Davide Rizzo
Elisa Marraccini
Sylvie Lardon *Editors*

Landscape Agronomy

Advances and Challenges of a Territorial Approach to Agricultural Issues

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Editors
Davide Rizzo
InTerACT UP 2018.C102
Institut Polytechnique UniLaSalle
Beauvais, France

Elisa Marraccini
Department of Agricultural, Food,
Environmental and Animal Sciences
University of Udine
Udine, Italy

Sylvie Lardon
INRAE, AgroParisTech
UMR Territoires
Clermont-Ferrand, France

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This book is dedicated to Enrico Bonari (Scuola Superiore Sant'Anna, Pisa) and Marc Benoît (INRAE, Mirecourt) for their crucial contribution to the emergence of Landscape Agronomy and their central role to set the scene for its development in Italy and France, as well as for their support from the very beginning of this book.

Preface and Overview

Agricultural activities manage most land on Earth and cause faster changes than any other human land use. Although the landscape is widely identified as a relevant target by both integrated policies and the disciplines involved in resource management and territorial planning of land uses, agriculture is still addressed mainly at the field and farm levels. This book aims at providing a stronger interface between agronomy and landscape science to better describe and understand farmers' practices within a territorial context. To this end, the book provides an overview of various research approaches that address agriculture at the landscape level, expanding on two seminal articles that first introduced the Landscape Agronomy conceptual model (Benoît et al. 2012) and then developed its approach for research, education and training within the domain of farming system research (Lardon et al. 2012). Landscape Agronomy promotes greater involvement of agricultural sciences in this domain by increasing the attention paid to the dynamics that relate farming practices to natural resources and the temporal and spatial patterns of land cover and land use.

Structure of the Book

The book covers the background that improved the interdisciplinary and transdisciplinary interface between agronomy and spatially explicit disciplines, such as landscape ecology, geography and other landscape-research domains, for purposes of research, education and training. The ten chapters of this book are organised in a three-part structure that revolves around three key research actions to address agricultural landscape dynamics—observing, understanding and supporting actions (Fig. 1)—which were inspired by books on geoagronomy for territorial management (Benoît et al. 2006; Lardon 2012).

Chapter 1 summarises the scientific background and state of the art about how agriculture is addressed at the landscape level. As such, it provides an overview of the distinguishing characteristics of Landscape Agronomy based on the scientific

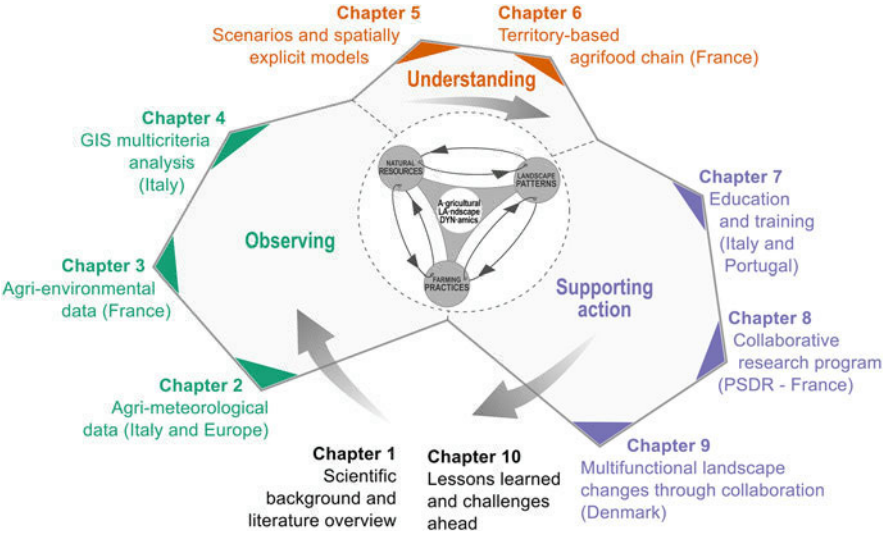

Fig. 1 Overview of the book's structure and organisation of its ten chapters into three parts. The Landscape Agronomy conceptual model lies at the centre. (Adapted from Benoît et al. 2012)

literature. After this introduction of the key concepts that led to the development of the Landscape Agronomy conceptual model, eight chapters provide examples of and insights into how to observe (Part I), understand (Part II) and support stakeholders' actions (Part III) to address agricultural landscape dynamics.

Part I, Observing. The specific characteristics of Landscape Agronomy are to know how to combine natural and human data in order to combine the three dimensions—material, ideal and organisational—of the territorial approach of Di Méo (1998). The three chapters in Part I show how and why observing agriculture at the landscape level is relevant. Chapter 2 starts with agro-meteorological data across Italy and the rest of Europe, while Chap. 3 expands on several agro-environmental databases and how they are integrated into modelling, with a focus on France. Finally, Chap. 4 provides an example of a spatially explicit approach to identify agricultural management hotspots at the landscape level.

Part II, Understanding. The Landscape Agronomy conceptual model focuses on spatial and temporal patterns produced by interactions between practices and resources. Observing past and present practices, resources, and patterns can also feed the spatially explicit prospective by learning from the past to manage the present and anticipate possible futures. Chapter 5 discusses methodological issues and prospects of combining scenarios and spatially explicit models to explore futures in agricultural landscapes, using modelling to increase understanding of their dynamics.[1] Chapter 6 supplements understanding by highlighting the relevance of governance

[1] Chapter 5, the first contribution received for the book, was written in 2016; consequently, its references are not as recent as those in other chapters.

as the organisational dimension of the territorial approach, using Quality Management Systems in territory-based agrifood chains as a case study. Indeed, food production highlights a highly integrated perspective that is characterised by conflicts and coordination among supply chains and logistics, supply areas and production areas (see also Le Bail and Le Gal 2011). This perspective ultimately includes consumers and other stakeholders in the multi-part governance of the environmental and agricultural landscape (Acevedo 2011; Kissinger et al. 2013; Scherr and McNeely 2008).

Part III, Supporting action. By combining farming practices with resources and patterns, the Landscape Agronomy conceptual model supports the development of interdisciplinary research, as well as education and training programmes, which facilitates dialogue between researchers and stakeholders through cross-learning (Moonen et al. 2010; Orchard and Hackney 2016). By shifting the focus from the farm to the landscape level and beyond, Landscape Agronomy encourages a cross-scale approach in both space and time. This approach integrates the viewpoints of multiple stakeholders by addressing the complementarities of practices and patterns (see Munroe et al. 2014); ultimately, it helps identify the relevant space for action (i.e. land-management units) in which to pursue synergies and manage conflicts (Kågström and Richardson 2015; Rizzo et al. 2013). Nevertheless, new skills must be developed to support action at the landscape level; this can be done by integrating interdisciplinarity, reflexivity and connection to the field in a wider spatio-temporal method that is adapted to landscape changes (Lardon and Albaladejo 2012). Chapter 7 illustrates how to combine disciplines and connect research and action in training programmes. Then, Chap. 8 analyses a multidisciplinary approach to understanding territorial dynamics and issues by discussing the example of a French collaborative research programme. Finally, Chap. 9 discusses outcomes of collaborative landscape planning in Denmark that was performed over a long period and involved different types of farmland owners and other stakeholders, including public authorities.

