2FO1CR		1FO STA. VAR.		1FO	VAR. 1CR STA.		1TR VAR. 1CR
z1_G2	1CR 1FO 1FO1CR			1FO 1FO1CR 1CR	1CR STA.		1CR VAR.	VAR.	1FO 1TR VAR.
z1_G3				STA.		1FO	1IN		1FO
z2_G1	STA.			1FO 4FO1CR	STA.		1CR		1TR
z2_G2			1FO1CR STA.	1FO 1TR2CR STA.			1CR 1FO1CR		1TR VAR.
z2_G3					STA.				1TR
z3_G1	1CR 1FO VAR.		1FO	1FO 1FO3CR STA.		STA. VAR.	VAR. 1IN 1CR		1TR 6FO1CR
z3_G2	1FO STA. VAR.	3FO1CR	1IN 6FO1CR STA.	2FO1CR 3FO1CR VAR.	1CR 1FO1CR VAR.	1FO STA. VAR.	STA. 1CR 1FO	1FO	1TR 1FO VAR.
z3_G3	1CR 1FO2CR	STA. VAR.	VAR.	1FO		1FO1CR	STA.		1IN
z4_G1					1FO VAR.		1IN		
z4_G2				VAR.		VAR.	1FO 1FO1CR		
z4_G3				1FO					
z5_G1									
z5_G2									
z5_G3									

Table 4.3: in the table the 3 most frequent rotational schemes are reported for each environment and farm structure. Only ORG sequences are taken into account. Rotational schemes shows the same legend of previous chart, except for other STABLE sequences (STA.) and VARIABLE ones (VAR.). The super activities which describe farm structures are so abbreviated: ARA = A, NAT = N, TRE = T, ZOO = Z.

The high number of CON sampled farms allows to quite completely fill the table which describes 135 homogeneous farm pools. The variable (VAR) and other stable (STA) sequences record high variability in these pools where there are a lot of farms. High number of farms could be caused by the agronomical vocation of environment (plain) which also influence farm structures, and by dimension of phyto-climatic zone. In these situation presence of VAR or STA is usually recorded. Only in 8 pools (OTHER is not considered because it is sum of more farm structures) all 3 most frequent rotational schemes are detailed. VAR and STA do not appear also in several pools of extreme environments where often only one or two rotational schemes describe all arable lands. It is the case of 1IN and 1FO. 1FO is also one of the most common rotational schemes, except for ARA where 1IN and 1CR are relevant. 1FO appears especially when husbandry is considered.

Rotational schemes, which can correspond at classic crop rotation with FO and CR, are more common in warm climates in all types of slope for z1 and especially in G2 and G3 for z2. Other rotational schemes which consider FO and IN are present in cold climates. Also rotational schemes with CR and IN are present, but in environment completely opposite. The practice of set a side is really relevant only in OTHER structures. It suggests an intensive approach to agriculture for CON farms.

The table 4.3 reports ORG situation. This table records a lot of missed farm sequences for cold climate and environments with warm climate and high levels of slope (G3). 1CR is more relevant in structures without ZOO and 1IN, which is really less common than in CON, appears quite only on TRE+ARA. Also in ORG, OTHER structures reveals high presence of TR for each environment. 1FO is relevant for structures with husbandry as in CON situations for all environments.

The rotational schemes which can describe a real crop rotation, are present in larger range of climates than CON. They considers only FO and CR together and are more relevant on gently slope (G2), especially for temperate/cold climates as z3 and z4. ORG regimes also reported a rotational scheme which places side by side CR and TR.

It is interesting as in both regimes the most common rotational scheme is a biannual succession 1FO1CR. At the same time a lot of farm pools records 1FO and 1CR as the most common rotational schemes. More over 4 pools report 1FO1CR, 1FO and 1CR together. Indeed the CON rotational schemes which consider FO and CR together, are usually present side by side with 1FO. In the same way ORG rotational schemes which consider FO and CR together, are associated at 1CR, 1FO or both. It could be suggests the presence of both spatial and temporal approaches on field.

5. Discussions

5.1 General discussions

5.1.1 Data source stability

An improvement of the RICA database has been observed in the analysed period 2007-2011. A lot of classifications of the farm parameters report some modifications. They have created several difficulties to collects historical dataset for each farm, which have to be described by the same classification codes. However, also other aspects have affected the historical data analysis.

