Farm and land system dynamics in the Mediterranean basin

Debolini Marta[a], Elisa Marraccini[b]

[a] *INRA – UMR EMMAH, Avignon (France), marta.debolini@inra.fr*

[b] *UniLaSalle, UP INTERACT 2018.C102, Beauvais (France), elisa.marraccini@unilasalle.fr*

Abstract: *Mediterranean land and farming systems (Med LFS) have a long history of producing food, fodder and fiber to supply the population, contemporary contributing to many other cultural and regulating ecosystem services. In the last decades, Med LFS have known significant changes in terms of agricultural land use and practices. An abandonment of marginal or low intensity agricultural areas generates a re-naturalization; at the same time, coastal and plains areas are subject to a growing urbanization, generating increased competition on the access to land resources. Finally, the most fertile agricultural areas are experiencing a process of intensification, particularly in the southern side of the Mediterranean area. So there is a contemporary trend of changing the location and nature of the agricultural areas in the Mediterranean basin, following a set of tensions and opportunities taking place at different scales, from the local one to the basin scale. Three main research questions will be addressed on the panel session: (1) how Med LFS can be affected by land use dynamics such us urbanization on the most fertile plain area or abandonment on marginal areas? How they can adapt themselves to the environmental conditions and the attended global changes? (2) What is the role of specific Med LFS in improving sustainable food security and how transition land management models are affecting food sustainability? And (3) What are the new organization forms at territorial level and how they are contributing to farming system sustainability?*

Keywords: *Mediterranean agriculture, agricultural systems, farm trajectories, intensification, abandonment, marginal areas, urbanization*

State of the art

Current land use and land cover changes (LULCC) have been related to different environmental impacts, such as biodiversity loss (Haines-Young, 2009), soil organic carbon loss (Edmondson et al., 2014) or soil redistribution patterns (Debolini et al., 2013). At the same time, the alteration of the ecosystem functioning can impact on the well-being of human societies (MEA 2005). Changes in land use and land cover can result from local competition between different uses within the agricultural sector. In this case, changes affect the dominant practices, e.g. traditional family farming vs. corporate agriculture (Bontkes and Keulen, 2003) or intensification of agricultural activities (Temme and Verburg, 2011). On the other hand, LULCC can act between agricultural and other land use types like urban sprawl, in particular on coastal areas (Salvati et al., 2012). These main changes are not independent and act in a feedback chain: disturbance of traditional agriculture surrounding urban areas due to cities expansion leads to the development of a market-oriented agriculture further away from the cities, while these developments disturb ecosystems in rural areas (Benaoun et al., 2014). In order to support sustainable land management, an overall understanding of the feedback mechanisms and on the human-environment interactions at this level is needed (Foley et al., 2005). In this, context, the Mediterranean basin appears as a highly relevant case-study for assessing what type of environmental and agricultural analysis would help reconciling human needs in terms of land demand for food production, habitat space and ecosystem long-term functioning. Environmental challenges are indeed particularly exacerbated in the Mediterranean basin which is one of the 34 global hot-spots of biodiversity and presents some environmental and socio-economic specificities (Médail and Quézel, 1999). From an agricultural perspective, the Mediterranean basin has a long history in terms of production of food, fodder and fiber for the provisioning of civilizations. In parallel,