Chapter 10 concludes the book by describing some lessons learned. It uses the Landscape Agronomy conceptual model to examine three examples of public policies in order to highlight some challenges ahead for supporting action at the landscape level, at which agriculture is expected to be a major player.

Recommendations

The main target audience of this book includes researchers and policy- and decision-makers who need or want to describe, understand and manage agriculture beyond the farm level by involving farmers and stakeholders who operate at a landscape level. This book follows the ideas of the French book *Pays, Paysans, Paysages* (INRA-ENSSAA 1977), which brought attention to the crucial role of agriculture in managing the local economy, resources and culture by associating the territory (as an administrative entity), farmers and the landscape. The book's authors intended "landscape" to represent an overall agricultural outcome that included the economy, environment and local socio-cultural identity. More than 40 years later, the title could be rephrased and developed as "Participation, Prospective and Public Policies" (Lardon 2017) to address agriculture within the wider commitment to achieve sustainability of human activities, among which the United Nations' Sustainable Development Goals are the best known targets.

This book also draws upon the original article about Landscape Agronomy (Benoît et al. 2012), which highlighted interactions among farming practices, natural resources and landscape patterns. The conceptual model frames all approaches to agriculture at the landscape level within a global vision, which helps understand what may be lacking to reach a system perspective. The Landscape Agronomy conceptual model is meant to guide the design of research, education and training (Lardon et al. 2012) by raising awareness about the components and relations of a system approach to agriculture within the landscape sciences. The ten chapters of this book show that the conceptual model has helped to do the following:

- Combine natural and human data
- Integrate the three dimensions of a landscape-level approach: materiality, projectuality and socio-institutional organisation
- Connect space and time, by learning from the past, helping to manage the present and anticipating the future, based on interactions among the three pillars of a landscape-level approach to agriculture (practices, resources, and patterns)
- Bridge academia and action, as well as research and education within academia
- Connect multiple scales and levels of space and time

The chapters also highlight some challenges ahead for Landscape Agronomy. In addition to further developing ***methods*** that can integrate the three pillars of the conceptual model, agronomy is also called upon to deal with new ***stakeholders***, intermediate structures, entrepreneurs and a variety of "citizens' groups" who are stakeholders of multiple transitions at the landscape level. Here, ***transitions*** refer to integrated, participative and cooperative approaches that call for the systemic dimension of territorial management, which involves all stakeholders concerned, considers the impacts of projects and connects sectoral policies. In this vein, research and knowledge production could therefore benefit from developing and using integrated (i.e. interdisciplinary and transdisciplinary) education and training programmes. It is also important to consider the deep influence of the ***digitalisation*** of knowledge production and sharing in agricultural and rural areas (Debryune et al. 2021). To continue to achieve these goals and meet the challenges of system transitions towards sustainable agriculture, this book formulates the following recommendations for agronomy and other disciplines that address agriculture at the landscape level:

Develop spatially explicit prospective modelling to help farmers and other land managers design context-aware futures.

Enhance integration of local knowledge to enrich scientific expertise by increasing the involvement and participation of all stakeholders who support farmers and to develop with them agricultural knowledge and information systems.

Hybridise knowledge from multiple disciplines and between academia and local stakeholders by integrating goals of multiple stakeholders to address the territorial transitions underway, whether agroecological or of other types.

Strengthen interactions between agronomy and other disciplines to design new forms of landscape-level organisation of agricultural development models.

Support development of adapted territorial governance methods and policies by easing the context-aware integration of technical governance (e.g. services, practices) with political governance (e.g. agreements, protocols, methods) and financial governance (i.e. resources, prioritisation) in a system perspective.

The book shows that the Landscape Agronomy conceptual model remains relevant to help bridge agronomy and other disciplines involved in observing, understanding and supporting actions of agriculture at the landscape level. In particular, it highlights the specific contribution of agronomy to landscape science, namely, to enhance synergies between farming practices and other territorial activities. However, new tools and approaches are required to implement it further. We hope this book will serve as an inspiration for those agronomists who seek to address agriculture from a landscape perspective, as well as for colleagues from other disciplines and practitioners who deal with agricultural landscape dynamics, to capture potential interactions and opportunities.

Beauvais, France — Davide Rizzo
Udine, Italy — Elisa Marraccini
Clermont-Ferrand, France — Sylvie Lardon

References

Acevedo MF (2011) Interdisciplinary progress in food production, food security and environment research. Environ Conserv 38(2):151–171. https://doi.org/10.1017/S0376892911000257

Benoît M, Deffontaines J-P, Lardon S (2006) Acteurs et territoires locaux. Vers une géoagronomie de l'aménagement. Editions Quae, Versailles

Benoît M, Rizzo D, Marraccini E, Moonen AC, Galli M, Lardon S, Rapey H, Thenail C, Bonari E (2012) Landscape agronomy: a new field for addressing agricultural landscape dynamics. Landsc Ecol 27(10):1385–1394. https://doi.org/10.1007/s10980-012-9802-8

Debryune L, Brunori G, Casares B, Nieto E (2021) Key digital game changers in shaping the future of agriculture in 2040. View's from DESIRA's rural digitalisation forum experts. DESIRA EU Project

Di Méo G (1998) Géographie sociale et territoires. Nathan Université, Paris

INRA-ENSSAA (1977) Pays Paysans Paysages dans les Vosges du Sud. Les pratiques agriocoles et la transformation de l'espace. I. INRA, Paris

Kågström M, Richardson T (2015) Space for action: How practitioners influence environmental assessment. Environ Impact Assess Rev 54, 110–118. https://doi.org/10.1016/j.eiar.2015.06.003

Kissinger G, Brasser A, Gross L (2013) Reducing risk: landscape approaches to sustainable sourcing. EcoAgriculture Partners, on behalf of the Landscapes for People, Food and Nature Initiative, Washington, DC

Lardon S (2012) Géoagronomie, paysage et projets de territoire. Sur les traces de Jean-Pierre Deffontaines. Editions Quae, Versailles

Lardon S (2017) Agricultures et territoires : parcours insolites et permanences inattendues. Agron Environ Soc 7(2):149–155

Lardon S, Albaladejo C (2012) Analyzing research-training practices for agriculture and territory development: issues for research and education. In: Noe E, Kjeldsen C, Alroe H, Christensen J, Sriskandarajah N, Milestad R (eds) Producing and reproducing farming systems. New modes of organisation for sustainable food systems of tomorrow. International Farming Systems Association, Aarhus, p 9

Lardon S, Moonen A-C, Marraccini E, Debolini M, Galli M, Loudiyi S (2012) The territory agronomy approach in research, education and training. In: Farming systems research into the 21st century: the new dynamic. Springer, Berlin, pp 257–281

