Stéphane Bellon
Servane Penvern *Editors*

Organic Farming, Prototype for Sustainable Agricultures

Springer

Organic Farming, Prototype for Sustainable Agricultures

Stéphane Bellon • Servane Penvern
Editors

Organic Farming, Prototype for Sustainable Agricultures

Springer

Editors
Stéphane Bellon
Unité Ecodéveloppement
INRA
Avignon Cedex 09
France

Servane Penvern
Unité Ecodéveloppement
INRA
Avignon Cedex 09
France

ISBN 978-94-007-7926-6 ISBN 978-94-007-7927-3 (eBook)
DOI 10.1007/978-94-007-7927-3
Springer Dordrecht Heidelberg New York London

Library of Congress Control Number: 2013957940

Printed on acid-free paper

Springer is part of Springer Science+Business Media (www.springer.com)

Preface

Organic Farming–A Role Model for Productive and Ecologically-Sustainable Farming Systems

Europe has been the pacesetter for organic farming for 40 years. The fact that between 10 and 20 % of the farms and the agricultural land area have become certified organic in a few leading countries has attracted the attention of the scientific community and of policy makers. Scientific studies on public goods delivered by organic farms have become more numerous and encompass topical aspects such as soil fertility building, carbon sequestration, biodiversity at the plant, animal, and microorganism levels, and eutrophication of semi-natural and natural ecosystems, etc. Support schemes for farmers have compensated for the delivery of public goods.

The steady economic growth of the global organic food market has further fueled the public interest in organic agriculture. Is it a viable strategy that reduces the trade-offs between food and feed production on the one hand, while maintaining the regulating and supporting ecosystem services and landscape quality on the other? "Yes, but…" is the most often heard answer. "Yes" for the fact that organic farms are likely to reduce detrimental impacts on the environment and to maintain the quality of ecosystems. "But" because crop and livestock yields are, on average, less on organic farms. Without any changes to the wasteful way in which society handles, uses, and consumes food, a large-scale transformation of high-yielding farmland to organic cultivation might accelerate deforestation and (re)cultivation of ecologically-sensitive land.

The state-of-the art of scientific data on productivity is divergent and controversial. While the crop productivity of organic farms appears to be 0.7–0.8 of that of intensive farms in temperate zones, the yield ratio in marginal regions of Africa where subsistence farming is still widely spread, has been found to be in favour of organic farms Hence, in resource- and income-poor countries, organic farming seems to offer an appropriate and low-cost way to increase productivity and to improve farm livelihood.

Despite its success in Europe and for specific cash crops on the world market, organic farming is still a niche, with only 1 % of agricultural land under organic

cultivation worldwide. Organic agriculture is challenged to unlock its potential: both as a role model and a real pathway to sustainability in agriculture and food systems. As a farming system, it is knowledge-intensive and resistant to overspecialisation. This is a challenge for scientists, farm advisors and farmers, and needs to be addressed by improving education and by enabling participation and inter-disciplinary research.

The concept of eco-functional intensification goes far beyond the restrictive use of fertilisers and pesticides. It requires a fundamental redesign of farms and fields, and entails more co-operation within the organic sector. Accordingly, livestock needs to be integrated into the nutrient and organic matter circuits in order to improve the robustness and resilience of both crops and animals, with the selection of well-adapted varieties and breeds. Finally, development pathways in organic agriculture also challenge agricultural sciences. While the basic principles of organic agriculture are persuasive and dynamic agroecological approaches, existing standards for the certification of farms and foods have become outdated. Creative research work and out-of-the-box thinking are needed to unleash social, ecological, and technological innovation in organic agriculture.

This book gives an outstanding analysis of what has been achieved, as well as an insight into what the future avenues for organic farming will be.