it has also delivered many typical land uses and landscapes after sometimes strong reshaping of the environment (e.g. terraces and irrigation canals, hedgerows, agro-silvo-pastoral systems) (Pinto-Correia and Vos, 2004; Blondel, 2006). For these reasons, the current agricultural systems and the complementarities between crops are pretty complex and inherited from a long history of agricultural and cultural purely Mediterranean traditions (Zeder, 2008). In this context, several agricultural practices are known to provide food production and while they are desirable for a good functioning of ecosystems. Some of these agricultural practices were traditional in the past, and have been abandoned in favour of more economically profitable ones during the 20th century (Pinto-Correia and Vos, 2004). Silvo-pastoralism, agroecological practices, agroforestry and organic farming are among them. They often sustain biodiversity and are still currently used on both sides of the Mediterranean basin (Bugalho et al., 2011). Nowadays, agronomists look at agroforestry and agroecology with a renewed interest, as recent studies have shown how it could potentially enhance the production and diversify the farmers' incomes and the resistance of farms and production to climate change (Daoui and Fatemi, 2014). Besides agroforestry, agroecology and silvo-pastoralism, innovative practices targeting soil conservation and its ability to retain water, and that rely on functional agro-biodiversity, increasingly appear to be more sustainable than conventional high-input practices (Francia-Martinez et al., 2011).

At the same time, the Mediterranean basin is characterized by a scarcity condition for agriculture (poor and shallow soils, steep slopes and a dry summer), a limited availability of resources, mainly water, and a complementarity of different and complex agricultural systems (Caraveli, 2000). This region also presents some particularities in its social organization, such as the low level of entrepreneurship in some hilly/mountain marginal regions, mainly characterized by traditional extensive farming systems (Petanidou et al., 2008), a property structure based on family lands considered as a heritage more than as a production factor and a low level of taxes on land ownership (Otero et al., 2013). Finally, from an environmental perspective, the Mediterranean climate offers unique conditions for a rich biodiversity to coexist, while future climate changes are expected to lift species climatic suitable conditions northward (Ruiz-Labourdette, et al., 2013). The Mediterranean Basin is projected to become increasingly dry and warm, while inter-annual climate variability is also expected to increase particularly during the summer (Giorgi & Lionello, 2008). The combined effects of a changing climate and land-use patterns are likely to impact on ecosystems and the services they deliver.

There are currently two main approaches for assessing relations between LULCC and correlated agricultural and natural diversity. On the one hand, at a broad scale often rested on extrapolations of a set of values and functions that may ignore the precise functioning and feed-backs between local dynamics of ecosystems (Costanza et al. 1997). On the other hand, the assessments centred on a located ecosystem or on a small field-study (e.g. the spatially-explicit biological model of Polasky et al. 2008), which is able to highlight complexity of relationships between ecosystems or between ecosystems and society, but which are not easily usable at the public policy scale. Formally, the first studies on LULCCs were mostly based on the diachronic analysis of land cover dynamics through satellite images or aerial photos, or complementary data such as agricultural census or surveys, and focused mainly on the relative impact on landscapes (Lambin, 1997). Researchers then became increasingly involved in explaining the drivers of these changes and at the same time in simulating possible future scenarios (Veldkamp, 2009). In these studies, the focus was more on land cover as a proxy of land use, while the type of management, the farming intensity or the complexity of the landscape were barely considered. Recent advances on land use studies highlighted the coupling of empirical local studies on land use change and multi-scale modelling as a major need for research in this field (Rounsevell et al., 2012). In a planning perspective, the issue at stake is the integration of two approaches aiming to provide significant levels of precision in a tool usable at the policy level (MEA, 2005). In particular, in the last few years, following the increasing availability and quality of land use data, the development of more sophisticated methodologies and the increasing interest in the management of different land uses, LULCC studies have tended to combine the concepts of land use and management through "land systems" (Verburg et al., 2013). In this case, the

geographical unit for modelling and predicting future changes is not directly the land cover or the land use, but a more complex type of classes that combines land use and its management through various possible indicators (e.g. population density, irrigation systems, agricultural inputs). The aim of this systemic approach is to consider the world as a complex system where natural/environmental and human/socio-economic components are fully integrated and considered at the same time (GLP, 2005). Human actions and behaviours have been recognized as the main drivers in determining and forcing current land system dynamics, thus research needs to directly integrate human components within LULCC modelling, as well as possible feedback on how humans have adapted land systems (Veldkamp, 2009).

