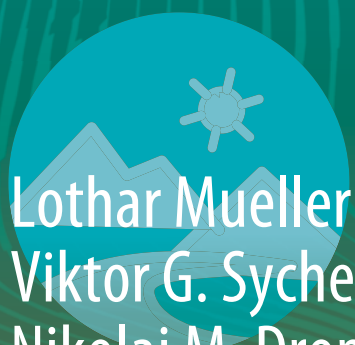Lothar Mueller
Viktor G. Sychev
Nikolai M. Dronin
Frank Eulenstein *Editors*

Exploring and Optimizing Agricultural Landscapes

Springer

Innovations in Landscape Research

Series Editor

Lothar Mueller, Leibniz Centre for Agricultural Landscape Research
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Aims & Scope

The Springer series "Innovations in Landscape Research" presents novel methodologies and technologies to understand, monitor and manage landscapes of the Anthropocene. The aim is to achieve landscape sustainability at high productivity. This includes halting degradation of landscapes and their compartments, developing cultural landscapes, and preserving semi-natural landscapes. Clean water and air, fertile and healthy soils for food and other ecosystem services, and a green and bio-diverse environment are attributes of landscapes for the survival and well-being of humans who inhabit them.

How do landscapes function? How do future landscapes look like? How can we sustainably develop intensively used and stressed kinds of landscapes? Scientific innovations and decision tools are key to answer and solve those challenging questions. The series will inform about advanced methods and results of disciplinary, interdisciplinary and transdisciplinary work in landscape research. It presents a broad array of methods to measure, assess, forecast, utilize and control landscapes and their compartments. These include field and laboratory measurement methods, methods of resource evaluation, functional mapping and risk assessment, and sensing methods for landscape monitoring, advanced methods for data analysis and ecosystem modeling, methods and technologies for optimizing the use of multi-functional landscapes, for the bioremediation of soil and water, and basics and procedures of landscape planning. The series provides a new view on landscapes with some focus on scientific and technological innovations, on soils and problems of optimizing agricultural landscapes under conditions of progressive urbanization. Landscape research in a globalized world of the Anthropocene is based on gathering big data and scenario modeling. International long-term experiments and agri-environmental monitoring systems will deliver data for ecosystem models and decision support systems.

Edited volumes of this series will address the following topics at high priority: Status and Trends of Landscape Research; Understanding Key Landscape Processes; Landscape Services, Functions and Biodiversity; Assessing Soil Resources and Quality; Water Resource and Quality Monitoring; Landscape Monitoring Concepts and Studies; Landscape Sensor and Monitoring Technologies; Landscape Modeling and Decision Support; Agricultural Soil and Plant Management; Basics and Tools for Landscape Planning; Tools for Water and Wetland Management; Forest Management and Agroforestry; Rehabilitation of Degraded Landscapes.

The books of this series are a source of information for researchers, teachers, students, and stakeholders interested in the topics of landscape science and related disciplines. They present status analyses, methodical chapters and case studies showing the practical relevance and feasibility of novel decision tools and technologies. Thus, the books of this series will be a particular valuable information basis for managers and decision makers at various levels, from local up to international decision bodies.

An author/editor questionnaire, instructions for authors and a book proposal form can be obtained by contacting the Publisher.

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Preface of Editors

Dear Reader

This book is devoted to our understanding of agricultural landscapes. These are the regions where our food is produced and where nearly half of the world's population lives. Future generations should also have enough to eat and many people need to have a still better, healthy, peaceful and meaningful life.

Our earth is limited in terms of its size and resources, but economic strategies are directed towards growth. Interconnected problems and locally specific decisions about the degree to which humans and nature interact are inevitable. In the book "Current Trends in Landscape Research" we have shown that the landscape perspective can help to find specific solutions for changes to the landscape in some parts of the globe. Therefore, from a scientific point of view, it is worth taking a more detailed look at agricultural landscapes and their inhabitants. We want to show how landscapes have changed under our influence and how necessary it is to carefully analyse and understand developments. Only better knowledge about the processes in agricultural landscapes enables us to predict future developments, avert threats to human beings and nature, and generate lasting improvements.

Our analysis centres around agricultural production and the purposeful interaction of man and nature in the rhythm of biological processes. We would like to inform you about the latest scientific methods used to analyse and optimize these processes without destroying our environment. In addition, we must take into account the external factors of development on agriculture and its field of action, the agricultural landscape, and question and classify our own role in this context.

Our world has changed drastically, especially in the last 50 years. Science and technology have blossomed, and economic growth has produced prosperity for many. The world population has doubled. Our consumption of resources has increased by two and a half times in terms of CO_2 emissions. Not only information technologies and globalization but also many unresolved political and social conflicts, the decay of cultural assets and values, the littering of the biosphere, the loss of biodiversity and large-scale land grabbing shape many parts of the world of today. These processes are continuing with increasing speed, with modern agriculture and the rural landscape in their midst.