Le Bail M, Le Gal P-Y (2011) Analyse et Conception Des Systèmes de Production Végétale à l'échelle Des Bassins d'approvisionnement Agro-Alimentaires. Agron Environ Soc 1(2):75–86

Moonen AC, Galli M, Lardon S, Rapey H, Silvestri N, Benoît M, Thenail C, Marraccini E, Rizzo D, Debolini M, Bàrberi P, Bonari E (2010) A winter school in landscape agronomy and the synergies it created. In: Darnhofer I, Grötzer M (eds) Building sustainable rural futures. The added value of systems approaches in times of change and uncertainty. University of Natural Resources and Applied Life Sciences, Vienna, pp 2176–2183

Munroe DK, McSweeney K, Olson JL, Mansfield B (2014) Using economic geography to reinvigorate land-change science. Geoforum 52:12–21. https://doi.org/10.1016/j.geoforum.2013.12.005

Orchard PW, Hackney B (2016) A simple tool for extending agronomic management on a landscape basis. Landsc Ecol 31(2):239–242. https://doi.org/10.1007/s10980-015-0251-z

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

Scherr SJ, McNeely JA (2008) Biodiversity conservation and agricultural sustainability: towards a new paradigm of "ecoagriculture" landscapes. Philos Trans R Soc Lond B Biol Sci 363(1491):477–494. https://doi.org/10.1098/rstb.2007.2165

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Contents

Contributors

Roberta Alilla CREA Research Centre for Agriculture and Environment, Rome, Italy

Jean-Noël Aubertot UMR AGIR, INRAE, Université Fédérale de Toulouse, Castanet-Tolosan, France

Rémy Ballot UMR Agronomie, Université Paris Saclay, INRAE, AgroParisTech, Thiverval-Grignon, France

Marion Bardy US InfoSol, INRAE, Orléans, France

Maria Carmen Beltrano CREA Research Centre for Agriculture and Environment, Rome, Italy

Patrick Bertuzzi US Agroclim, INRAE, Avignon, France

Enrico Bonari Center of Plant Sciences, Scuola Superiore Sant'Anna, Pisa, Italy

Pierre Cellier UMR EcoSys, Université Paris Saclay, INRAE, Thiverval-Grignon, France

Julie Constantin UMR AGIR, INRAE, Université Fédérale de Toulouse, Castanet-Tolosan, France

Philippe Debaeke UMR AGIR, INRAE, Université Fédérale de Toulouse, Castanet-Tolosan, France

Marta Debolini INRAE, Avignon Université, UMR 1114 EMMAH, Avignon Cedex 9, France

Flora De Natale CREA Research Centre for Agriculture and Environment, Rome, Italy

Patrick Durand INRAE, Institut Agro, UMR SAS, Rennes, France

Chiara Epifani CREA Research Centre for Agriculture and Environment, Rome, Italy

Stanislao Esposito CREA Research Centre for Agriculture and Environment, Rome, Italy

Laurence Guichard UMR Agronomie, Université Paris Saclay, INRAE, AgroParisTech, Thiverval-Grignon, France

Thomas Houet LETG – Rennes Laboratory UMR 6554 CNRS, University of Rennes, Rennes, France

Frédéric Huard US Agroclim, INRAE, Avignon, France

Eric Justes UMR AGIR, INRAE, Université Fédérale de Toulouse, Castanet-Tolosan, France
Persyst Department, CIRAD, Montpellier, France

Lone Søderkvist Kristensen Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark

Sylvie Lardon INRAE, AgroParisTech, UMR Territoires, Clermont-Ferrand, France

Christine Le Bas US InfoSol, INRAE, Orléans, France

Elisa Marraccini Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Udine, Italy

Catherine Mignolet UR ASTER, INRAE, Mirecourt, France

Giovanni Dal Monte CREA Research Centre for Agriculture and Environment, Rome, Italy

Anna-Camilla Moonen Group of Agroecology, Center of Plant Sciences, Scuola Superiore Sant'Anna, Pisa, Italy

Nicolas Munier-Jolain UMR AgroEcologie, INRAE, Dijon, France

Barbara Parisse CREA Research Centre for Agriculture and Environment, Rome, Italy

David Qvist Pears Ministry of Environment and Food of Denmark, Copenhagen, Denmark

Teresa Pinto-Correia MED – Mediterranean Institute for Agriculture, Environment and Development & Departamento de Paisagem Ambiente e Ordenamento, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal

Antonella Pontrandolfi CREA Research Centre for Agriculture and Environment, Rome, Italy

Jørgen Primdahl Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark

Nalini Rakotonandraina InTerACT UP 2018.C102, Institut Polytechnique UniLaSalle, Beauvais, France

Guy Richard DEPE, INRAE, Paris, France

Davide Rizzo InTerACT UP 2018.C102, Institut Polytechnique UniLaSalle, Beauvais, France
IRD, UMR LISAH, Montpellier, France

Tiziana Sabbatini Center of Plant Sciences, Scuola Superiore Sant'Anna, Pisa, Italy

Loïc Sauvée InTerACT UP 2018.C102, Institut Polytechnique UniLaSalle, Beauvais, France

Claudine Thenail UMR 980 BAGAP, INRAE, Rennes, France

Olivier Therond UMR LAE, Université de Lorraine, INRAE, Colmar, France

André Torre UMR Sadapt, University Paris Saclay, INRAE, AgroParisTech, Paris, France

Peter H. Verburg Environmental Geography Group, Faculty of Science, VU University Amsterdam, Amsterdam, The Netherlands
Research Unit Landscape Dynamics, Swiss Federal Research Institute WSL, Birmensdorf, Switzerland

Frederic Wallet UMR Sadapt, University Paris Saclay, INRAE, AgroParisTech, Paris, France

Jean-Pierre Wigneron UMR ISPA, INRAE, Villenave d'Ornon, France

Chapter 1
Agriculture at the Landscape Level: Scientific Background and Literature Overview

Davide Rizzo, Marta Debolini, Claudine Thenail, Sylvie Lardon, and Elisa Marraccini

Abstract Addressing agriculture at the landscape level leads to dealing with agricultural landscapes, defined here as landscapes that contain mainly agricultural land uses. In this chapter, we focus on how agronomy and other disciplines have addressed to date agriculture beyond field and farm management. The landscape agronomy framework suggests that addressing agriculture at the landscape level allows farmers to be included with other stakeholders involved in spatially explicit management of natural resources. This framework also bridges gaps with other disciplines that work to describe and understand agricultural landscapes and their management. In addition to this qualitative summary of the scientific background, we present results of a bibliometric analysis that used the CorTexT platform to explore research keywords, (inter)disciplinary bridges and emerging issues related to these topics. The results highlighted the emergence of climate change, ecosystem services and management practices in the literature related to agronomic terms, especially when landscape is explicitly mentioned in publications' titles, abstracts

D. Rizzo (✉)
InTerACT UP 2018.C102, Institut Polytechnique UniLaSalle, Beauvais, France

Present address: IRD, UMR LISAH, Montpellier, France
e-mail: davide.rizzo@ird.fr

M. Debolini
INRAE, Avignon Université, UMR 1114 EMMAH, Avignon Cedex 9, France

IAFES Division, CMCC Foundation – Euro-Mediterranean Centre on Climate Change, Sassari, Italy

C. Thenail
INRAE, UMR 980 BAGAP, Rennes, France

S. Lardon
INRAE, AgroParisTech, UMR Territoires, Clermont-Ferrand, France

E. Marraccini
Department of Agricultural, Food, Environmental and Animal Sciences, University of Udine, Udine, Italy

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or keywords. In the end, we draw conclusions about potential improvements to this conceptual framework and introduce the structure of the present book about advances and challenges of a territorial approach to agricultural issues.