One of these aspects is the administrative NUTS changing among years. The list of municipalities (NUTS 4) records several changes. Some municipalities have been cancelled, instituted or modified in terms of surface and name. These variations have delayed the analysis of farm identity code, the farm location and of the phyto-climatic zone attribution. Sometimes the farms that are in suppressed municipalities must be neglected, because phyto-climatic information can not be attributed.

Moreover, a lot of farms with arable land report high variability among the years in terms of surfaces. This has forced the neglect of a lot of historical farm sequences. This neglection deeply affects rotational schemes results. The arable land variability could suggest that the fluctuations of farm surfaces among years are a frequent phenomenon, more than expected. On the other hand, also crop and land cover classification could affect the surface interpretation by reporting misrepresent information. It could be possible to reduce the variability by considering surfaces in term of size classes and not in terms of hectares, especially for small surfaces. Indeed, the small farms record a high level of percentage variability, which usually consider only 1-2 hectares, which are not so relevant at a farm scale.

Also, the amount of husbandry reports a high variability among years, which affects indicator levels of farm structures with ZOO, especially for conventional regime.

5.1.2 The FADN and analysis results representativeness

Definitely, the FADN representativeness is not under questioning. However, it is possible that the analysis results do not record the same representativeness of the data source. The FADN sampling method does not explicitly take into account regime, slope or phyto-climatic zone, but it only considers administrative region, UDE and OTE. So, sampled farms would not report the same ratios, appearing on field, among regimes, slopes and phyto-climatic zones.

If regimes, slopes and phyto-climatic zones were homogeneously distributed among each ISTAT universe layer, the previous observations would not affect the results representativeness. But actually, these homogeneous trends are not credible because organic farms are less than conventional ones; moreover, slopes and phyto-climatic zones cover a different amount of surfaces in each administrative region.

In addition to that, FADN is representative of each ISTAT universe layer because it counts a specific number of farms in each layer. But usually this farm pool is reduced by the analysis selection, because it eliminates some farms. Therefore, a part of the whole layer representativeness gets lost.

The results representativeness is affected also from a historical point of view. Each year a complete FADN farm pool represents an ISTAT universe layer. In each pool different farms could be selected every year. For this reason a lot of farms are sampled just one year and only few farms are sampled for more years. This reduces the historical sequences by affecting historical analysis.

For all these reasons, results can be considered as a starting point to investigate Italian agriculture. Even though they should not be considered representative as FADN database, especially in those cases described by the presence of few farms.

However, there are not other data sources that collect so many and detailed farm informations, at a national level. Only the census data counts more farms than FADN. It also reports information to define farm structures and rotational schemes. However, census data is collected every 10 years, whereas FADN data records a high variability among years. For this reason a time step of 10 years could be too wide to describe the farm dynamics. Therefore, on one hand the census data could be a better source, because it has a high representativeness than FADN. But on the other hand, census data has not enough replicas to describe so variable situations among years.

5.2 Organic regime versus conventional one

The discussion about results representativeness have to be taken into account when going to compare conventional and organic regimes.

Data does not report a stable gradient between regimes. The main reason is that there is not a unique prototype of conventional agriculture to compare with a unique prototype of organic agriculture. Indeed, data records a huge diversity inside both regimes. Farm performances are more affected by farm structure types than by differences in terms of technical restrictions established by organic certification. Also other less evident aspects influence the farm performances.

Differences among farm structure frequency and geographical location are recorded for the two regimes. In figure 2.7 a different frequency among regimes is evident in several farm structures. Within them also TRE, ARA and TRE+ARA are considered, which are the most common Italian farm structures.

The geographical analysis reports a different distribution of farm structures among administrative regions, as shown in figure 2.16. Also, farm distributions, analysed by phyto-climatic zone and slope, record differences among the regimes. These differences are quite less strong than differences among farm structures, according with less detailed classifications of these aspects. Moreover, several farm structures show marked differences in two or all the three aspects reported in figures 2.16, 2.17 and 2.18 (as ARA+ZOO, NAT+ARA and NAT+TRE). Among them also ARA is considered.

The differences among ARA farms are enough to define that conventional and organic farm patterns are different at a national level, in terms of geographical distribution. On one hand, the farms with ZOO show a higher level of difference than ARA farms. On the other hand, farms with TRE show a lower level of difference than ARA ones.

The indicators performances report a high variability inside the regime, but few differences between the same farm structure in conventional and organic regimes (as in figure 3.2). Only some farms with ZOO report high level of differences for some indicators (as in figure 3.1 and 3.6).

