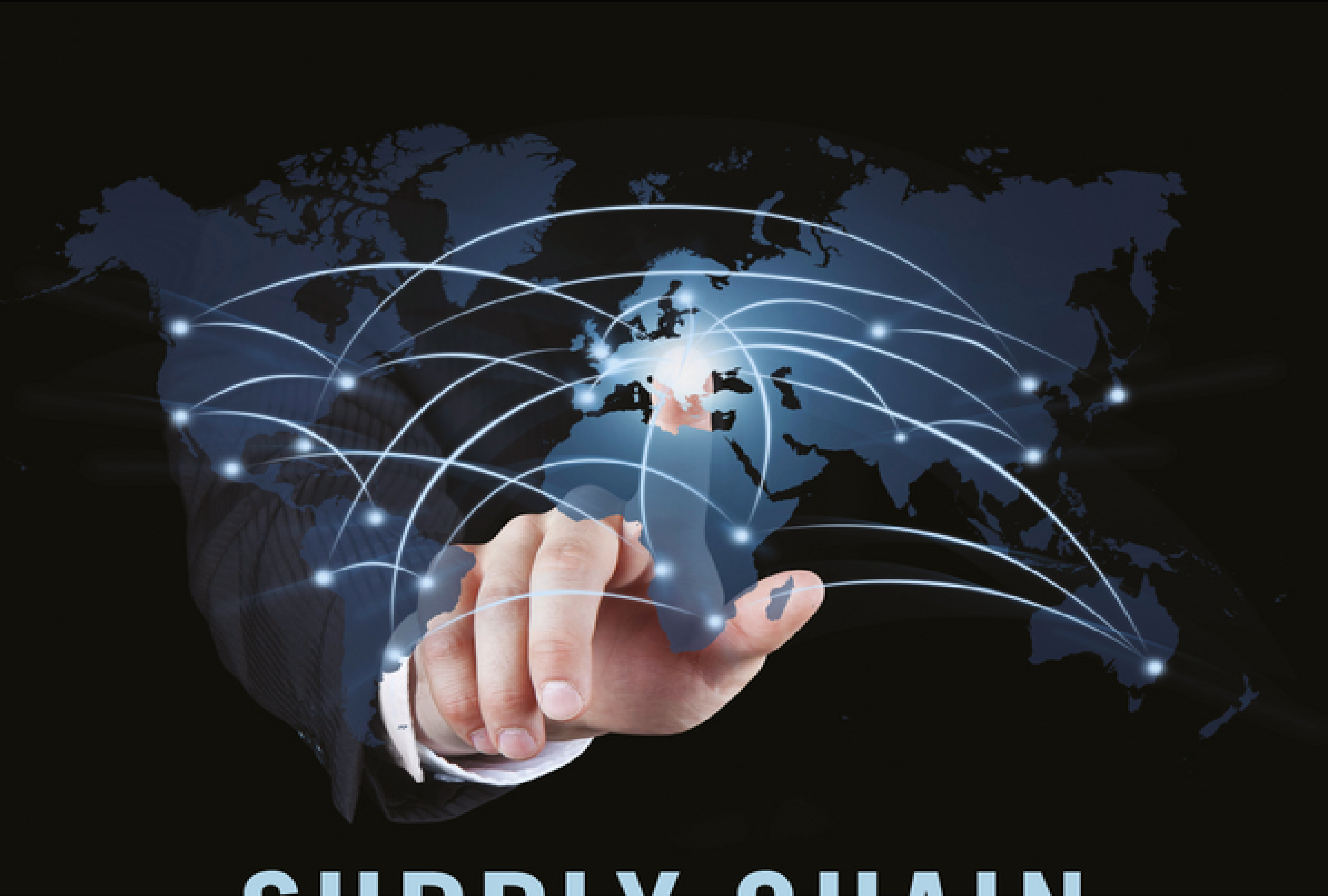

SUPPLY CHAIN MANAGEMENT

FOR SUSTAINABLE FOOD NETWORKS

EDITORS

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Preface

The agrifood industry is a sector of significant economic and political significance. It is one of the most regulated and protected sectors with significant implications for sustainability such as the fulfillment of human needs, the support of employment and economic growth, and its impact on the natural environment. According to the European Commission, the food and drink sector contributes to some 23% of global resource use, 18% of greenhouse gas emissions, and 31% of acidifying emissions.[1] Growing environmental, social and ethical concerns and increased awareness of the effects of food production and consumption on the natural environment have led to increased pressure by consumer organizations, environmental advocacy groups, policy-makers, and several consumer groups on agrifood companies to deal with social and environmental issues related to their supply chains within product lifecycles, from "farm to fork."

The agrifood industry is expected to grow in the next couple of years after a long period of recession. To that end the industry is facing new challenges that arise from:[2]

1. New consumer trends.
2. The need to comply with stricter and often non-harmonized national regulatory interventions regarding product safety, quality and traceability.
3. Increased sources of risk throughout its supply chains.

This book was motivated by a three-year leading research project (2012–2015) that was funded by the European Union (EU). Specifically, the Green-AgriChains Project has received funding from the EU's Seventh Framework

Programme (FP7-REGPOT-2012-2013-1 under Grant Agreement No. 316167) and it involved eight leading EU universities along with four business clusters. To that effect, the gracious support of the European Commission is gratefully acknowledged.

This book intends to provide a holistic, up-to-date, interdisciplinary framework for designing and operating sustainable supply chains for agrifood products and it intends to add value to both practitioners and academics alike. The aim is to present sustainable practices that are unique for agriculture (such as organic products or precision farming), as well as practices that already have been implemented in other industrial sectors [such as transportation emissions control or corporate social responsibility (CSR)]. All book chapters include decision-making procedures and methodologies, most of which are quantitative. Even though we do discuss the most emerging state-of-the-art relevant technologies, our focus is more on the managerial dimension of the examined policies.