Director of the Research Institute of Organic Agriculture (FiBL) Switzerland

Professor of Research Management, University of Kassel-Witzenhausen Germany

Urs Niggli

Acknowledgments

We, as editors, would like to thank all the contributors who accepted to write chapters and who made this book possible. We are particularly indebted to them for their flexibility in adapting their needs to the overall demands of such a project. Through their involvement in organic research projects and communities, they were able to contribute state-of the-art research results and provide new avenues for research. We also warmly thank the invisible colleagues who, despite their busy schedules and heavy workloads, accepted and took the time to review the manuscripts of all of the chapters: Claudine Basset-Mens, Patrick Brachet, Yvan Capowiez, Marianne Cerf, Peter Cornish, Enrique Dapena, Ika Darnhofer, Jean-Philippe Deguine, Dominique Desclaux, Jean-Jacques Drevon, Philippe Fleury, Ken Giller, Stuart Hill, Louise Jackson, Claire Lamine, Edith Lammerts van Bueren, Derek Lynch, Rod MacRae, Ian A Merwin, Michel Meuret, Naoufel Mzoughi, Astrid D. Oberson, Guillaume Ollivier, Susanne Padel, Daniel Plénet, Alain Ratnadass, Michael Raviv, Ewa Rembialowska, Paul Robin, Natacha Sautereau, Otto Schmid, Eva Schmidtner, Bernard Seguin, Sylvaine Simon, Marc Tchamitchian, Isabelle Vagneron, Patrick Veysset and Christoph Winckler.

We also thank the Internal Committee for Organic Agriculture (CIAB), comprising representatives from various scientific disciplines and responsible for the implementation of INRA's research programme, for the book rational preparation, reviewing and support: Joel Abecassis, Didier Andrivon, Marc Benoit, Jacques Cabaret, Philippe Debaeke, Sophie Prache and Isabelle Savini.

The structure and content of the book is also the fruit of the many interactions we had with various colleagues: from our research unit, Ecodevelopment (INRA, Avignon, France); and during meetings of the Scientific Council of Organic Agriculture (CSAB) and the various activities of the Mixed Thematic Network dedicated to OF&F development (RMT DévAB). Many exchanges with various stakeholders in the French organic sector also encouraged us to move forward with this initiative. Mentioning all of them would be too long, but organic farmers and their representative organisations were indeed a major source of inspiration to address current issues and dynamics. At the international level, we highly benefited from the relationships established with people involved in research projects, conferences and events. In addition to allowing us to compare our ideas with those of other communities, it

also enabled us to improve our synthesis of the existing knowledge, to discover and appreciate other books, and to contribute to new projects. A pioneer scientist, Bertil Sylvander, requires special mention: he opened the way for research in OF&F at INRA, both with the CIAB and through international commitments. Concerning the editing of this book, we are grateful to Maryse Walsh (from Springer) who allowed us to see this book project through to the end.

We would also like to express our gratitude to Isabelle Savini and Alice Vettoretti, both deeply involved in getting this book into print. Their constructive comments and assistance made it possible to complete the project. We also thank Gail Wagman for her contribution in revising and improving the final English versions of the various chapters.

Contents

Contributors

Aude Alaphilippe INRA, UE695 UERI Unité Expérimentale Recherches Intégrées, Saint Marcel les Valence, France

Claude Aubert Lempdes, France

Laurent Bedoussac ENFA-INRA, UMR1248 AGIR, Castanet-Tolosan Cedex, France

Stéphane Bellon INRA, UR0767 Écodéveloppement, Domaine Saint Paul, Site Agroparc, Avignon Cedex 9, France

Marc Benoit INRA, UR1213 Herbivores Saint-Genès-Champanelle, France

André Blouet INRA, UR055 SAD ASTER, Mirecourt, France

Riccardo Bocci AIAB, Florence, Italy

Jacques Cabaret INRA-Université de Tours, UMR1282 Infectiologie et Santé Publique, Nouzilly, France

Université Paris I—Sorbonne, Paris, France

Aurélie Cardona INRA, UR0767 Écodéveloppement, Domaine Saint Paul, Site Agroparc, Avignon Cedex 9, France

Véronique Chable INRA, UR980 SAD-Paysage, Rennes, France

Philippe Chauvelon Tour du Valat, Research Centre for the Conservation of Mediterranean Wetlands, Arles, France

Caroline Chylinski INRA-Université de Tours, UMR1282 Infectiologie et Santé Publique, Nouzilly, France

Bruno Colomb INRA-INP Toulouse, UMR1248 AGIR, Castanet-Tolosan, France

Xavier Coquil INRA, UR055 SAD ASTER, Mirecourt, France

Guénaëlle Corre-Hellou LUNAM Université, Groupe ESA, UR LEVA, SFR 4207 QUASAV, Angers Cedex 01, France