Objectives and hypotheses

The organisation of this panel session is supported by an informal scientific network started in 2014 and called AgroMed. The AgroMed mission is to create a stable and comprehensive pool of scientist coming from different disciplines, spread across the Mediterranean basin and specialized on the analysis of the dynamics of agricultural and land system and their trade-offs on biodiversity, economy and ecosystem services. The network was firstly funded through an ENVI-MED projet, which ended with the first international AGROMED conference in 2016 (https://agromed2016.wordpress.com/). Currently, some members of the network are involved in an international research project (Arimnet2) called DIVERCROP (2016-2020). Most of the issues proposed on this session are based on the reflexions coming from the DIVERCROP project.

The first objective of the panel session is to analyse the land and farming system dynamics in the Mediterranean Basin and to identify their main drivers at different scales. Moreover, the link between identified environmental patterns and the capacity of the agricultural systems to contribute to the local food system of cities is investigated. Specific conceptual models and tools that may be used to investigate the functioning of Med LFS will be discussed.

Four paper will be presented on the first part of the session, in order to open the discussion on the main questions that we aim to address. In particular, the discussion will be related to these research questions: (1) how Med LFS can be affected by land use dynamics such us urbanization on the most fertile plain area or abandonment on marginal areas? How they can adapt themselves to the environmental conditions and the attended global changes? (2) What is the role of specific Med LFS in improving sustainable food security and how transition land management models are affecting food sustainability? And (3) What are the new organization forms and the possible farming practices (e.g. agroecology, sustainable intensification) at territorial level and how they are contributing to farming system sustainability?

In the following section we present a summary of the four panellist presentations that will be discussed during the session. The session will be organized as follow: the four panellist will give a brief presentation highlighting some problematic aspects linked to the research questions in terms of methodology, public policies or new possible form of organization. Then, the two organizers of the session and two external discussants (Rosalia Filippini from the University of Milan, Italy, and Esther San Sanz from INRA, France will introduce the discussion.

Multiscale spatial organization and dynamics on Mediterranean land and farming systems.

Authors: Johanna Fusco and Marta Debolini

In the last decades, Mediterranean farming systems have known significant changes in terms of agricultural land use and practices. The pressures on agricultural lands, added to environmental threats and climatic variability, highly endanger the improvement of food

productivity that will be required by the fast population increase in the coming decades. In this context, there is an urgent need to understand the current processes which affect Mediterranean farming systems, their drivers and the subsequent impacts on their nature and their spatial organization. This knowledge is essential to identify the territorial levers and brakes which contribute to farming systems sustainability, in order to better anticipate the upcoming changes.

Hence, our purpose is to characterize and to map Mediterranean farming systems diversity based on their agricultural characteristics (type of crops, irrigation…), the territorial features and the ways in which they impact farming systems structure and changes at different scales (environment, socio-economic characteristics, land use and land management …), and their temporal dynamics, that is to say, how, where and when they change, and the drivers that make them shift from one state to another.

While the territorial dimension of farming systems has been widely studied and analysed through local case studies, performing this assessment at the macro scale (in our case, the Mediterranean basin) is a real methodological challenge, which requires specific and innovative tools and methods. This approach involves finding an intermediary subtlety level between the fine and precise but spatially and methodologically scattered micro-scale farming system studies, and the macro-scale models, yet spatially homogenous and reproducible, but which inevitably utterly simplify the complexity of spatial and temporal interactions, which are the essence of such systems. Furthermore, farming system typologies rarely include dynamic parameters in their calculation; the included variables are defined by their state at time t or by a mean calculated from time series. The observation of dynamics is then usually performed after farming system definition, in order to examine their shifts from one category to another, or their stability. In our approach, we postulate that the nature, the intensity, and the multiscale drivers of changes affecting farming systems give us relevant information on their inner nature. Their assessment should not be kept as a separate a posteriori analysis from farming system characterization and typologies, but should play a predominant role in this characterization. In other words, two similar farming systems from a purely “static” point of view might belong to two different categories in our spatio-temporal typology, if they display opposite reactions to identified changes (or to stability) in their neighbourhood at several scales. Our methodological and theoretical approach then involves finding innovative ways to characterize and to categorize the spatio-temporal trajectories of farming systems at macro scale, that is to say, to detect how, where, when and why agricultural land use changes (or not), and to detect and to categorize the resulting spatio-temporal patterns.