Chapter 1 is an introduction to *sustainable agrifood supply chain (AFSC) management.* The chapter summarizes the unique challenges for supply chain managers especially related to sustainability. These challenges are then further fine-tuned for the agrifood business. The purpose of this introductory chapter is to provide the basic managerial knowledge and motivation for the readers of the book, merging the worlds of operations management, supply chain management, and agriculture. It begins by presenting the generic system components along with the unique characteristics of AFSC networks that differentiate them from traditional supply chains. The authors then identify and discuss the most critical issues for the design and planning of AFSCs, along with the most relevant emerging technologies. They then present a critical synthesis of the related existing state-of-the-art literature efforts in order to identify major gaps, overlaps, and opportunities. These issues were further mapped accordingly on the recognized natural hierarchy of the relevant decision-making process and key findings and managerial insights are presented.

Chapter 2 discusses *knowledge-based farming.* The chapter covers the implementation of engineering management in agrifood production systems as a basis for the creation of a new generation of intelligent and sustainable processes by employing novel system approaches realized by embedded intelligent technologies for planning and controlling the use of all involved resources. It further demonstrates how robustly managed systems can address the inherent complexity and dynamic nature of bio-production systems. First, a general outline of Precision Agriculture (PA) as applied to crops is provided. Then, a general plan of its application describing the relevant data collection methods for capturing the variability of the fields and the crops is discussed. An account of the data analysis and the methods to use the data in the site specific management of the crops is provided. Several applications are presented indicating the potential of PA to lead to an optimization of the usage of resources such as fertilizers, chemicals, water, and energy leading to reduced inputs and minimizing adverse effects to the environment. In several applications the economic benefits to the farmers are also substantiated. PA can address the main components of agriculture sustainability. From an economic perspective PA can improve income to farmers, from a social perspective it can improve working conditions for farmers and the farming communities bringing the farmers to the cutting edge technological era, while from an environmental perspective the adverse effects on the environment are greatly addressed by reducing inputs and resource use.