Ika Darnhofer Department of Economic and Social Sciences, University of Natural Resources and Life Sciences, Vienna, Austria

Julie Dawson Department of Horticulture, University of Wisconsin-Madison, Madison, WI, USA

INRA-CNRS-INAPG-Université de Paris 11, UMR0320 Génétique Végétale, Gif-sur-Yvette, France

Jean-Philippe Deguine CIRAD, UMR PVBMT, Saint-Pierre, La Réunion, France

Sylvestre Delmotte INRA-SupAgro-CIRAD, UMR0951 Innovation, Montpellier, France

Dominique Desclaux INRA, UE398 Diascope, Mauguio, France

Jean-Louis Fiorelli INRA, UR055 SAD ASTER, Mirecourt, France

Isabelle Goldringer INRA-CNRS-INAPG-Université de Paris 11, UMR0320 Génétique Végétale, Gif-sur-Yvette, France

Gaël Goulevant INRA-SupAgro-CIRAD, UMR0951 Innovation, Montpellier, France

Henrik Hauggaard-Nielsen Department of Chemical and Biochemical Engineering, Technical University of Denmark, Lyngby, Denmark

Frank Hayer Agroscope Reckenholz Tanikon ART, Zurich, Switzerland

Felix Heckendorn Department of Livestock Science, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Stuart B. Hill School of Education, University of Western Sydney (Kingswood Campus), Locked Bag 1797, Penrith, Australia

Philippe Hinsinger INRA, UMR1222 Eco&Sols, Montpellier, France

Hervé Hoste INRA-Université de Toulouse-ENVT, UMR1225 IHAP Interactions Hôte-Agents Pathogènes, Toulouse, France

Machteld Huber Department of Healthcare & Nutrition, Louis Bolk Institute, Driebergen, The Netherlands

Laurent Jamar Department of Life Sciences, Unit Breeding & Biodiversity, CRA-W, Gembloux, Belgium

Erik Steen Jensen Department of Biosystems and Technology, Swedish University of Agricultural Sciences, Alnarp, Sweden

Étienne-Pascal Journet CNRS, UMR2594 LIPM, INRA, UMR1248 AGIR, Castanet-Tolosan, France

Eric Justes INRA-Université de Toulouse-INPT, UMR1248 AGIR, Castanet-Tolosan, France

Gabriel Laignel INRA, UR 1213 Herbivores, Saint-Genès-Champanelle, France

Denis Lairon Univ d'Aix Marseille-INSERM-INRA, UMR1062 NORT Nutrition, obésité et risque thrombotique, Marseille, France

Claire Lamine INRA, UR0767 Écodéveloppement, Domaine Saint Paul, Site Agroparc, Avignon Cedex 9, France

Marc Lateur Department of Life Sciences, Unit Breeding & Biodiversity, CRA-W, Gembloux, Belgium

François Laurens INRA, UMR IRHS, Beaucouzé Cedex, France

Pierre-Eric Lauri INRA, UMR AGAP, Montpellier, France

Christophe Le Page CIRAD, UPR Green, Montpellier, France

Laure Le Quéré INRA-SupAgro-CIRAD, UMR0951 Innovation, Montpellier, France

Santiago Lopez-Ridaura INRA-SupAgro-CIRAD, UMR0951 Innovation, Montpellier, France

Derek H. Lynch Department of Plant and Animal Sciences, Dalhousie University, Truro, Nova Scotia Canada

Ralph C. Martin Department of Plant Agriculture, University of Guelph, Guelph, Ontario, Canada

Veronika Maurer Department of Livestock Science, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Helena Mejer Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Frederiksberg, Denmark

Catherine Mignolet INRA, UR055 SAD ASTER, Mirecourt, France

Jean-Claude Mouret INRA-SupAgro-CIRAD, UMR0951 Innovation, Montpellier, France

Adrian Muller Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Christophe Naudin LUNAM Université, Groupe ESA, UR LEVA, SFR 4207 QUASAV, Angers Cedex 01, France

Mireille Navarrete INRA, UR0767 Écodéveloppement, Domaine Saint Paul, Site Agroparc, Avignon Cedex 9, France