Also, the net revenue and efficiency indicators report strong differences among regimes (figure 3.4 and 3.5). But also a higher variability is recorded inside conventional farm structures. So, a no clear comparison between regimes could be done. Indeed, there is the risk to compare situations that are too much different from an economical viewpoint.

Arable land analysis does not show a strong difference among regimes at a national level. Both regimes report arable surfaces covered only by one crop. Only intensive crops are sensibly less frequent in organic regimes. The rotational schemes that express a classic crop rotation (more than 1 crop), report differences in terms of frequency and type. Even though they are not so relevant at a national level (as reported in figure 4.6).

However, the differences clearly appear (figure 4.9 and 4.10) considering also other aspects, which affect crop presence as farm structure and environmental conditions. The crop patterns that report more variability among regimes are 1CR, 1FO, and a combinations of them (1-6FO 1-3CR).

5.3 Discussions on farm structures and farm typologies

Farm structures defined in this analysis are different from other common classifications. The results show that the farm structure suggests informations about all types of managed surfaces, land covers and husbandry practices. For this reason farm structure adds information to OTE farm classification, which does not describe marginal or not productive elements of farms. Farm structure information could be more important for landscape management, especially from an environmental viewpoints. A useful tool for policy maker could be to link these marginal areas (just from productive viewpoints) with the farmer, who manages and preserves them. On the other hand, farm structures could be used to define different types of landscapes at a territory scale. More over, these areas often represent a connection with the surrounding context as ecological corridors, ect. In general having a whole description of the farm is a way to better define farm processes and connections between farm and surrounding context.

The farm structure classification does not eliminate other ones. Especially farm size classification and UDE are complementary aspects which could be integrated among information of farm typologies.

5.4 Discussion on indicator performances

Indicator levels record a high variability in terms of performances, which are often strictly dependent from farm structure. Among regimes differences are not so evident. This could be due to the applied methods used to estimate indicator levels. The methods are often based on attribution of score to land covers without any difference among regimes. So the indicator levels record high variability among farms with same regime, but different structure or rotational scheme. On the other hand, farms with the same structure or rotational scheme record similar indicator levels for both regimes. Farm structures and rotational schemes show some differences in terms of distribution among regimes. But they are not strong enough to report a clear trend also among indicator levels.

On the other hand also indicators, based on technical coefficients diversified for regimes, report a high variability inside farm structures, more than among them. This could be a signal that regimes actually do not present differences for some analysed indicators. On the other hand, it is also credible that technical coefficients are too much general to detect differences among regimes. And also farm structures could be too generic to detect regime differences.

To reduce farm variability the level of farm typology detail has been improved to a macro activity, municipality and farm size levels, in last indicator analysis. But also this effort has not been enough to detect clear trends of indicator behaviours among regimes. Indeed, also in this more detailed analysis, it is possible that ORG olive trees and CON citrus or chestnuts have been compared together.

The analysis among regimes requires more data to force comparisons among farms with same crops and same context. Indeed it is not possible to find these specific farm pool on RICA database. Maybe the national scale of analysis is too wide to detect differences among regimes, which do not report two unique theoretical managements. Indeed they have developed several managements according with each hint of surrounding context.

For this reason it is impossible to declare statements among regimes at a national level, with these types of indicators and technical coefficients. A better performance of one regime above the other is limited in terms of farm structure, subset of indicators or both of them. However, also a hypothetical difference of efficiency between two regimes is not recorded. At this detail of analysis, some indicator behaviours often show information that have already been suggested by the farm structure, such as presence of natural areas.

To improve some indicators also FADN could be taken into account. Indeed since 2008 information about phytopharmacies and fertilisers consumption is collected in terms of quantity and toxicity for each product.

5.5 Discussion on arable lands description

The arable land analysis reports a lot of rotational schemes, which can not be easily interpretated as classic crop rotation. The abundance of rotational schemes that record only one crop, could be interpreted as a prevalence of the temporal approach. However, several continuous crop sequences are recorded also for five years. So these types of sequences could be considered as extreme rotational schemes of just one crop, therefore these sequences could represent a spatial approach management.

Direct comparisons between the two approaches report a prevalence of temporal approach in the major part of analysed cases. However, in other cases, the spatial approach records more sequences than the temporal one. Indeed a lot of sequences interpreted with temporal approach could be attributed to so many different rotational schemes. So that it is impossible to be sure to recognise a management approach and rotational schemes only by crop ratio. Indeed, also stable sequences, which record the same rotational scheme for several years, can describe two separated farm bodies where continuous crops are grown.

