Contribution of agronomy to land management issues - A Comparison of five interdisciplinary PhD theses

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Abstract:

An introductory literature review highlights the growing attention within the processes taking place at farming region and landscape scale beside the classical spatial scales at cultivated/experimental plot level. This recent evolution in agronomy finds its origin in newly emerging land management issues. Meanwhile, geography and other disciplines are stressing the need for a greater integration of multifunctional agricultural activities into the decision-making processes at the various levels of land management, such as provinces, municipalities or watersheds. This requires also that studies on farmland management include explicitly the different environmental and social contexts influencing farming activities. In this paper we aim to analyse how recent agronomic oriented research are facing and supporting various land management issues. We have compared five interdisciplinary PhD theses examining their definitions and methods of analysis for: the farming system, the local land management issues at stake, the spatial scale selected for the study, the stakeholders' involvement and the interaction with other disciplines. Common issues which emerged from this comparison are delivery of agro-environmental services, sustainable land management and landscape conservation. Multiple spatial levels were considered, which included at least one administrative unit of policy decision/implementation. Consequently, the explicit (re)definition of some agronomic concepts and methods was needed. Regarding the interdisciplinary framework, the theses have stressed the interactions among agronomy, geography and ecology. All theses aimed at delivering tools for decision-making support, mainly in the form of cartography. Nevertheless the participation of local stakeholders was generally included as a final step; herewith the settings of stakeholders' involvement were various. In conclusion, we discuss how the produced knowledge has enhanced the land management issues in local planning tools. On these bases, we stress finally the issues at stake to strengthen the roles and contributions of agronomic oriented education and research to agricultural land management and development.

1. Introduction: literature review on spatial scales in agronomy

In the last decades, research has been increasingly challenged by land management issues (hereafter LMIs) (Caron, 2006; Moreno-Mateos and Comin, 2010). LMIs involve different stakeholders from local to regional levels. They concern different human activities, including agriculture, which represent a vast share of the anthropic land uses since it interests 38% of the

global land (World Bank, 2009).Therefore, considering land uses as well as agricultural activities and actors, becomes central in social and biotechnical sciences approaches.

Agronomic research should contribute to this issues with its specific concepts, mainly developed at the field and farm levels but that can adapted to other larger spatial levels. Figure 1 displays how agronomy is able to tackle different LMIs at each spatial scale through specific research concepts (e.g. crop management, crop rotation/sequence, farm management, land evaluation) and other concepts adapted from other disciplines (e.g. land use). These concepts have been initially applied at specific spatial scales, but in the recent literature there was a shift between scales and concepts to adapt to new research questions. Because farmers are the main land managers only on their farmland, the research focus on wider scales requires agronomists and other researchers to explicitly take into account the interaction among multiple stakeholders.

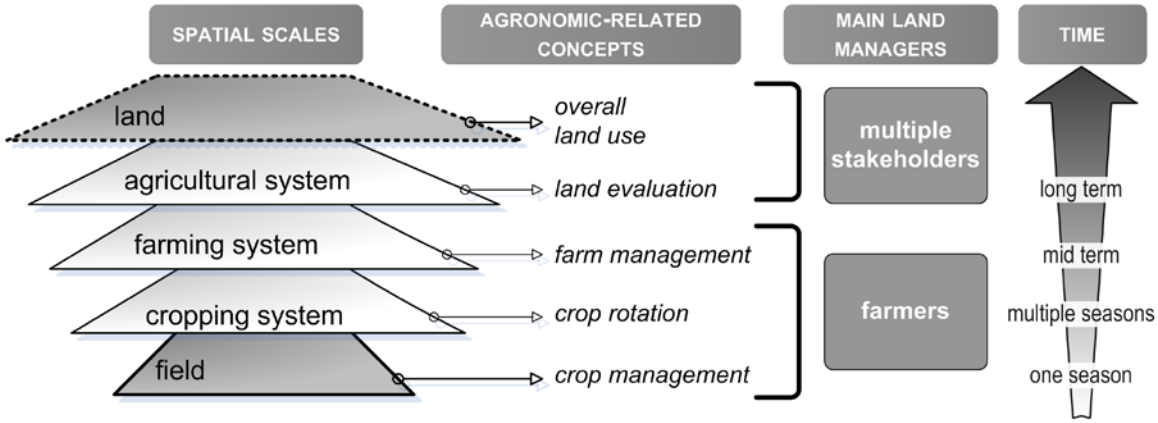

Figure 1: relationship within agronomic research between spatial and temporal levels, agricultural land management issues, types of land managers.