Keywords Agronomic literature · Conceptual framework · Bibliometric analysis · Interdisciplinarity · Landscape sciences

1.1 Introduction

Agriculture is the largest human land use. Based on FAOSTAT data for 1990–2019, agriculture—including tilled and fallow land, and naturally grown permanent meadows and pastures used for grazing, animal feeding or other agricultural purposes—covers ca. 4.8 billion hectares, corresponding to 37% of the Earth's total land area (i.e. excluding inland and coastal waters). The remaining land uses are ca. 31% of forest and 32% for all other land uses (see faostat.org). The general definition of "agricultural land use" describes a wide variety of practices and thus of territorial dynamics (i.e. dynamics associated with the design, control and management of land by farmers and related stakeholders). Farmers have direct control over farm fields. Beyond the fields, however, many stakeholders are involved in agricultural land use, with dynamics that connect local and global processes, public stakeholders and civil society and expert knowledge and lay knowledge. In this context, landscape agronomy (Benoît et al. 2012) calls agronomists, as well as other researchers who study agriculture, to join the arena of landscape research. In fact, agricultural research can contribute operational knowledge about farming practices beyond the field and farm levels to the spatially explicit and integrated management of natural resources.

Addressing agriculture at the landscape level leads to dealing with agricultural landscapes, defined here as landscapes that contain mainly agricultural land uses. In this vein, agricultural landscapes are "dynamic systems" in which changes in the underlying human and natural processes shape structures, functions (e.g. the provision of environmental services) and the related values and costs (Tapio-Bistrom et al. 2013). More generally, "landscape" is a polysemic word that is defined based on the aims of the stakeholders concerned. Nonetheless, the Council of Europe Landscape Convention defined "landscape" as part of the land, as perceived by local people or visitors, which evolves through time as a result of being acted upon by natural forces and human beings (see COE 2000 art. 1a). As such, it also helped to clarify actions and interactions with landscapes, especially public authorities' awareness of the need to frame and implement landscape policies (Council of Europe 2014). Altogether, each landscape results from the dynamic combination of elements whose multiple functions and properties emerge from the decision-making processes that rule and shape its features and, ultimately, its character.

This chapter provides a scientific background and literature overview of how agriculture has been addressed at the landscape level. First, we briefly recall the history of agronomic approaches beyond the field and farm levels, up to the landscape level, to explain why the development of landscape agronomy as a framework for addressing agricultural landscape dynamics matters. We widen the perspective to other scientific approaches that address agriculture, moving from farming system research to land science and the landscape approach. We then describe how we analysed the scientific literature to identify current and emerging trends in publications related to agricultural topics, with a focus on subsets of the landscape-oriented literature. We conclude by describing the main lessons learned from this qualitative and quantitative overview and summarising why addressing agriculture within dynamic systems of the agricultural landscape remains relevant. The conclusion illustrates the topics and structure examined in detail in the rest of the book.

1.2 Approaches to Agriculture at the Landscape Level: Why Landscape Agronomy Matters

Since the early twentieth century, agronomy has been defined as the science and engineering of the biotechnical management of productive vegetation cover. It combines knowledge on biotic and abiotic processes and techniques to enhance crop/grass management (van Ittersum et al. 2003; Stöckle et al. 2003) and, ultimately, production practices. Practices are farmers' diverse ways of achieving production goals based on a given (theoretical) production technique. As such, agronomy bridged towards ethnology to study crop management and farming practices, and towards management science and system theories to study cropping systems and farming systems. A crop management system is a set of field operations (techniques/practices) designed and coordinated to result in a given quality and quantity of crop production (Aubry et al. 1998; Renaud-Gentié et al. 2014). The crop management system and the associated crop sequence (theoretically, a crop rotation) are combined into a "cropping system" (Sebillotte 1990).

Beyond the crop level, production practices are organised within a farm system, in which a specific management system implements one or more production systems, such as crop or animal production (Keating et al. 2003). Farm systems are framed in the wider definition of a "land-use system" in which biophysical subsystems are implemented by managing diverse inputs and outputs (Stomph et al. 1994). In this sense, agroecology, as presented by Altieri (2002), is an example of the awareness of the need to include the entire farming system within the wider socio-environmental context. In their exhaustive review, Darnhofer et al. (2012) discussed the history and main topics of farming system research. Farming system research emerged in the 1980s as a response to several questions that were poorly addressed by agricultural research, which focused more on a continual search for economic and technical efficiency. The mainstream approach appeared to be particularly successful under stable and homogenous conditions but failed to consider the complexity of production conditions. Initially, farming system research focused on the farm as the unit of study for several issues related to agricultural production. Later, the scale of analysis was broadened to include natural, social or economic contexts that interact with farms. Currently, the farm remains the main element of the system studied in farming system research, although this discipline has widened its boundaries towards all issues in which the farm dimension plays a role. As such, three characteristics are being integrated into farming system research: systems thinking, interdisciplinarity and a participatory approach.

Moving the focus beyond the field and farm addresses two higher levels: territory and landscape. The concept of territory is related to the assessment and administration of human interests that manifest themselves in a given area. The concept of landscape deals instead with how to help manage a spatial entity whose boundaries cross multiple human territories and support a variety of ecological and societal functions that surpass administrative zoning. For instance, the landscape level is relevant for addressing agriculture within a water catchment, which is an ecological entity that includes multiple farm management systems (Rizzo et al. 2019).

Farm management has a strong territorial management dimension, which used to be addressed by geography. In social geography, a social group's appropriation, identification and management of a given area define a territory that involves classification, communication and control (Di Méo 1998; Sack 2001). Describing and understanding forms of farm territorial management became the basis for identifying agrarian/agricultural systems in regional and geographical studies. The concept of "agrarian system" describes all relationships between an agricultural society and the land under its control and management. The French term "terroir" is similar to the concept of territory when associated with an agricultural system characterised by specific types of (food) production (Prévost et al. 2014). This terroir constitutes the specific unit of organisation of the agricultural society in space (Sautter and Pélissier 1964). The boundaries of an agrarian system or terroir can be fixed and well defined in certain cases (e.g. for products labelled with a protected designation of origin) but mobile or fuzzy elsewhere (Cochet 2012).