This uncertainty could be contrasted by combining other data sources as cadastre parcel or satellite pictures. But privacy management of FADN data obstructs the geo referencing of farm boundaries.

Moreover, to investigate crop rotations and practices to maintain soil fertility, other types of data might be taken into account as cover crops, manure consumption, green manure, crop consociations, deep of ploughing, which are not collected by FADN. Information about other ways to maintain soil fertility (considering also fertiliser consumption) is really important because arable land sequences report a high not clearly organised variability. Indeed, spatial or temporal approach, in a pure meaning, describe only a little part of sample arable lands. A high variability among surfaces, years, farm bodies or field managements affect results. But these aspects could explain only a part of all diversity.

It is possible that a so high variability is the result of no fixed rotational schemes. In this prospective, crop rotations are not a stable ratio of crop over time or surface, but an open scheme which can evolve over time. Every year farmers can plant what they prefer without any connection with previous crops by using the previously mentioned practices. In this prospective farms can better answer the market request. But in general they also become more dependent from out-farm inputs and they decrease environmental quality and sustainability.

For all these reasons, crop pattern could be a better definition of rotational scheme.

Agronomical relations among crops are not expected, but only surface ratio is considered. The analysis of crop patterns could be applied also to other farm surfaces. It could improve or substitute farm structure, which now reports only the presence of super activities. The crop patterns can describe and characterise farm and territory, even though they do not describe crop sequences.

6. Conclusion

The study analyses some relevant differences between conventional and organic Italian agriculture. The farm structures report different patterns in terms of frequency and geographical location between the two regimes. Also arable crop patterns, inside each farm structure, show differences among regimes. On the other hand, performances of farm indicators record too much variability inside each farm structure and regime. Therefore it is not clear how to link the whole performance level to the regimes. The farms with husbandry report the most relevant differences among regimes, according to farm structure distribution, arable land management and some indicator levels.

The farm typologies well describe the high variability inside agricultural situations reported by FADN data, especially at a national level. This farm classification is a useful tool to describe farm and territory, and it can be supported by other classifications as size and UDE.

Even the arable land analysis could have a high potential to describe farm and territory patterns, also in terms of dynamics. The arable land analysis made by FADN data is not able to detect crop rotational schemes, but it reports crop patterns, which are an important aspect of farm management and landscape.

This analysis tries to investigate the agronomical situation and considers a vast level of variability over time and space, at a national level. Each step of the analysis, which groups together similar farms or crops, affects the results. For this reason the crop classification constitutes the core of analysis; but other classifications as phyto-climatic zone, slope or rotational scheme definition have a relevant role, too.

Some data classifications, as slope and farm location, come from FADN data. Is not easy improve their detail, because it would mean to change the FADN database. For other classifications the analysis is more malleable and it could be quite easy to operate improvements. It is the case of crop classification and rotational scheme attribution. The possibility to improve these aspects is an important characteristic of the theoretical approach, proposed in this study.

The irrigation is not considered in this study because the MAD model does not consider it. However, not to consider irrigation could be one of the most important limitations of analysis. Farm structures are affected by its presence; water consumption is one of the most important productive aspects in agriculture and it is described by several indicators. Moreover, the presence of crop on arable fields is strictly dependent from water availability, which can sensibly alter rotational schemes. For all these aspects, in future the irrigation could be taken into account, also because FADN reports types of irrigation for each crop.

Adding information to farm typologies could also allow to have a more precise estimation of several indicator levels. By considering type of soil (at least granularity), slope and presence of irrigation it could be possible to develop a model to better estimate soil dynamics, in terms of soil organic matter levels and nutrient availability. This information, integrated in MAD, could be used also for production estimation. On the other hand, soil fertility deeply affected also rotational schemes. Since 2008 RICA database collects also information about soil conditions.

Another relevant aspect from an agronomical point of view is meteorological conditions. But their high variability among seasons, years and space does not allow any generalisations. Phyto-climatic zones description is an attempt to describe global climatic conditions which are quite stable over time. But at a farm level meteorological data is required, especially to improve model of soil dynamics.

Also, the social farm aspect could be improved to explain the whole farm and context description. Age and instruction level of farmers are useful data reported in FADN database since 2008. Farm labour is described by gender, origin country, wage and other aspects.