Thomas Nesme BORDEAUX SCIENCES AGRO-INRA, UMR1220 TCEM Transfert Sol-Plante et Cycle des Éléments Minéraux dans les Ecosystèmes Cultivés, Gradignan Cedex, France

Christian Nicourt INRA, UR1216 RiTME, Ivry, France

Jean-Marie Nolot INRA-Université de Toulouse-INPT, UMR1248 AGIR, Castanet-Tolosan, France

Luciana Parisi INRA, UR407 Pathologie Végétale, Avignon Cedex 9, France

Servane Penvern INRA, UR0767 Écodéveloppement, Domaine Saint Paul, Site Agroparc, Avignon Cedex 9, France

Jocelyne Porcher INRA-SupAgro-CIRAD, UMR951 Innovation, Montpellier, France

Sophie Prache INRA, UR1213 Herbivores, Saint-Genès-Champanelle, France

Loïc Prieur CREAB Midi-Pyrénées, LEGTA Auch-Beaulieu, Auch, France

Adrien Rusch INRA-Université de Bordeaux, UMR1065 Santé et Agroécologie du Vignoble, Villenave d'Ornon, France

INRA-Université de Bordeaux, UMR1065 Santé et Agroécologie du Vignoble, Villenave d'Ornon, France

Alain Sandoz Tour du Valat, Research Centre for the Conservation of Mediterranean Wetlands, Arles, France

Jean-Pierre Sarthou Université de Toulouse-INP-ENSAT-INRA, UMR1248 AGIR, Castanet Tolosan, France

Sylvaine Simon INRA, UE695 UERI Unité Expérimentale Recherches Intégrées, Saint-Marcel-lès-Valence, France

Smaragda Sotiraki Veterinary Research Institute (VRI), Hellenic Agricultural Organisation "Demeter" (former NAGREF), Thermi, Thessaloniki, Greece

Bernhard Speiser Research Institute of Organic Agriculture (FiBL), Frick Switzerland

Jennifer Sumner Department of Leadership, Higher and Adult Education, Ontario Institute for Studies in Education, University of Toronto, Toronto, Ontario, Canada

Lucius Tamm Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Geneviève Teil INRA-AgroParisTech, UMR1048 SADAPT, Paris, France

Stig Thamsborg Department of Veterinary Disease Biology, Faculty of Health and Medical Sciences, University of Copenhagen, Frederiksberg, Denmark

Mette Vaarst Department of Animal Science, Aarhus University, Tjele, Denmark

Christine A. Watson Scottish Agricultural College, Aberdeen, UK

Franco P. Weibel Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

Eric Wyss Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

GLOBE Switzerland, c/o Federal Office for the Environment, Berne, Switzerland

Chapter 1
Organic Food and Farming as a *Prototype* for Sustainable Agricultures

Stéphane Bellon and Servane Penvern

Abstract Many agricultural models claim to serve as a foundation towards sustainability. This introductory chapter examines how research results in organic food and farming (OF&F) may contribute to meaningful innovations and transitions for sustainable agricultures. To support this, we refer to three different interpretations of the concept of prototype. Each of them is developed in the three sections of the book. First, prototype theory is used as a mode of graded categorisation in cognitive sciences where categories are relative and boundaries may be fuzzy, making it possible to confront OF&F to other agricultures. The first section addresses production, protection and agro-ecological processes with the aim of increasing self-sufficiency. It addresses the validity domain of research findings for other agricultures. The second interpretation of OF&F as a prototype refers to its ability to outperform existing agricultures. This could also serve as a basis for outcome-based OF&F, which is currently mean-based. Three main challenges are developed in the second section: environmental issues, animal welfare and the quality of organic products. The third interpretation refers to OF&F development pathways. OF&F internal dynamics can be seen as enabling transformations. The third section combines two implications: renewal of an organic framework open to other stakeholders and identification of transition pathways for OF&F systems, including the territorial level. The prototype concept is useful for tackling the multiple challenges of the dynamic relationships of OF&F with other forms of agriculture. If OF&F is more than a niche, shifting from a *prototype* to a generalisable model still remains an issue.