To this purpose, we apply exploratory spatial data analysis (ESDA) as an original and highly relevant methodological framework, as it enables exploring and revealing systematically the impacts of spatial and temporal dimensions in the statistical relationships observed between the variables describing the studied spatial units (Anselin, 1999). The nature and the intensity of these impacts and relationships (caused by spatial or temporal autocorrelation, neighbourhood relationships, or path dependence phenomena for example), how they vary through space and time, and the scales at which they manifest, build the so-called spatio-temporal structures (Abler et al, 1971). The exploration philosophy of ESDA lies mostly on testing and chaining various quantitative tools and methods, and in so doing, highlighting various facets of spatio-temporal structures and gaining insight into the characterization of spatial and temporal relationships between the studied spatial units (Banos, 2001). In our approach, ESDA tools are considered as statistical probes helping to explore, to quantify and to map the spatial and temporal interactions between the variables describing Mediterranean agricultural land use and territorial characteristics and the underlying spatio-temporal structures.

If ESDA tools can highlight various spatial and temporal links between variables and spatial units, these interactions have, of course, to be interpreted in order to produce a relevant, meaningful and useful spatio-temporal farming system typology. In our presentation, we will (after exposing briefly our objectives, methods and dataset) show some intermediary results of ESDA treatments, in order to fuel a discussion on the interpretive dimension and

translation of such results in farming system characterization. Our purpose in this presentation is to discuss to what extent it is possible to give sense to the observed spatio-temporal structures and phenomena at such scale; in other words, to assess the amount, the nature and the quality of information and knowledge this approach could bring comparatively to usual macro or micro scale approaches.

Sustainable Intensification in the vineyard farming system of Utiel-Requena (Valencia, Spain)

Authors: Olga Moreno Perez, Raul Compes Lopez, Lorena Tudela Marco and Dionisio Ortiz Molina

There are several definitions of the concept of sustainable intensification (SI). For this study, we take the definition of Pretty (1997), who understands SI as a process or system that allows increasing agricultural yields without causing a negative environmental impact or increasing the agricultural land. The originality of the concept lies in the combination of two terms that are well-known separately, "sustainability" and "intensification", and in the core message that achieving both goals simultaneously is possible through different productive models (Pretty et al., 2014). SI is a paradigm of “mainstream” agricultural development that incorporates the need to preserve the future viability of agriculture (Rockström et al., 2016).

Although SI is conceived as a ‘global’ paradigm, its application is locally-driven, as it depends on the conditions existing in different territories and agricultural ecosystems. It may be necessary to make a balance between the needs of "sustainability" and "intensification" (Garnett and Godfrey, 2012), placing more emphasis on the most critical element at each place. In the case of EU, more attention should be paid to sustainability (Backwell Report), in response to the citizens’ concerns regarding biodiversity, climate change, soil protection, water management and agricultural cultural landscapes. In the realm of wine production, SI is more challenging than in other agri-food sectors, as there is a well-known trade-off between the quantity and the quality of the grapes produced. The agricultural intensification practices in vine production are greatly contested when it comes to produce high-quality wines, as they have a negative influence on the grape characteristics and the type of wine obtained.