A literature review (Fig. 2) showed an increasing trend of agronomic research on different aspect of land management. The “farm management” issues, however, seems to have a weaker increase than the other topics related to field or land management issues. As displayed by Figure 2, the agronomic-related concepts, e.g. crop rotation or land evaluation, are increasingly taken into account in literature. This trend is observable for all agricultural land management issues and especially for those taking place beyond the farm and field levels (Laurent, 2005).

Two hypotheses could be formulated about this trend. First, society and policy makers growingly expect land management to integrate conservation and sustainable management of natural resources and sustainable development. It follows that a greater interest is accorded to the different spatial components of land management, thus widening the role of the spatial analyses. This could have induced the steady increase in the association between crop management and land, followed by the crop rotation. Second, research on technical choices and single effects of practices at the field level increased because of the increasing emphasis on the links between agriculture and environment. Based on these observations, we could retain that agronomy is growingly considering the LMIs. However, a big challenge remains to articulate in an operational manner the LMIs to the different levels of analysis, from the field to the overall land use. A landscape perspective could be adopted in order to integrate management choices and decision processes of the different stakeholders (Martin et al., 2006).

In this paper we aim to analyze how recent agronomic-oriented research is facing and supporting various LMIs. We have chosen to perform this analysis through PhD theses that illustrate the complexity of LMIs. This will help us pursuing a twofold tradeoff. On one side a PhD thesis generally give a complete description of the research path which is not present in scientific articles due to limited space and difference in objectives of the communication. Consequently, they provide insights on the research otherwise not easily retrievable from journal papers' analysis. On the other side, the theses generally account for all the methodological facets of a project or for the step-by-step interactions with stakeholders.

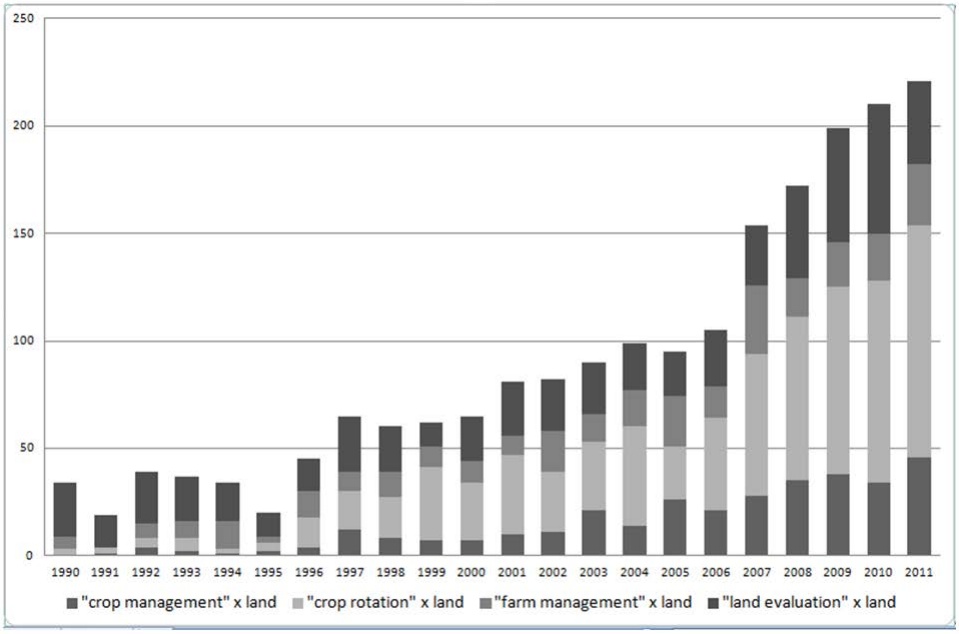

Figure 2: overall increasing trend of studies considering "agricultural land management issues". Results of a bibliographic research performed on the whole SciVerse Scopus® database. The four expressions were searched in title, abstract, key-words of articles and review published in 1990-2011 time span.