Keywords Alternative agricultural model · Innovation · Redesign · Transition · Prototyping · Performance · Development pathways · Research

S. Bellon (✉) · S. Penvern
INRA, UR0767 Écodéveloppement, 228 route de l'Aérodrome, Domaine Saint Paul, Site Agroparc, CS 40509, 84914 Avignon Cedex 9, France
e-mail: stephane.bellon@avignon.inra.fr

S. Bellon, S. Penvern (eds.), *Organic Farming, Prototype for Sustainable Agricultures*,
DOI 10.1007/978-94-007-7927-3_1,

1.1 Introduction

Many agricultural models claim to serve as a foundation towards sustainability (Koohafkan et al. 2011). Organic food and farming (OF&F) is one of these candidate models, and probably the most acknowledged worldwide. It is recognised in the scientific and political arenas (McIntyre et al. 2009; National Research Council 2010), as well as by society as a whole. In spite of the limited share it occupies on the global food market, everybody has an opinion about OF&F practices or can identify its products. The legitimacy of OF&F is also due to its history and evolution in terms of practices, principles and regulations (Besson 2009; Francis 2009; Kristiansen et al. 2006; Lockeretz 2007). Several books and many articles about OF&F are published every year in various languages. They concern OF&F's ability to address agricultural and societal challenges: how to feed humanity, how to alleviate the impacts of climate change, how to enhance ecosystem services, etc. As the number of outcomes expected from agriculture multiplies, we are increasingly aware that there is no ready-made solution to address complex issues. Moreover, it is expected that research will contribute to the design of such solutions, together with stakeholders who have created and implemented promising initiatives and transition pathways. Among the possible solutions to be explored, we can mention the shift from intensive or high external-input agricultural systems to "knowledge intensive" or "ecologically intensive" agricultures.

In this book, our purpose is to identify to what extent and under what conditions research results in OF&F may contribute to meaningful innovations and transitions for sustainable agriculture. Its ambition is to present and critically review major biotechnical and socio-economic aspects of organic agriculture that can also be relevant to other agricultures. In this perspective, French scientists who contributed to a national organic congress, DinABio[1], were identified as potential authors, together with scientists from other countries and continents. These research scientists from Europe, North America and Australasia have all made important contributions and are all still active in organic research projects. They represent a wide range of scientific disciplines and use most of the available research methods. Subsequently, the topics addressed in this book combine different cultures and realities of organics.

OF&F is considered as a *prototype* both in its own dynamics and in its relationships with other forms of agriculture. Beyond the abandonment of chemical fertilisers and pesticides, OF&F is studied on the basis of its own acquisitions and diversity: process-based more than product-based; reconnecting agriculture with its ecological origins; broader than the traditional focus on soil fertility and dynamics in that its rules and practices are constantly evolving; and building on the combination of modern science and farmers' own experiences, references and

[1] The first DinABio congress took place in May 2008 at the INRA Centre of Montpellier (SupAgro). The proceedings were published in the online journal "Innovations Agronomiques" (available at: http://www6.inra.fr/ciag/Revue/Volume-4-Janvier-2009). The second congress took place on the 13–14th of November 2013 in Tours (France). Proceedings available at: http://www6.inra.fr/ciag/Revue/Volume-32-Novembre-2013.

knowledge of organic terrain. OF&F is also related and sometimes overlaps with other agricultural regimes (e.g., Ollivier and Bellon 2013). Such relationships are a premise of this book. Reference to OF&F as a *prototype* was introduced in the first French action plan for OF&F development (1998–2003) by its coordinator (Riquois 1999). His main argument was that due to its principles and strong constraints, OF&F is a laboratory for the development of sustainable agriculture and food production. Without chemical crutches or safety nets, organic farmers must imagine alternative methods that can be relevant to other situations. This position puts stress on the modernity of organic agriculture, while strongly reconnecting it with other forms of agriculture instead of relegating it to a ghetto or a niche. The concept referred to in this book is also shared in McIntyre et al. (2009) and Halberg and Muller (2013), who both focus on the contribution of organic agriculture to sustainability.

In the first section of this introductory chapter, we incorporate the concept of *prototype* and expand it in three directions. Each of them is then developed in three subsequent sections, briefly presenting a group of chapters that support a specific facet of the *prototype*.