This contribution aims to analyse the process of SI that the wine productive system of the county of Utiel-Requena (Spain) has undergone over the last two decades. This area is worth studying as it is a good example of the Spanish traditional model of bulk wine production at low prices. The vines, which used to be cultivated extensively, have undergone a gradual intensification process.The aim of this contribution is threefold: first, to analyse the mechanisms of intensification of the vine production in the case study; second, to examine the productive models of SI in the vineyards of Utiel-Requena, and third, to determine the driving factors of intensification in the county and their limits. The methodology is based, first, in a literature review on sustainable intensification and wine production, and second, in a workshop held on 2nd February that brought together different stakeholders related with the vine and wine production in Utiel-Requena.

Utiel-Requena is a county located in the in-land area of Valencia. It has a surface of 1,726 km2 and occupies a plateau with an average height of 750 meters. There is a long history of winemaking in this area - the origins of the wine production date back to the 6th century BC (Martínez and Maronda, 2013). By 1944, grapes had surpassed grain production, and the process of specialization that have led to the current vine monoculture accelerated ever since (Piqueras, 1976). The local traditional variety, called ‘Bobal’, is dominant in this plateau due to its high yields and its resistance to agro-climatic adverse events such as droughts, pests and oidium - although it is very sensitive to mildium.

At present, Utiel-Requena is the main wine producing area in the Valencian region. Wine production is the core economic activity in this county, and it is organised around the Protected Denomination of Origin (PDO) of “Utiel-Requena”, which covers most of the vine surface. The membership of the PDO is made up by 5.515 vine producers and 98 wineries.

Furthermore, there is an important auxiliary industry and a number of organisations that shape a wine cluster with high potential of growth.

The wine system in Utiel-Requena is very heterogeneous, embracing farms and wineries with very different technological and productive practices. An intense process of modernization has been taking place since the 1990s. New bottling wineries appeared, all the actors in the value chain have increased their professionalization and investments have been made in new technologies and manufacturing techniques. Although the relative importance of the wine sold in bulk has decreased, it is still dominant.The traditional wine system is characterized by bush-trained vines – mostly rain fed – with a low density (2,000 plants/ha approximately, although it can reach 3,000) cultivated in medium or small-scale farms. The cultivation is little mechanized and there is an intensive use of labour; traditional varieties prevail and the yields, which are medium to low, are very variable (between 1,000 and 6,000 kg/ha), depending on weather conditions, the age of the strains, the location of the vineyard - altitude and latitude - and the crop management. This type of vineyard is intended for both the production of grapes for quality wines with medium-high prices (normally with low agricultural yields) and low-priced wines sold in bulk. The latter is still prevalent, because the price premium of the quality grape does not compensate, in most of the cases, the lower yields of the extensive productive practices. Meanwhile, some unconventional production systems are emerging such as organic or biodynamic production. Their demand is expected to increase, and the favourable natural conditions of the area could eventually allow for a greater diffusion of these productive models.

The modern grape production is characterized by the trellised vineyard, the narrow and high density plantation framework, the highly mechanized cultivation (including harvesting), the systematic use of irrigation, the coexistence of 'Bobal' native variety with foreign varieties (e.g. 'Tempranillo' or 'Cabernet Sauvignon'), and medium-to-high average yields with less variability than in the traditional vine cultivation (the approximate average yield is 12,500 kg/ha). The farms that adopt these practices are medium to large sized. The grapes are destined to the production of a wide typology of wines, excepting those of high quality range. The critical element of the system is the need for irrigation. There have been no significant water supply crises so far, although, by all accounts, an improvement of water management is needed. As has happened in the Spanish wine sector as a whole, there has been a great expansion of the intensive model of production in the region of Utiel-Requena over the last two decades. This transformation is mainly explained by economic reasons – on-farm cost reduction and yield increase-, the existence of public incentives –European subsidies for vineyards restructuring - and new investments made by non-traditional entrepreneurs of the wine business, many of which have opted for intensive production. The underlying driving force of the intensification is the persistence of a model of bulk sales and low prices, which compels producers to increase yields as a way to increase their income. In the medium term, this rationale will deepen in the vicious circle of more quantities and lower prices - a circle that can only be broken by a change in marketing strategies in the search for product differentiation and increase in its price.