Agriculture is the major driver of land-use/land-cover changes (LUCCs) at multiple spatial scales, hence a key factor that influences global changes (e.g. climate, biodiversity), and an activity that should adapt in turn to these changes. Awareness is increasing that agriculture relies not only on specific biological processes and farming practices but on the diversity of ecological processes and territorial dynamics; describing, understanding and managing these dynamics require going beyond the field and farm levels to the landscape level, especially for the assessment and provision of ecosystem services (Robertson and Swinton 2005). Addressing agriculture beyond the field and farm levels thus means considering multiple biophysical systems and administrative/economic systems (Dalgaard et al. 2003; Stomph et al. 1994). Research on land-use systems in geography, economics and ecology has described these systems at large scales. The landscape level has thus become a research target for a variety of scientific perspectives, including agricultural perspectives. The main gap in knowledge to meet these goals fully is identifying who will manage these ecosystem services and how they will do so. At the same time, agronomists, agricultural advisers and other stakeholders involved in agricultural innovation are expected to help farmers address many new demands: how should farm biodiversity be maintained? How should soil erosion be reduced from a catchment perspective? How should green corridors be maintained and managed from local to European scales? How should farmers adapt to or mitigate local impacts of climate change? How should activities be diversified to improve connections with peri-urban and urban communities (Tapio-Bistrom et al. 2013)?

Ultimately, is agronomy needed and suited to address agriculture at the landscape level? The etymology of the word "agronomy" (*ἀγρός*, field + *νόμος*, rule) refers directly only to the "field" and not to any other temporal or spatial concepts. Agronomy has been defined as systematic knowledge of rules that govern fields (Buisson 2013; Sebillotte 2006). In line with this, agronomy essentially seeks to increase crop yields by improving the farming practices applied to fields (van Ittersum and Rabbinge 1997; Russell 1917). Nevertheless, agronomic approaches have gone beyond the field level to explore its relationships with neighbouring fields and contextual features. Examples include studies of the planning of land reclamation (Serres 1600; Tyagi and Dhruva Narayana 1983) or of drainage and irrigation systems (Ritzema et al. 2006), measures to prevent soil erosion (Joannon et al. 2006; Ridolfi 1827; Stanchi et al. 2012) as well as landscape-level assessment of terracing (Cots-Folch et al. 2006; Tarolli et al. 2019; Zanchi 2005) and hedgerows (Thenail 2002). This also reflects the gradually increasing recognition of agricultural landscapes as complex socio-environmental contexts that may influence field management (Costantini and Barbetti 2008; Deffontaines et al. 1995; Galli et al. 2010; van Mansvelt 1997; Sereni 1997; Valbuena et al. 2010). Some authors highlighted that, in the past few decades, the mainstream agronomic literature seems to have neglected the relevance of spatially contextualising cultivated fields beyond the farm level (Cavazza 1996; Hatfield 2007; Nesme et al. 2010; Osty et al. 2008; Veldkamp et al. 2001), thus leaving knowledge gaps for both agronomy and landscape research.

While other disciplines set the stage for agricultural landscape indicators (Dramstad and Sogge 2002), French agronomists dedicated the second meeting of *Entretiens du Pradel* (originally promoted by the French Academy of Agriculture), held in 2002, to take stock of relationships between agronomists and the territorial and landscape levels (Prévost 2005). Three profiles of agronomists were examined to address agriculture at the field, farm and territorial levels (Sebillotte 2005). Involvement of agronomists at the territorial level was further developed by Boiffin and colleagues (Boiffin 2004; Boiffin et al. 2014), who identified the need to extrapolate, aggregate and/or include agronomic knowledge to contribute to spatial classification and zoning and thus to support spatial management and decision-making. Furthermore, the participants highlighted the need to form bridges with ecology and geography to support decision-makers in the management of agriculture. These interdisciplinary collaborations were addressed in part by geoagronomy (Deffontaines 2004; Deffontaines and Caron 2007), which reintegrated visual observation as a relevant method to describe and understand agricultural systems and support their management (Benoît et al. 2006). Territorial agronomy further opened this approach to stakeholders and issues not directly involved in farming, applied mainly to frame training, education and project management, thus providing for co-evolution of research-education-action platforms in order to address questions of territorial reorganisation (Lardon et al. 2012b). This approach underlies the design of "interdisciplinary land-management science" (Lardon and Pinto-Correia 2021, this book), in which the territorial dimension of agriculture requires merging the agronomic conceptual and methodological approach with territorial and ecological approaches (Lardon et al. 2012a).

In its history, agronomy has therefore gradually integrated the landscape as a level at which to address agricultural activities while explicitly considering the spatial context beyond the field and farm. In particular, this allowed agronomy to contextualise crop and grassland management to address the landscape as a socioecological and technical system in which farmers interact with other land managers and address various ecosystem services. To date, the landscape appears as the most promising level at which to re-embed farming practices and other place-based spatial knowledge into the design of innovative land-management systems. In this perspective, "landscape agronomy" was defined as the domain of agronomy that focuses on characterising, assessing and modelling farming systems in landscapes designed by farmers (Benoît et al. 2012). This research perspective interprets agricultural landscapes in terms of land patterns designed by farmers who exploit and manage natural resources (Fig. 1.1). It follows that the landscape agronomy

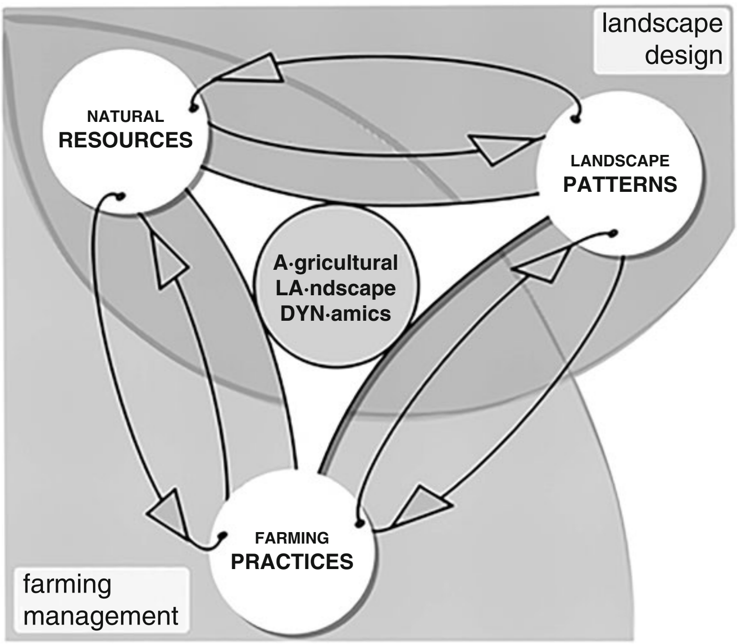

Fig. 1.1 Conceptual model of agricultural landscape dynamics, which structures relationships among natural resources, landscape patterns and farming practices. (Source: Benoît et al. 2012)

perspective pursues the interaction between agronomy and landscape ecology with some shared concepts, as well as with the wide range of disciplines traditionally involved in landscape research, such as geography, planning, architecture and sciences involved in natural resource management (see Liu and Taylor 2002). Making relationships between natural resource use and farming practices explicit at large spatial scales led agronomy to embrace socio-economic disciplines as well (Dalgaard et al. 2003). Decisions about how to exploit natural resources depend strongly on the socio-economic context of farmers' professional activities.