1.2 Three Facets of the Concept of *Prototype*

The concept of *prototype* frames to what extent OF&F is a good representative of sustainable agricultures. Prototype theory is a mode of graded categorisation in cognitive science that stresses the fact that category membership is not homogenous and that some members are better representatives of a category than others (Qi et al. 2006; Rosch and Mervis 1975). Whereas the apple is a good representative of fruits, the penguin is not the best one for birds. However, every categorisation is relative, and boundaries are sometimes fuzzy between production models. A given farming situation can thus also be characterised in terms of distance between several categories of agricultural regimes. For example, OF&F and agroecology share some commonalities in their principles and practices (Bellon et al. 2011a). Both OF&F and low-input farming have been addressed jointly in research projects (e.g., Quality Low Input Food project: http://www.qlif.org/). Analogies can be made with the way the concept of prototype is used in the industrial sector, e.g., in car design. As an example, safety belts and other equipment such as ABS were tested and used in racing cars—where constraints are high—before being commonly used in all cars. There is, however, a difference between designing a solar-powered car and working on reducing fuel consumption on a car engine to minimise the use of non-renewable resources. The same comparison can be applied to agriculture, with its biotechnical and ecological processes. This is a first interpretation of *prototype*.

The second interpretation of OF&F as a *prototype* refers to its ability to achieve a set of performances. For example, increasing productivity or closing yield yaps can be done at the expense of closing nutrient cycles and achieving a health-enhancing food system. According to various authors (Azadi et al. 2011; Dima and Odero

1997; Lampkin et al. 2006; Leifeld 2012; Lockie et al. 2006), OF&F appears as a promising and innovative means of tackling the challenges facing agriculture and food production with respect to sustainability (climate change, food security and safety, biodiversity and enhancement of ecosystem services, endogenous rural development). Its outcomes in terms of environmental stewardship are also acknowledged. There is nevertheless a disagreement on the exact nature of the relationships between OF&F and sustainable agriculture (Bergström et al. 2008; Leifeld 2012; Rigby and Cáceres 2001). Hence, OF&F is either advocated or questioned, like two sides of the same coin. In the search for more sustainable agricultures, several issues must be addressed in parallel. For example, combining food security and environmental preservation can be tackled at the expense of social justice for farm workers. Alternative agricultural models will have to combine a wider range of performances. Given the uncertainties of future developments, previous concepts that guided research—such as stability, income maximisation, technical fine-tuning and biological optimisation—need to be balanced with system properties—such as adaptability, resilience and flexibility. Maintaining or strengthening such properties will also orient and determine both system performances and the criteria to evaluate them. The issue of assessing and combining OF&F multiple performances is still pending. Such debates are an important premise of this book. Although there is probably no definite answer, readers will find elements based on research findings from scholars involved in OF&F research, acquainted with the history and reality of the organic movements.

The third perspective of prototyping refers to OF&F development pathways. OF&F internal dynamics and diversity can be approached as enabling transitions or transformations. This is closely linked to the idea of sustainable agriculture considered as a programme, not as a steady state. Organic agriculture is also involved in a progress loop (Rahmann et al. 2009). However, there are no steps or linear timelines in transitions. Subsequently, the Efficiency-Substitution-Redesign (ESR) model presented by key authors in agroecology (Gliessman 2010; Hill 1985; Rosset and Altieri 1997) as levels of conversion to sustainable agriculture in a stepwise process reflects neither the complexity of farmers' trajectories nor the dynamics of the organic sector. Interestingly, Gliessman (2007) refers to a fourth level of agroecological transitions that enables "a more direct connection between those who grow the food and those who consume it, with a goal of re-establishing a culture of sustainability that takes into account the interactions between all the components of the food system". This specific link with the food system is an integral part of OF&F premises and is treated in the third section of this book.

These three facets of prototype are in fact interrelated, in as much as production processes are also valuated within the scope of expected new performances such as OF&F ecosystem services (Sandhu et al. 2010), whether separately or in combination, as a potential development pathway (Fleury 2011). Beyond the classical version of sustainability as a "3-legged stool" based on people, planet and profit, we also suggest that these three other "P"s are relevant in OF&F achievements and challenges: processes, performances and pathways. They are addressed as a series of integrated chapters in the three sections of this book.