Chapter 3 deals with *biomass from agricultural wastes.* Biomass logistics encompasses two parts, each different in scope. The first part involves the farm production of biomass and the dedicated transport system as the initial steps in the biomass supply chain. It is characterized as a low industrialized process, where planning and execution remain very much implicit and internal with only a sparse tradition for using formalized planning tools. The other part involves the biomass processing facilities comprising the specific bio-energy production/processing; it is characterized as a highly industrialized process with a long tradition of explicit formalized planning and execution tools. The overall goal of this chapter is to identify research actions for improving the overall biomass waste logistics systems by extending the methods and technologies of industrial operations and production management to include a biologically constrained production system, while taking into account the sustainability (environmental, greenhouse gas emissions, energy balance) of the entire system.

Chapter 4's theme is *maintaining sustainability.* Stakeholders' demands have been suggested to affect the environmental and social activities of firms which in turn influence various performance dimensions. This chapter contributes to the analysis of this relationship by looking at the extent to which stakeholder demands are related to the integration of management activities within the firm, and by testing the hypotheses related to moderation effects of industry, firm type, and governance structures. Using data from the manufacturing sector in the UK and Germany, it examines the way in which stakeholder pressures are associated with management integration and economic as well as environmental performance, as defined by means of six sub-dimensions. Applying structural equation modeling it is documented that stakeholder pressure inevitably leads to economic and environmental performance integration, but that important moderation effects do exist.

Chapter 5 is an amalgamation of academic research efforts, offering *a review of quantitative optimization methodologies employed for evaluating the economic and environmental impacts of implementing green supply chain management (GSCM) decisions*. More specifically, the main GSCM decisions that may affect the economic and environmental performance of the three main physical drivers of a supply chain, namely products, facilities, and transportation, are identified, along with the quantitative optimization models employed for quantifying these impacts. Finally, these decisions are mapped into strategic, tactical, and operational decision phases accordingly and a critical synthesis of the academic research efforts is provided.

Chapter 6 discusses *safety, security, and traceability.* Traceability is a tool for sharing product related information among all members in the AFSC. It helps in terms of transparency of the network, contributing toward improved production and distribution management, promoting health, safety, and quality issues of agrifood product while mitigating associated risks in the entire chain. Overall, traceability can help in terms of product differentiation and provides significant financial benefits. The first part of the chapter deals with an extensive investigation of the most effective tracking and tracing systems that are already used in AFSCs. The aim of the second part of the chapter is to present new technologies, mainly based on information technology (IT) systems, for more sophisticated traceability systems, which can ensure the quality and safety of agrifood products in the entire chain.

Chapter 7 revolves around *IT in agrifood supply chains*. Nowadays, the emerging role of Information and Communication Technology (ICT) and farming technologies is recognized as a driver for change in the agrifood sector. Many researchers stress the importance of adopting ICT and farming technologies by AFSC stakeholders, as these technologies are a major driver for innovation. The chapter intends to demonstrate the main technological trends that can be employed in the entire agrifood chain and their key role. A holistic approach is employed and an analysis of all available IT applications and techniques is conducted in all levels of the AFSC. Emphasis is given on the primary sector where a number of IT innovations has been employed (e.g., satellites, sensors for precision agriculture, etc.). IT has been a key enabler in the supply chain environment, acting as the power of process automation, the enabler of information sharing and collaboration or the supporter of management decisions and optimization logic. Especially in food supply chains, this role has been even more critical due to enhanced requirements for short life cycles and speed of response, traceability and food quality considerations, environmental constraints and sustainability. Ultimately, in the chapter, a contemporary view of this enabling role of IT in the supply chain environment is provided and a high-level IT architecture integrating the views of automation, information sharing/collaboration, and decision support is proposed. This architecture is then discussed in the context of current opportunities and challenges of food supply chains, namely radio frequency identification (RFID)-enabled supply chain management, carbon footprint monitoring and shared logistics. The chapter concludes with an overall discussion of the main barriers and drivers behind IT adoption in the supply chain and a future outlook on anticipated developments.