Motive for the Book: Looking Backwards

We, the editors, come from Germany and from Russia and have been cooperating in the field of soil and agricultural science for some years. During our scientific field work at the foot of the Seelow Heights and in other regions of Europe, we sometimes came across ammunition remains; remnants of a war-torn past. As a joint research team of German and Russian agronomists, we visited the Belgorod and Kursk regions in the late summer of 2011. We had meetings and scientific symposia in research institutes and at universities, visited field trials with new agro-technologies, and sampled and evaluated soils. The black soils of this region are among the most fertile on the planet.

The village of Prokhorovka is found in this gentle undulating forest steppe region characterized by productive agriculture. It is a heritage site commemorating the awfulness of war and the need for peace. In July 1943, tanks rolled through wheat fields and destroyed human life and the food of the survivors around Prokhorovka. Fascist Germany had invaded numerous countries, including the Soviet Union in 1941. What happened on and around the Prokhorovka fields is known as "Battle of Kursk", the biggest tank battle in human history. Standing on the fields of Prokhorovka, we remembered the words "Peace is not everything, but without peace everything is nothing" (Willy Brandt, former German chancellor and Nobel Peace Prize laureate, in a speech on 3 November 1981).

It is just our fathers' generation that was forced to fight in the opposing dugouts of the terrible Second World War. Our parents survived this war and the subsequent time of hunger and poverty. They enabled us to grow up and learn in a peaceful environment. When it became clear that we children were interested in agriculture, we had their goodwill and support.

It was a good and useful decision to deal with agriculture and its scientific basis. Developing scientific tools for exploring and optimizing agricultural systems and landscapes is a challenging task. It requires trans-disciplinary work and international cooperation. It has also offered us an opportunity to get to know other countries, regions, people and cultures and to develop understanding, tolerance and sympathy across borders. During our cooperation, trust has grown and good individual relationships with colleagues have developed. This is important for achieving success. This book is one outcome of the paths that have led us on this journey.

Content and Structure of the Book

The book has 39 individual chapters in five parts. These are:

- Part 1: Functions of Agricultural Landscapes and Key Research Topics
- Part 2: Agricultural Land and Its Productivity
- Part 3: Agro-Ecological Problems and Their Monitoring

- Part 4: Preserving and Developing Genetic Resources of Agricultural Landscapes
- Part 5: Regional Optimization of Landscape Processes through Soil, Plant and Water Management

Overall, we hope to have addressed the major challenges and opportunities of agricultural landscapes in these sections and chapters. However, dealing with such a broad field of research required us to focus on some topics and to shorten or omit others. The overall book has a clear European and Eurasian perspective and focuses on cropping systems in agricultural landscapes. We are hoping that other editors and authors also feel encouraged to fill existing gaps in the knowledge on sustainable animal husbandry, pastoral farming systems, and farming and rural development in other regions of the globe. The Springer series "Innovations in Landscape Research" (ILR) provides an appropriate framework for such publications.

Readers, Authors and Editors

This book addresses many overlapping and conflicting topics. The authors of the different chapters have pioneered novel methods of research, as well as being innovative and experienced scientists. The chapters reflect the authors' findings and particular interpretations within a given time and place. As editors, we accept approaches and conclusions that are not shared by us in every technical detail. Possible divergences between the findings, conclusions and statements of individual authors, between authors and editors, and between authors and you as informed and experienced readers are natural.

In some chapters, trade names are used to provide specific information about proven technologies applied in the study. Mentioning a trade name does not constitute a guarantee of the product by the authors or editors. It also does not mean a preference for, or recommendation of this product.

We hope to have provided information and inspiration. Readers are encouraged to contact the authors for more information. It is up you to draw conclusions on how best to act responsibly.

Acknowledgements

like to thank all funding bodies and other supporters for their help and engagement. It was our pleasure to serve as editors of this book by coordinating and reviewing the findings and concepts written by motivated, enthusiastic scientists.

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January 2020	

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His strongest background is in soil science and agriculture. Lothar Mueller has published more than 350 papers, amongst them more than 100 peer-reviewed publications and book chapters. Since 2013 he has been an Honorary Professor at the State Agricultural University of the Kuban in Krasnodar (Russian Federation). He was appointed as an Honorary Doctor of the Russian Research Institute of Rice in Krasnodar, of the Pryanishnikov Institute for Agrochemistry in Moscow and of the Institute for Soil Science and Agrochemistry in Almaty, Kazakhstan.

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Aim and content. This part of the book demonstrates how important agriculture and its setting —the agricultural (rural) landscape—are for humankind and biological cycles on earth. Chapters 1–3, on the development of agricultural practices, describe the role of peasants, farmers and rural inhabitants in a historical context. These chapters address the status quo and current trends in agricultural systems and rural landscapes, resulting in contradictions between human society and nature, and challenges for improving agricultural sustainability and evolving rural landscapes. This includes the need not only to increase productivity by means of intensification but also to reduce threats to the soil, water, biodiversity, ecosystem services and landscape heritage. Based on this, the authors derive a research agenda for better understanding and forecasting sustainable strategies and development paths for agriculture and rural landscapes. Some recent progress is revealed in exploring the basic processes occurring in different features of the landscape (soils, waterbodies, the atmosphere, biota), and approaches and practices for achieving sustainable production and thriving landscapes which provide multiple ecosystem services (Chaps. 2 and 3).