In landscape agronomy, the field remains a crucial concept because it is the main spatial unit used to explain and manage land-use patterns and natural resources (Deffontaines 1991; Le Ber and Benoît 1998; Thenail et al. 2009) and thus to explain and drive changes in agricultural landscapes (Rizzo et al. 2013). In this sense, land-use patterns in agricultural landscapes should be interpreted not only as land-cover/ land-use patches but mostly as a result of specific human activities (Turner and Meyer 1994), namely, farming practices (Baudry and Thenail 2004; Levin 2007; Osty et al. 2008). It follows that agronomic knowledge could greatly help societies design agricultural landscapes that are desirable from socio-economic, environmental and aesthetic viewpoints (Beuret 2002; Domon 2011; Gaucherel et al. 2010; Gobster et al. 2007; Groot et al. 2010; Veldkamp et al. 2001). As such, landscape agronomy can complement knowledge about farming practices in the design paradigm developed by Nassauer and Opdam (2008).

In parallel to developments in agronomy, development of indicators to describe and understand agricultural landscapes, their structure and processes also benefitted from convergence among physical geography, landscape planning and especially landscape ecology (Forman 1990). An example of this cross-fertilisation is the set of agricultural landscape indicators presented at the NIJOS/OECD expert meeting in 2002, which expanded the involved approaches to social geography, landscape architecture and aesthetics (Dramstad and Sogge 2002). The character of an agricultural landscape was ultimately summarised into three main layers: the main biophysical structure, vegetation and land-use patterns and cultural elements (Wascher 2002).

Several current approaches seek to consider the spatio-temporal organisation of agriculture at local to regional levels to address issues of land-use and/or landscape sustainability and resilience. First came "land science", in which agriculture was one of many land uses in a given area. Then came the "landscape approach" (sensu Sayer et al. 2013), which focuses on integrated management of human activities. As such, the rationale was to move from land-management units under farmers' control towards the wider land system and multi-stakeholder governance.

Land-system science includes agriculture among other land uses. LUCCs are one of the most direct effects of demographic, socio-economic and environmental global changes (Foley et al. 2005; Hersperger et al. 2010; Turner et al. 2007). Starting in the early 1990s, many studies were performed to show how, how much and where LUCCs had occurred and what impact they might have on biodiversity (Carlesi et al. 2013; Fusco et al. 2021), soil erosion (Claessens et al. 2009; Debolini et al. 2013), soil carbon stocks (Schulp and Verburg 2009) and ecosystem services in general

(Metzger et al. 2006; Schröter et al. 2005). In the past few years, following the increasing availability and quality of land-use data, development of more sophisticated modelling methods and increasing interest in managing different land uses, land-use studies have tended to combine the concepts of land use and land management into "land systems" (Rounsevell et al. 2012; Verburg et al. 2013). This systems approach aims to consider the world as a complex system in which natural/environmental and human/socio-economic components are fully integrated and considered at the same time (GLP 2005). Human actions and behaviours have been recognised as the main drivers that determine and force current land-system dynamics; thus, research needs to include human components directly within LUCC modelling, as well as possible feedback on how humans have adapted land systems (Veldkamp 2009). The main advantage of this approach is that it analyses and measures the intensity of land use and its management (Erb et al. 2013); for this reason, it is particularly adapted to understanding agricultural dynamics, such as intensification or extensification (Ruiz-Martinez et al. 2015). However, there is a growing issue with the availability and use of data: the main limitations concern data on agricultural practices, used to define agricultural systems and then characterise entire land systems, as well as data on existing and currently applied agricultural and management policies. Measuring land-use intensity implies considering multiple indicators in order to describe it as a complex and multidimensional phenomenon (Kuemmerle et al. 2013) and new methodological approaches that consider highlighted relationships among cropping systems, management practices and the supply of ecosystem services (Rega et al. 2020).

At the end of the spatial spectrum of approaches to agriculture at the landscape level, beyond the farm and the land system, lies the "landscape approach", in particular as defined by Sayer et al. (2013). It stresses the need to achieve holistic management of natural resources by identifying the landscape as a range of key scales for action (Dernier et al. 2015). The United Nations Food and Agriculture Organization promoted the landscape approach in its *Climate-Smart Agriculture Sourcebook*. In it, the principles that underlie the landscape approach were selected based on the Millennium Ecosystem Assessment to guide "how to pursue different land-use objectives and livelihood strategies" (FAO 2013: 45). The Millennium Ecosystem Assessment highlighted the relevance of a landscape approach for its "potential to address both biodiversity conservation and sustainable resource use considerations through the implementation of a range of strategies and levels of protection" (McNeely et al. 2005). This approach was based on 38 case studies summarised by Bennett and Wit (2001), who focused on conserving biodiversity at the ecosystem, landscape or regional level. It was further developed into "eco-agriculture" (McNeely and Scherr 2003) for climate-smart agriculture (Scherr et al. 2012). Eco-agriculture, as one way to connect agriculture to other land uses, was defined as "a framework that seeks to achieve simultaneously improved livelihoods, conservation of biodiversity, and sustainable production at a landscape scale" (McNeely et al. 2005: 149). In summary, we observe a switch from nature-conservation strategies towards active involvement of multiple stakeholders, including those actively involved in agriculture, as one of the main activities that manage natural resources at the community level. The basis for this switch was to compare ecological network initiatives (Bennett and Wit 2001). The active involvement of different stakeholders was then extended to pursue and assess nature conservation goals (McNeely et al. 2005) and ultimately integrated into a landscape-management perspective to develop both climate-smart agriculture (Scherr and McNeely 2012) and sustainable sourcing of agricultural production systems (Kissinger et al. 2013). At its core, the landscape approach highlights the three pillars of the landscape agronomy framework: natural resources, spatial patterns and agricultural practices.