2. PhD theses comparison

We compared our five theses (Rizzo, 2009; Toillier, 2009; Debolini, 2010; Marraccini, 2010; Planchat, 2011). Although not exhaustive of the doctoral production on agricultural land management issues (LMIs), we considered these theses as sufficiently illustrative of different interdisciplinary approaches, levels of LMIs analysis, and societal issues at stake. In order to analyze the different ways LMIs are considered in the PhD theses, we defined five points of comparison: the farming system involved (type, location), the local LMIs, the methods used, the spatial scale selected for the study including the levels of analysis, the stakeholders' involvement and the interaction with other disciplines.

The five theses focus on three main topics: the relationships of farming systems with multiple functions of agriculture (Debolini, 2010; Marraccini, 2010), the management priority assessment of a given landscape (Rizzo, 2009), the role for agriculture in territories dominated by environmental and landscape issues (Toillier, 2009; Planchat, 2011). A brief description of each PhD thesis will follow.

2.1 Relationships of farming systems with multiple functions of agriculture

The landscape is not a static system: it is subject to various dynamics driven by landscape processes. These dynamics are strongly interconnected and influence landscape functions. The soil conservation function is a major issue for Mediterranean agricultural landscapes. Debolini (2010) aimed at the characterization and the analysis of environmental degradation processes in a Mediterranean hillside, highlighting agricultural soil uses and drivers of changes. The goal was to evaluate how soil functions have been affected by land use changes on the latest years, and which kind of agricultural management can reduce the risk of function loss. The study applied a multi-scale approach, passing from a regional scale to a watershed scale. The land use change analysis showed constant dynamics, in particular for agricultural lands. Abandonment has been a significant issue since 2002, mainly in the hilly and mountainous areas. As a consequence, an increase in soil erosion has been predicted. In terms of land management, the results could be relevant for policy makers to plan mid-term measures for erosion control by actions for the preservation of traditional agricultural systems and reduction of land abandonment in higher-risk erosion areas.

European policies target several environmental resources used for farming. Difficulties in considering multiple agro-environmental functions (AEF) and farming activities, along with lack of databases, hinder the implementation of such policies at regional scale. Marraccini (2010) proposed an empirical, multi-level and spatial-explicit method to qualify AEF fulfillment at landscape and regional levels, hypothesizing a link between land use patterns and AEF fulfillment obtained from geo-physical conditions influencing agro-environmental concerned processes. The method was tested in two European regions Puy-de-Dome (France) and Grosseto Province (Italy), presenting similar agro-environmental heterogeneity (e.g. varying from arable crops plains to extensive livestock mountains) and different conditions (e.g. soil quality, land use, climate). Even though facing some different AEF, both areas presented a good correspondence between the AEF fulfillment at the farming region and landscape scales. However, different results were obtained on the relationships between land use patterns and AEF fulfillment. Land use patterns may thus be a promising tool to assess AEF only when there is a high AEF spatial variability. This can support the elaboration of a spatial indicator based on land cover configurations for the implementation of territorial agro-environmental policies.

2.2 Assessment of management priorities in an agricultural landscape

The modeling of the relations between bio-physical and management components to evaluate the agro-environmental fragility of a Mediterranean terraced landscape was the aim of Rizzo (2009). The LMI he dealt with was the local need for a decision support system to prioritize the hotspot management areas. This was tackled by developing a conceptual model of the vulnerabilities coupling the environmental constraints and the changes in farming practices. The research had two goals: (i) the co-construction of a landscape information system to consolidate and integrate the knowledge about the farming system management; (ii) the redaction of a handbook to formalize and transmit technical skills necessary to mitigate these vulnerabilities and to answer the LMI. The work was organized in three steps: description, explanation and proposition. The available and the remote-sensing data retrieved to characterize the terraced landscape (“description”) were processed in a GIS-based multi-criteria analysis (“explanation”). The relevancy of the resulting landscape information system was then enhanced by associating a handbook gathering management recommendations (“proposition”). The main results were the two maps of environmental and overall fragilities of the studied terraced landscape. The method proved to be reliable at identifying the extreme classes of fragility. This means that the

assessment of the overall fragility did not check all the most fragile areas but the mapped areas quite reliable.