As previously mentioned, this analysis could consider also farm dynamics. In this study only stable farms or arable lands are taken into account. But if the historical sequences to analyse are longer than few years, making a separation of the period in homogeneous group would be interesting. The ARPEnTAge software recognises homogeneous periods inside a unique land cover sequence. Indeed, it has been developed in France to investigate Teruti data (Mari, Lazrak, & Benoit, 2013). By combining this methodology and the analysis reported in this study, farm and territory dynamics would be possibly investigated in terms of pattern and surface variation.

Even though the technical coefficients and some classifications could be improved, the approach can remain the same. By describing the whole farm area and farm activities is possible to analyse the farm and its connections to the context. And also by describing the context is possible to investigate farm processes at a more detailed level.

On the other hand, the farm analysis could be easily oriented to several other topics, just by modifying some technical coefficients. The FADN data availability at an european level and the plasticity of analysis suggest that the farm typologies and crop patterns descriptions can be useful methods to investigate agriculture and territory, at a farm or local level. Indeed the results of these analyses could support farm and land managements.

7. Bibliography

AA.VV. (2013). *Bioreport 2013 L'agricoltura biologica in Italia*.

Albertazzi, S., Baldoni, G., Della Chiara, M., Cardillo, C., Trisorio, A., Vitali, G., & Canavari, M. (2012). Identification of main crop rotations in different Italian environments from RICA farm database. In *12th Congress of the European Society for Agronomy. Book of Abstracts* (pp. 582–583).

Darnhofer, I., Gibbon, D., & Dedieu, B. (Eds.). (2012). *Farming System Research into the 21st Century: The New Dynamic* (p. 135). Springer. doi:10.1007/978-94-007-4503-2

Diamond, J. (2005). *Collapse. How Societies Choose to Fail or Succeed*. Giulio Einaudi editore spa.

E.C. (2013). *Facts and figures on organic agriculture in*.

EC. (2008). Regulation EC No 1242/2008. *Official Journal of the European Union*, (13.12.2008 EN), L 335/3–24.

EEC. (1991). *Reg.EEC No.2092/91*.

Inan, H. I., Sagris, V., Devos, W., Milenov, P., van Oosterom, P., & Zevenbergen, J. (2010). Data model for the collaboration between land dministration systems and agricutlrual land parcel identification systems. *Journal of Environmental Management*, *91*, 2440–2454. doi:10.1016/j.jenvman.2010.06.030

INEA. (2000). *Linee metodologiche e istruzioni per la gestione dei dati RICA - Continea 7* (pp. 206–208).

INEA. (2014). *Italian Agriculture in figures 2013*.

Mari, J.-F., & Benoit, M. (2010). Landscape regularity modelling for environmental challenges in agriculture. *Landscape Ecology*, *25.2*, 169–183.

Mari, J.-F., Lazrak, E.-G., & Benoit, M. (2013). Time space stocastic modelling of agricultural landscapes for environmental issues. *Environmental Modelling & Software*, *46*, 219–227.

Medici, G., & others. (1974). *Modelli di azienda per l'aggiornamento della nostra agricoltura* (Vol. 1, p. 94). Accademia Nazionale di Agricoltura.

Moore, N. W. (1965). Pesticides and birds-a review of the situation in Great Britain in 1965. *Bird Study*, *12.3*, 222–252.

Poore, D. (1986). *The vanishing forest. The human consequences of deforestation.*

Ratcliffe, D. A. (1970). Changes Attributable to Pesticides in Egg Breakage Frequency and Eggshell Thickness in Some British Birds. *Journal of Applied Ecology*, *Vol. 7, No*, 67–115.

Rizzo, D., Marraccini, S., Lardon, S., Rapey, H., Debolini, M., Benoit, M., & Thenail, C. (2013). Farming systems designing landscapes: land management unit at the interface between agronomy and geography. *Geografisk Tidsskrift-Danish Juornal of Geography*, *113:2*, 71–86. doi:10.1080/00167223.2013.849391

SINAB. (2013). *BIO in cifre 2012*. Retrieved from www.sinab.it

Smith, P., Martino, D., Cai, Z., Gwary, D., Janzen, H., Kumar, P., … Sirotenko, O. (2007). Agriculture. In Climate Change 2007: Mitigation. In *Fourth Assessment Report of the Intergovernamental Pannel on Climate Change* (p. 499).

Solomon, S., Garcia, R. R., Rowland, F. S., & Wuebbles, D. J. (1986). On the depletion of Antartic ozone. *Nature*, *321.6072*, 755–758.