1.3 Bibliometric Overview of the Topics Addressed by Landscape Agronomy: Recent Trends and Emerging Perspectives

We performed a comprehensive bibliometric analysis to capture recent research trends in key topics for landscape agronomy and then use this information to discuss perspectives. The bibliometric analysis aimed to provide an overview of the scientific literature related to key agronomic terms and focus on how the landscape has been addressed to date. As such, it was expected to clarify the structure of existing knowledge and to highlight strategic gaps that need to be addressed. To this end, we focused on three terms that characterise agronomic research: “cropping”, “farming” and “agricultural”. As a more generic reference, we also added “land”. The terms were truncated with an asterisk—“crop*”, “farm*”, “agr*” and “land*”—to identify all publications associated with derived terms. These were combined with three relevant dimensions for agronomy, as suggested by Marraccini et al. (2012): “practice”, “management” and “system” (Table 1.1). The search was performed in the Scopus database (2 March 2021) in titles, abstracts and keywords, considering them as an expression of the research focus of each publication. To improve comparability among the corpora, the search was limited to 1990–2020. Nevertheless, to encompass the broad spectrum of literature that addressed the terms of interest, the search

Table 1.1 Corpora obtained for the bibliometric analysis from queries performed on 2 March 2021. Queries were limited to terms in titles, abstracts and keywords; see Appendix for the complete queries

Topic	Target of the query	Entire corpus	Landscape sub-corpus
Crop*	“Crop* practice” *OR* “crop* management” *OR* “crop* system”	29,438	1017
Farm*	“Farm* practice” *OR* “farm* management” *OR* “farm* system”	30,717	2189
Agr*	“Agr* practice” *OR* “agr* management” *OR* “agr* system”	50,681	4128
Land*	“Land* practice” *OR* “land* management” *OR* “land* system”	26,632	6766

strategy included all publication types (e.g. article, chapter) and scientific subject areas (i.e. not limited to agricultural and biological sciences only).

In the bibliometric analysis, we first described each corpus to set a baseline and to verify the consistency of the terms chosen. We then analysed the occurrence of terms that described patterns and processes, which constitute the novelty that landscape agronomy claims is necessary to address agricultural dynamics properly at the landscape level (Benoît et al. 2012). Each corpus was processed individually assuming that each search term represented a specific scientific community: "crop*" being related to field agronomy, "farm*" addressing organisation of agriculture at the farm level, "agr*" being the most general and "land*" providing a wider perspective beyond agronomy. In parallel, we have analysed the sub-corpora that explicitly contained the term "landscape" in titles, abstracts and keywords ("landscape" sub-corpora in Table 1.1).

The bibliometric analysis was performed with the online CorTexT Manager instrument of the CorTexT platform (cortext.net). Its Natural Language Processing scripts were used to parse the corpora and extract terms. This analysis simplified each corpus by identifying common multi-word terms that contained up to three words and occurred at least three times inside each document (i.e. minimum frequency). Monograms—one-word terms such as "yield", "wheat", "rice", "maize" and "agroforestry"—were excluded as they are often considered less relevant (Stephens and Barbier 2021). Proxies emerged for some terms, such as "dry matter" for "yield".

Temporal dynamics of the extracted terms were then identified using the Epic Epoch script, which presents results in a Sankey diagram of homogeneous term-to-term networks over time (see Ubando et al. 2021). In Sankey diagrams, tube thickness represents the frequency of a term, while the order may change by period, which identifies some of the emerging terms. We divided each corpus into five non-overlapping periods of equal duration and extracted the five most common terms per period. Occurrences were normalised as a function of the most common term per corpus per period (i.e. term frequency in each period equalled 100%). As a consequence, the final diagram includes all the terms that were at least once among the five most common terms per period.

Here, we present the result for each level, first describing each corpus to ensure its consistency with agronomy and then analysing each sub-corpus that included "landscape".

Crop* The most common terms were consistent with the main topic (Fig. 1.2). "Cropping system" was the most specific term over time. That is, the corpus was composed mainly of "cropping systems", "crop rotation" and "crop management", which remained stable over time. Nitrogen fertilisation was the most common crop management (practice) in the corpus. Starting in the 2000s, studies that addressed "nitrogen fertiliser" and "*Triticum aestivum*" may have been related. "Climate change" appeared to be the only term that was specific to this corpus, especially given its crop-related level. Moreover, "climate change" was the only term whose occurrence increased by a factor of 10; as such, it was an emerging topic for this

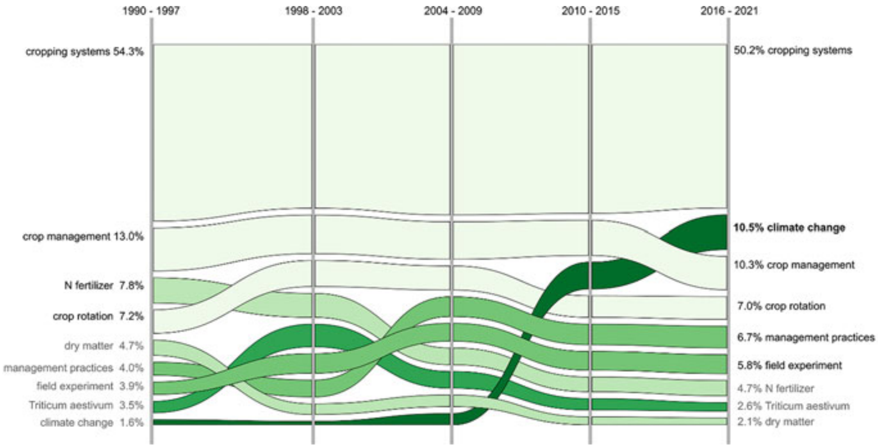

Fig. 1.2 Terms identified in the crop* corpus ($N = 29{,}438$) during five periods from 1990 to 2020 by Epic Epoch, normalised by frequency of occurrence. Percentages in bold text identify emerging terms

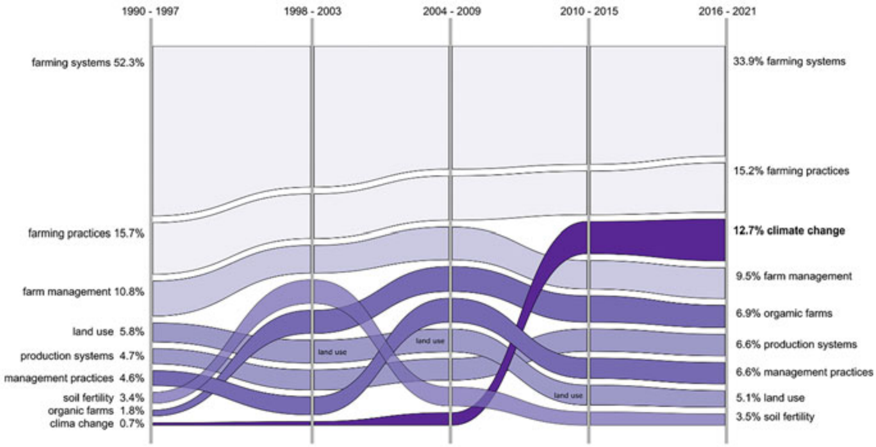

Fig. 1.3 Terms identified in the farm* corpus ($N = 30{,}717$) during five periods from 1990 to 2020 by Epic Epoch, normalised by frequency of occurrence. Percentages in bold text identify emerging terms

corpus. Overall, the most common terms appeared to exclude spatially related terms, such as “land use”.