2.3 The role for agriculture in territories dominated by environmental and landscape issues

Faced with the low success rates of protected areas in conserving natural forests and supporting rural development, the Malagasy government transferred forest management to local communities. Since 1996, contractual forest management involving the local population has been proposed as a solution to deforestation and poverty. Toillier (2009) highlighted the way in which contrasting farming systems can adapt to conservation constraints without threatening sustainability. Using methods from agronomy and geography, she explored farmers' household livelihood strategies and land use changes in response to changing forest access rules arising from community-based land management. Based on in-depth surveys and participatory mapping in the eastern rain forest highlands, she outlined patterns in farmers' responses, exploring the relationship between socio-demographic factors, livelihood strategies, and land use patterns. Results suggest that heterogeneity in farmers' adaptation capacities is closely related to different land use patterns. Furthermore, both conservation and agricultural sustainability have suffered from unintended impacts: an increase of forest clearing, intensification in cultivated area, and an impoverishment of the poorest households. These household adaptation processes suggested that the zoning-based management scheme would benefit from incorporating a more detailed farm level land use approach. Land use patterns can inform the design of improved conservation–development initiatives by revealing strategic indicators that could allow practitioners to target households for conservation measures according to their adaption capacities.

The integration of the farmers' point of view is rarely considered in planning procedures. Planchat (2011) presented a participatory method of landscape mediation called the Prospective Vision, involving graphic and social landscape representations as collaborative learning processes about the LMI. It is applied in two planning projects: Urban Local Planning in Billom (France) and the Landscape Charter of Attert (Belgium). The main results were that the use of landscape representations reveals specific landscape and territorial features at different scales of observation, and facilitates the expression of farmers' points of view and their involvement in planning operations. By the Prospective Vision, rooms for discussions about landscape changes can give birth to a better comprehension of the evolution of the land practices and its agronomic and ecological functions. This method, by sharing agronomic, political and lay knowledge, highlights the challenges of finding new methods for integrate farming stakes into urban planning ones. The way in which the participation of the farmers was encouraged raises the awareness of the officials affected by planning decisions.

3. Results and discussion

Through several criteria displayed in Figure 1 (spatial and temporal levels, agronomic concepts, stakeholders) as well the main points of the analytical grid proposed by Lardon et al. (2012) in terms of reflexivity, co-construction, connection to the field, spatial and temporal relationships and adaptation, we compared the five PhD research. Their common items and contrasts are analyzed hereafter.

3.1 Interdisciplinarity and specific methodologies

All these works were interdisciplinary. Interdisciplinarity can be defined as a mode of research that involves several unrelated academic disciplines in a way that forces them to cross subject boundaries to create new knowledge and reach a common research goal (Tress et al., 2009). Common mobilized disciplines among these studies, although with different importance, were agronomy and geography. This clearly emerged from the theses descriptions because of a large use of spatial analysis, mapping and territorial projects analyses. Hybridization of agronomy and geography can be seen on the spatial representation of farming activities which went beyond a single representation of land cover or land use. It implied, for example, a qualitative spatial representation of agricultural dynamics. Social sciences are also used to analyze ways and results of the stakeholders' involvement and knowledge into the definition and the evolution of the LMI. The researchers should develop specific methodologies to take into account hybridization of the tools, such as spatial representations, interdisciplinary to analyze their results and to integrate stakeholders and territorial issues. This was developed in different methodological Itineraries (Lardon, 2001) in three analyzed thesis: (1) by the use of choremes (Toillier, 2009); (2) by the integration of farmers point of views on landscape future scenarios (Planchat, 2011); (3) by the spatial integration between local agricultural systems and agro-environmental policy-driven zoning (Marraccini, 2010). The two other thesis's specific methods (Rizzo, 2009; Debolini, 2010) concern a multi-criteria model to analyze the integration of agronomical expert-knowledge.

Table 1: Comparison of the five PhD theses. LMI(s) = Land management issue(s). We listed the importance of the different disciplines mobilized during the PhD following from the main to the less important.