The results of these changes fit with the paradigm of SI only as the "intensification" term is concerned. Yields and production have increase while the cultivated area has been reduced. It is not possible, at present, to determine the degree of sustainability of these changes towards espalier and irrigated production, but there are doubts about their environmental impact in a climate change scenario.

Which drivers of farm intensification in Mediterranean coastal periurban areas? The case of Pisa, Italy

Authors: Elisa Marraccini, Irune Ruiz-Martinez and Marta Debolini

The periurban area of Pisa (Italy) is illustrative of the Mediterranean coastal areas urbanization dynamics outside metropolitan areas, showing an annual urban growth of +3%

between 1985 and 2011 (Marraccini et al., 2015). The farming systems in this case study are mainly characterized by cereal-industrial oriented farms representing the most frequent systems (≈50% of the total). The aim of our presentation is to highlight the main dynamics affecting farms in the periruban area of Pisa and which can be the drivers of these dynamics. In order to answer to these two questions, we firstly built a spatially-explicit database of the Italian LPIS (Land Parcel Identification System) data 2007-2015 linked to the cadastral parcels, where we selected a sample of farms having the same manager (67% of the LPIS database). Based on the dominance of crops or groups of crops, we identified 13 different farm types in 2007 and 2015 (Ruiz-Martinez et al., 2016). Among them, the arable crops-based one are the most frequent, e.g. cereal-industrial and cereal-legume systems. The comparison of the farm types in the considered time span allowed to identifying three main farm dynamics: farms unchanging, farms undergoing intensification dynamics and farm undergoing extensification dynamics. Most of the farms remain stable (71%), particularly in the dominant farm types as well as in the olive farm type, rather stable because being a permanent crop. The main transition between farm types is intensification (69% of the farm surface), e.g. cereal-legume farm types shifting to cereal-industrial, legume and legume-industrial types. Also diversified systems like mixed-crops tended to change towards cereal-industrial. On the other side, extensification regarded 31% of the farm surface, e.g. cereal-industrial farms shifting to cereal-legume, mixed-crops or cereal systems. A spatial analysis of the location of the three dynamics demonstrated that these dynamics are poorly spatial organized and do not seem to be linked to the distance to urban areas for the intensification dynamics or a concentration in the natural park area for the extensification one. In order to deeply understand the different drivers of these dynamics we developed a probit model to avoid bias in the analysis of drivers due to spatial autocorrelation effects. Through the modelling approach, we could highlight the farm types showing less changes were related to an increasing elevation and this is quite understandable if linked to the olive groves location, to the agricultural land availability and to the farm diversification (crops). On the other side, the areas having higher farm changes (intensification in this case) are those having fragmented land tenure and a good soil quality. In this context, there are few leverages for local policies to support farm transitions as these transitions mainly have seem to be driven by bio-physical or structural drivers rather than existing policies or individual farmers' characteristics.

Articulating local and regional levels to analyze territorial dynamics

Authors: Sylvie Lardon

In a previous study (Filippini et al., forthcoming), we have designed an inter- and transdisciplinary, multiscale and mixed methods approach to understand the Smart Agriculture (SA) development. We applied the methodology on two Italian case studies. The interdisciplinary findings will be used as a scientific base for the following discussion and work with stakeholders. Researchers have the possibility to test and update their scientifically-based vision of the region, and stakeholders are presented with an integrated scientific knowledge that can serve to impact their everyday life action. The circular system of the methodological pathway is the core of this inter and trans disciplinarity: the involvement of stakeholders nourishes and updates the scientific grid of analysis, thus affecting the quantitative and qualitative analyses and the spatial representation of the territorial dynamic. I will mobilize this approach to design multi-level analysis in a new research on land system dynamics in the Mediterranean basin (Napoleone & Debolini, 2016). The results expected will be presented and the main difficulties met in the previous study will be formalized to anticipate spatial integration.

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