Standford, G., England, C. B., & Taylor, A. W. (1970). *Fertilizer use and water quality*. United States Department of Agriculture, Agricultural Research Service.

United States Census Bureau. (2014). U.S. and World Population Clock. Retrieved March 04, 2014, from http://www.census.gov/popclock/

Vitali, G., Baldoni, G., Albertazzi, S., Signorotti, C., Cardillo, C., Della Chiara, M., … Canavari, M. (2012). Evaluating impact of organic agriculture in GHG emission at national level: analysis framework. In *12th Congress of the European Society for Agronomy. Book of Abstracts* (pp. 592–593).

Vitali, G., Cardillo, C., Albertazzi, S., Della Chiara, M., Baldoni, G., Signorotti, C., … Canavari, M. (2012). Classification of Italian farms in the FADN database combining climate and structural information. *Cartographica*, *47*(4), 228–236. doi:10.3138/carto.47.4.1478

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Acronym list and glossary

ARA	super activity, surfaces or practices refered to ARAble lands
AT	Austria
CON	conventional (regime, farms, farm structures, farm sequences)
CR	macro activity, surfaces or practices refered to CeReals
crop rotation	specific arable crops linked together in a unique management to maintain soil fertility
CZ	Czech republic
DE	Germany
EC	European Community
EC	European Community
EFF	Farm indicator of efficiency in term of production and labour
EL	Greece
ES	Spain
FADN	Farm Accountancy Data Network, database presents in EC countries
farm sequence	sequence of rotational schemes recorded for one farm
farm structure	list of main productive processes develop by farm (usually detailed at super activity detail)
farm typology	farm pool with same collocation, phyto climatic zones, slope, regime and farm structure
FO	macro activity, surfaces or practices refered to FOrages
FR	France
G1	plain slope <5%
G2	gently slope >5% and <15%
G3	high slope >15%
GHG	Green House Gasses
IBDL	Farm indicator of habitat biodiversity
iccs	Farm indicator of climate change sensibility
ighg	Farm indicator of GHG emission on farm
iint	Farm indicator of crop intensity
ilab	Farm indicator of labour amount
ilai	Farm indicator of GHG emission outside farm
iler	Farm indicator of soil erosion
IN	macro activity, surfaces or practices refered to INtensive crops
INAT	Farm indicator of natural area amount
INEA	National Institute of Agricultural Economics
ipcl	Farm indicator of phytopharmacy expense
ipfl	Farm indicator of fuel usage
ipnl	Farm indicator of self sufficiency of crop nutrients
isdz	Farm indicator of self sufficiency of animal feeing
ISTAT	Italian National Institute of Statistic
ISTAT universe	all farms considered by census data developed by ISTAT (in this study the 5th census data of 2000)
ISTAT universe	census data describing italian agronomical situation operated by ISTAT
IVNI	Farm indicator of net revenue
macro activity	the second most general level of productive processes /natural covers detail
MAD	Dynamic Farm Model which estimate farm indicator levels
NAT	super activity or surfaces refered to NATural areas
NUTS	Nomenclature of Territorial Units for Statistics; by Eurostat
ORG	organic (regime, farms, farm structures, farm sequences)
OTE	Economical Technical Orientation (to classify farm)
OTHER	group of elements (crops, farms, arable land, farm sequences or farm structures) not considering in specific analysis

Acronym list and glossary

phyto climatic zone	area described by homogeneous potential spontaneous vegetation
PL	Poland
preliminary pool	whole RICA farms sampled for years 2007-2011
regime	technical orientation: conventional or organic
RI	macro activity, surfaces or practices refered to RIce crop
RICA	Italian FADN database (Information Web of Agronomical Accounting)
rotational scheme	ratio among arable field macro activities which is considered as general types of crop rotations
sample period	number of samples for one farm
selected pool	Selection of RICA farms sampled for years 2007-2011 suitable for analysis of farm typologies
super activity	the most general level of productive processes /natural covers detail
TR	surfaces at set a side
TRE	super activity, surfaces or practices refered to TREe crops
UBA	Adult bovine Unite (to measure unit of husbandry)
UDE	Economical Dimension Unit (to classify farm)
UK	United Kingdom
z1	Warm lauretum (warm phyto climatic zone)
z2	Cold lauretum (warm phyto climatic zone)
z3	Castanetum (temperate phyto climatic zone)
z4	Fagetum (cold phyto climatic zone)
z5	Picetum (cold phyto climatic zone)
ZOO	super activity or practices refered to husbandry