Reference	Main LMIs	Farming system	Methods	Spatial scale(s)	Stakeholders involvement	Disciplines
Debolini (2010)	Assessment of soil conservation functions.	Winter cereals and forage-livestock system in internal hilly areas.	Remote sensing, land use change analysis, soil erosion modelling, on-farm surveys	1:250,000 (province) to 1:5,000 (watershed).	Definition of the LMI with intermediate stakeholders, validation of the results and farm management with farmers.	Agronomy, geography, landscape management.
Marraccini (2010)	Agro-environmental functions: surface water and soil quality, landscape conservation.	Mixed systems based on winter crops (Italy), Cattle systems based on grasslands (France).	Geographical clustering, remote sensing, on-farm surveys, textual analyses.	1:300,000 (region) to 1:10,000 (small landscape).	Definition of the LMI by the policy-makers, validation of the identified LMI.	Agronomy, Geography, Landscape Ecology.
Rizzo (2009)	Mapping management hotspots for the landscape conservation.	Agricultural terraced landscape characterized by surface drainage works (Italy).	Remote sensing, GIS, multicriteria analysis, expert panel validation.	1:10,000 to facilitate integration into the local land use planning.	Definition of the LMI, validation of proposals for action (end of the project).	Agronomy, geography.
Toillier (2009)	Manage forest conservation and agricultural development in the territories of the agricultural frontier in the eastern rainforest of Madagascar.	Rainfed farming systems, irrigated rice growing associated with cattle breeding, agroforestry systems.	Remote sensing, land use change analysis, in-depth surveys and participatory mapping at the farm and territory levels.	From the plot (1: 1,000) to 1:100,000 (region)	Land management scenarios at the territory and regional scales, using research results.	Agronomy Geography, management sciences.
Planchat (2011)	Development of participative approaches to integrate farmers and agricultural stakes into urban planning.	Cereals and arable crops on a volcanic area (France), agro-forestry with cattle (Belgium).	Surveys with the farmers and local stakeholders using landscape features and participatory tools.	1:25, 000 (municipality) to 1:1,000 (owner plot).	Characterization and visualization of the LMIs and integration of farmers' proposals into the final project.	Geography, sociology, agronomy, law.

Integration of agronomic and geographic concepts and tools required the in-depth knowledge of both disciplines. This knowledge can only be acquired during a long period (a PhD time span) and has to be well-targeted. There exist different ways to include such knowledge during a PhD path. In one case (Rizzo, 2009), two summer-schools on transdisciplinary methods were determinant to integrate the ordinary agronomic educational path. The two intensive courses (2004, Wageningen University and 2005, Nottingham University and Portuguese chapter of the International Association for Landscape Ecology - IALE) aimed to the interdisciplinary exchange

among PhD students and researchers affiliated to the landscape ecology community. The greatest part of the attendants was pursuing a thesis on a landscape-related research question but with different disciplinary backgrounds. This provided room for exchange about methods and practical problem (e.g. difficulties in dealing with real case-studies or semantic issues). Then the formal part of the course, also like a PHD master class (Planchat 2006; Tress et al., 2009), added information on theories for integrative researches, especially when interdisciplinary approaches are joined with stakeholders' involvement. In the case of Marraccini (2010), the participation to a training program on reflexivity analysis of the PhD, allow a better recognition of the specificity of agronomic knowledge contribution in the PhD research. The main points of the methodological path interacting with other disciplines were analysed. Finally, for four PhDs out of five, there was a common participation in winter schools in landscape agronomy performed in 2007 and 2009 with the aim of a better conceptualization of the contribution of agronomy to landscape issues (Rapey et al., 2008; Moonen et al., 2010).

3.2 The place of land management issues to highlight a new knowledge

Several Land Management Issues (LMIs) were analyzed in the theses, in different purposes, from environmental issues such as water and soil protection, landscape conservation and management to complex analysis of sustainability of the local resources uses. A part of them was related to the assessment of functions of agriculture (Debolini, 2010; Marraccini, 2010) recognized either by local experts either in local authorities plans and documents. Among them, common were those related to landscape conservation and soil quality protection. In other cases, the LMIs were more integrated to specific policies and plan implementation (Toillier, 2009; Planchat, 2011) by a specific work on local environmental or policy measures. An intermediate case was Rizzo (2010) whose fragility assessment of the terraced area was afterward included as one of the cartographic supports for the territorial planning documents of the local municipality.