Russian agriculture is the largest land user in Eurasia, but relatively little is known about its specifics, research trends and implications for sustainable development. These topics are addressed in Chapter 2 and consolidated in Chaps. 4 and 5. The need for better international research cooperation with Russia is highlighted.

Chapters 6–9 provide insights into further key trends of agricultural development and research topics. These include bioenergy production from agricultural landscapes (demonstrated based on the example of Germany, Chap. 6) and agricultural management practices (demonstrated by a comparison of cropping systems in Europe and China, Chap. 7). Chapters 8 and 9 explain why long-term experiments are important to understand landscape processes such as nutrient cycling and carbon sequestration, as a basis for reliable forecasting and developing strategies for landscape sustainability.

Agricultural Landscapes: History, Status and Challenges

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Abstract

Agricultural landscapes (rural landscapes, agrolandscapes) are territories shaped by agricultural production. They have enabled the development of human civilizations and are a cultural achievement. Peasants, farmers and agricultural enterprises feed society. They have created agricultural landscapes for their business and habitats for their life. To understand transformation processes in agricultural landscapes, we analyse the history of

Abdulla Saparov died of COVID-19 in 2020. The team of editors and authors mourns the loss of a highly esteemed scientist and will preserve his scientific legacy.

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agriculture with a special focus on Europe and Eurasia. Current agricultural landscapes in a crowded, globalized world are multifunctional, highly complex systems. They not only serve to produce food commodities and energy for the increasing and expanding urban population but also provide diverse ecosystem services and need to cater for the demands of the rural population. Current agriculture is highly productive in wealthy countries, but due to high inputs it is also responsible for environmental problems such as water pollution and loss of biodiversity. Industrial-style agriculture in large fields has resulted in increased productivity but simplified the structure of landscapes and eliminated elements of nature and rural culture. Major problems that urgently need to be addressed include trends towards disrupting natural cycles in agricultural production, soil and water degradation, ageing populations in villages and the breakdown of rural infrastruc-

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ture. Agricultural landscape research provides analyses to understand these processes and helps elaborate sustainable scientific, technical and cultural solutions.

1.1 Introduction: Essence of Agricultural Landscapes and a Research Agenda

Agriculture is one of humankind's oldest economic activities. It has developed since the Neolithic Revolution, when humans became more settled. Humans' production of food crops for themselves and their offspring required the cultivation and transformation of originally natural landscapes. Before the beginning of the industrial age, rural cultures and societies and multifunctional landscapes were typical. Agricultural productivity is increased through the further social division of labour, innovations and knowledge transfer in cropping technology and livestock breeding. Farmers and peasants created food surpluses that enabled people to live in cities. Agricultural production is based on human intervention in biological cycles. Agricultural landscapes require interaction between anthropogenic and natural processes in order to be productive in the long run. Agriculture is the largest land use sector on earth. It influences all major global cycles and operates in close interaction with other spheres of society.

Agricultural landscape (rural landscape, agrolandscape) means land (territory) shaped by agricultural production. An agricultural landscape constitutes a spatio-temporal structure in which many complex processes occur continuously and in parallel. The temporal dynamics of these complex processes result in complex interactions between nature and human society

(Mirschel et al. 2020). In geographical terms, agricultural landscapes form a mosaic of ecotopes and, functionally, an ensemble of ecosystems with varying degrees of anthropogenic influence (Haase et al. 1991). Agricultural landscapes have diverse functions for society and natural cycles. They convert solar energy into food and fibre; they supply water and air and guarantee their quality; they provide a suitable meso- and micro-climate; they recycle waste; they provide biodiversity; they have aesthetic value; and they are the basis for rural communities and their culture (Olson 1999). Agricultural landscapes over the globe are highly diverse due to geosystem characteristics and cultural history (Figs. 1.1, 1.2 and 1.3). Landscapes are "cultural" in a double sense. One is the cultivation of crops. The other is rural culture with its value in terms of settlements, the layout and maintenance of the land, the architecture of its buildings, its social life and natural life in rural landscapes (Vroom 1990).

Agricultural landscapes are not only a source of food, fibre, timber and other materials but are also important secondary landscapes for the leisure activities of the urban population. Agricultural land and associated forested, aquatic and other landscape elements are ecosystems that provide ecosystem services (DeClerck et al. 2016; Köppke and Schnug 2017; Kienast et al. 2019; Loos et al. 2019). Besides being agricultural producers, farmers become landscape stewards (Raymond et al. 2016), providing ecosystem services by managing agricultural landscapes.

As human civilisations developed, the pursuit of power and wealth increased, but also a sense of the beautiful and the sublime. Ever since landowners, peasants and farmers have lived in their agricultural environment, they have created useful and attractive landscapes and infrastructure. Under socio-economic conditions that were favourable locally, and over time, it became possible to revalue agriculture as an economic activity with elements of spirituality, art and science. Manor houses, religious places and buildings, farm buildings, schools, roads and other rural infrastructure developed. Ancient