Farm* The most common terms were consistent with expectations (Fig. 1.3). The corpus was represented mainly by “farming systems” and, to a lesser extent, by “farming practices”. Like for the “crop*” corpus, the main terms were related to systems, practices and management. The occurrence of “production system” was also consistent, as it is the French term used in farm-related studies (i.e. *système de*

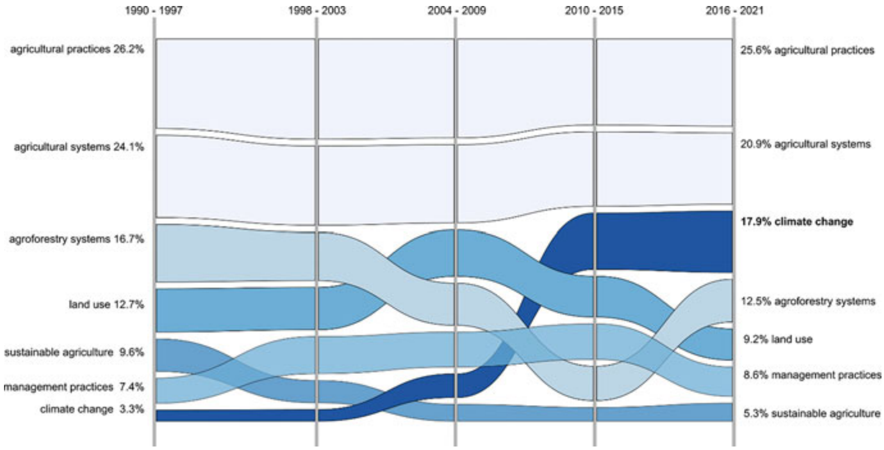

Fig. 1.4 Terms identified in the agr* corpus ($N = 50{,}681$) during five periods from 1990 to 2020 by Epic Epoch, normalised by frequency of occurrence. Percentages in bold text identify emerging terms

production) (de Bonneval 1993: 194 S151). Of note, "soil fertility" was the main term that appeared among the management practices. Some unexpected terms were "land use" and "climate change": the former remained stable over time, whereas the latter was a more recent emerging topic, which increased its occurrence by a factor of ca. 10 only in the most recent period (i.e. 2015–2020). Regarding the temporal dynamics of terms, "organic farming" was an emerging topic in the early 2000s but remained stable afterwards.

Agr* The agr* corpus was relatively simple, as it was represented most by "agricultural practices" and "agricultural systems" over time (Fig. 1.4), consistent with expectations. Beginning with the third most common term, however, we found unexpected terms such as "agroforestry systems" and "land use". Interestingly, the "agr*" corpus was the only one that included "sustainability" among the most common terms, probably because it was more open to other disciplines than the "crop*" or "farm*" corpora.

Land* The "land*" corpus was initially represented by "land management", "land system" and "land use", but only "land management" and "land use" remained in the most recent period (Fig. 1.5). "Ecosystem services" and "climate change" emerged as relevant terms for this corpus. As expected, this corpus was unrelated to a specific sector (e.g. agriculture). "Case study" was the target-related term, which may have been similar to the "field experiment" found in the "crop*" corpus. Of note, "soil erosion" and "water quality" emerged as specific issues. "Landscape" emerged for the first time because of the "land*" root, but only in relation to "landscape management".

Crop* and Landscape This was the smallest corpus, which may explain the heterogeneity of its content (Fig. 1.6). Thus, the following comments should be

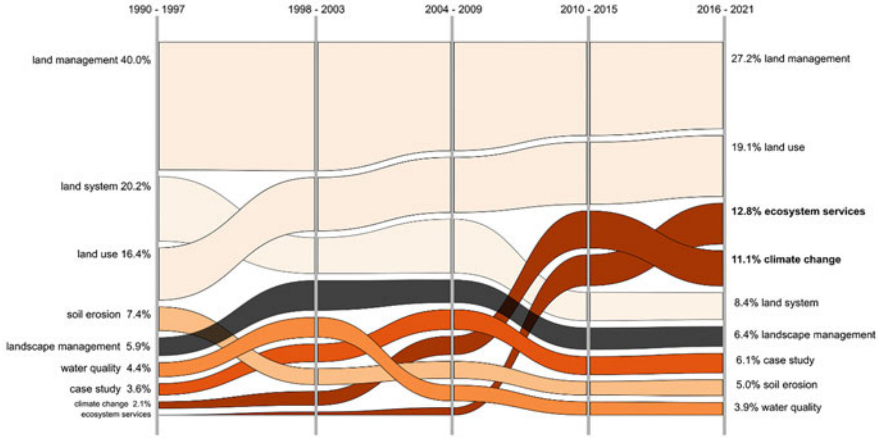

Fig. 1.5 Terms identified in the land* corpus ($N = 26{,}632$) during five periods from 1990 to 2020 by Epic Epoch, normalised by frequency of occurrence. Percentages in bold text identify emerging terms

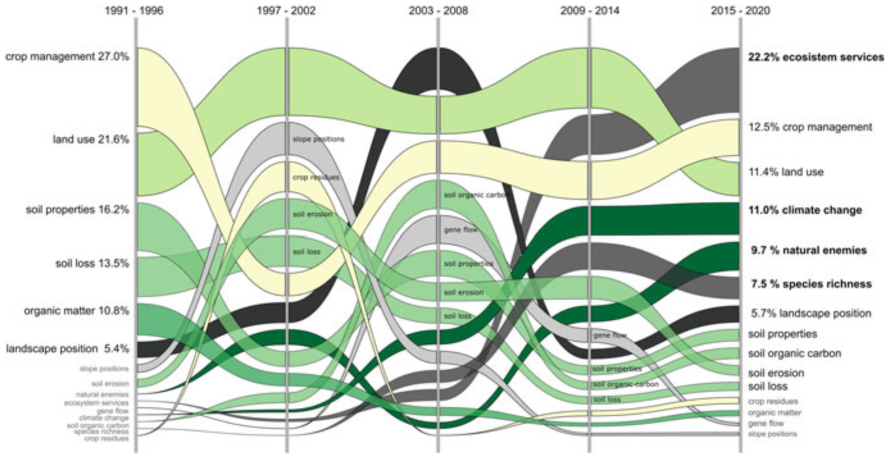

Fig. 1.6 Terms identified in the crop* landscape sub-corpus ($N = 1017$) during five periods from 1990 to 2020 by Epic Epoch, normalised by frequency of occurrence. Percentages in bold text identify emerging terms

taken with caution. Compared to the main "crop*" corpus, the terms "cropping system" and "crop rotation" disappeared, which left "crop management" as the specific term for this corpus. The subsample of publications that mentioned landscape included those that addressed "land use", which was absent from the main corpus. Thus, "land" use seemed to be specifically related to the landscape level for