LMIs have been approached in three different ways by the theses. A first approach aimed at supporting decisions of local stakeholders (Rizzo, 2009; Planchat, 2011). In this case, there was an early integration of the stakeholders into the research, fostered until a co-construction of the research question. A second approach concerned a better understanding of local dynamics (Toillier, 2009; Debolini 2010), which included different phases of stakeholders involvement. A third approach aimed at producing knowledge in order to design new indicators (Marraccini, 2010), which has the minimum involvement of stakeholders as source of local knowledge on farming practices and environmental issues. In synthesis, the relevance of stakeholders' involvement was depending on the research questions: where the LMI was known beforehand, the research was able to develop a deeper integration of the stakeholders' network (first approach). On the contrary, the involvement of stakeholders in the research were the LMI still required a more consistent assessment (second and third approaches).

In dealing with those LMIs, a common trend was the consideration of multiple case studies, either in the same country but concerning contrasted areas (Toillier, 2009), either concerning different countries (Marraccini, 2010; Planchat, 2011). When this was not done, a higher attention was giving on LMIs dynamics or on multi-spatial analysis (Rizzo, 2009; Debolini, 2010).

3.3 Spatial scales

Another common item on these researches was the consideration of multiple spatial scales in dealing with LMIs (Table 1) because of the impact it could have on the obtained results. These points on multiple case studies and multiple spatial/temporal levels are very important since they reinforce research findings, find different local answers to LMIs or test methodological adaptations. Among these scales, at least one was an administrative one, considered because of

the level of implementation or assessment or evaluation of the policies concerning the LMIs. Another common scale was those of the farm or group of farms functioning, which was a micro-scale going from 1:1,000 to 1:10,000. A relevant importance had the consideration of the watershed scale, because it can influence many environmental processes analyzed as LMIs. The use of multiple scales is justified in the theses by the need to cope with a complex field reality in the analysis and assessment of LMIs. Because such LMIs involve several levels that interact, there is a need to better understand and take them into account.

The mobilization of different spatial levels ask the PhDs to enlarge their competences, going beyond the level of farm functioning and considering also other dynamics and actors than farmers. Adapting the reading scale of the issues helps the different actors to appropriate the stakes and management of the LMIs according to their territorial point of view and knowledge. In many of the analyzed theses, such actors were not only coming from local authorities implementing policies, but were also intermediate between authorities and farming so being more indirectly involved in land management but indeed influencing land managers practices. Among them, members of co-operatives (Debolini, 2010; Marraccini, 2010), technical or institutional advisors (Rizzo, 2009; Toillier, 2009) but also urban citizens (Planchat, 2011). Because at each level and for each research question, methods and tools had to be adapted to the context, we believe that dealing with different scales and different actors is a challenge for agronomical studies in land management issues.

Conclusion

We analyzed the role of agronomy in dealing with land management issues from our five PhD theses. Common items of these works were the interdisciplinarity (mainly agronomy and geography), the analysis at multiple spatial levels (generally starting from the region and going to the farm/plot), the stakeholders involvement which took different forms (from the validation of the results to the co-construction of the research), and the general multi-site analysis (ranging from different case studies to different case studies location). All these items appeared to be essential when working in land management issues involving agricultural land in order to generalize research findings, taken into account the spatial mismatches between farming spatial levels (plot, groups of plots, farm, group of farms), environmental functioning (watershed, common feature landscape), planning (territorial processes) and stakeholders expectations (farmers, officials). Although agronomy could effectively contribute to better take into account farm functioning beyond a simple type of land use, this approach was poorly developed in our literature review. For agronomy these points call for a certain number of issues and especially a balance between practical applicability and theoretical advancement. Practical applicability is the ability of a PhD to adapt his research between fundamental research and the field reality. In agronomy, a PhD student needs to acquire the capacity to formalize specific methodologies, and organize them in a methodological itinerary. Furthermore, PhD needs specific education for participatory research practices. Hence, there is a need of a better involvement either on the educational side (MSc and PhD courses) either during PhD research, of a larger confrontation with other disciplines theories, hypothesis and methods. Finally, dealing with LMIs requires agronomy, as well as other environmental management sciences, to bridge the gap with human sciences particularly those related to geography and sociology.

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