Chapter 8 deals with the much-debated *carbon footprint management.* Carbon footprint management has emerged as an issue of pivotal corporate importance that has led to its inclusion at both the design and management phases of contemporary AFSC networks, in which profitability and environmental impacts have to be balanced. This chapter aims at identifying the most significant carbon hot-spots that may arise across the entire AFSC, while providing sophisticated decision support management tools, both qualitative and quantitative, for “decarbonizing” the entire chain. More specifically, state-of-the-art tools for measuring the carbon footprint of agrifood products from cradle-to-grave are presented and practice-oriented low carbon interventions are proposed to aid the related decision-making process.

Chapter 9 discusses *quality management systems.* Ecolabel/Certification Quality management systems are very popular in the agrifood sector as they often demonstrate the company’s ability to control food safety hazards in order to ensure that food is safe at the time of consumption. Nowadays, companies in the agrifood sector can develop and implement a number of available quality management systems (e.g., ISO22000:2005, ISO/TS 22004:2005, etc.). The main aim of the chapter is to present the key elements of the existing quality management systems available in the agrifood sector and to further investigate the employment of certain tools and techniques (e.g., trace and tracking systems) ensuring food quality and safety through the implementation of quality management systems.

Chapter 10’s focus is on *risk management for agrifood supply chains.* Modern AFSCs are exposed to a wide variety of natural, technological, and humanitarian risks, such as natural disasters, adverse weather conditions (related or unrelated to global warming), biological incidents, market instability and fluctuation of food and raw materials' prices, logistical and infrastructural disruptions, public policy interventions, and institutional reforms. These risks may inhibit their normal operations and provoke deviations, disruptions, or shutdowns to the supply chain's fundamental flows. Furthermore, despite the usually low probability of the associated triggering events, these risks may have a dramatic impact on their cost, efficiency, and reliability performance. To that end, there is a need for specific and efficient pre-, as well as post-, event risk mitigation and management strategies especially in the agrifood sector that becomes even more pressing due to the direct environmental impact of the sector.

Finally, **Chapter 11** deals with *regulatory policies/trends.* There are many researchers that have addressed the significant pressures from governmental regulators as one of the most important driving factors toward the sustainability of AFSCs. Regulatory interventions force AFSC stakeholders to adopt a high level of commitment to food safety and sustainable practices in the context of their CSR activities. On the other hand, the regulatory environment in the agrifood products is indeed rather complex. In many cases, the regulatory heterogeneity (indicatively, some impressive differences on import requirements among EU countries) on agrifood trade is a major challenge that AFSC stakeholders face. This chapter aims to demonstrate and analyze the main characteristics of the regulatory policies and their impacts on the various aspects of the AFSC (including, among others, food safety, quality, and implementation costs).

This book is aimed at both practitioners and academics alike. The potential audience includes researchers, C-level executives from throughout the food and beverage industry, supply chain managers, producers/manufacturers, farm managers/contractors, as well as stakeholders of AFSCs [producers, retailers, cooperatives, third-party logistics (3PL) companies, distributors, warehouse operators, policy-makers and other administrative and technical personnel].

The information contained in this book will be core to the interested parties that have to deal with the entire hierarchical decision-making process for the field. Specifically, this book provides essential input to policy-makers and C-level executives that deal with strategic decision-making (including the design of AFSC networks), as well as to supply chain stakeholders and farmers that have to tackle issues of competitiveness at the tactical and operational levels. Readers who will find this book a "must-have" include practitioners from different fields related to agriculture and the agrifood industry. Moreover, practitioners from the logistics and supply chain management sector can use the book as a guideline. In academia, the book can be used as a textbook in both existing and emerging Master courses in relative graduate programs including, for example, Sustainable Production, Agriculture Production Management, Operations Management, Logistics and Supply Chain Management, and Business Administration. Additionally, readers who will find this book "nice-to-have" may include researchers in fields of Operations Management, Logistics and Supply Chain Management, Business Administration, and Agriculture Sciences, as well as undergraduate students close to completing their studies, who will find it an essential aid for conducting their senior theses.

Sustainable supply chain management for agrifood companies is clearly an evolving and critical subject that has not been comprehensively addressed in the literature. While there are books that discuss the unique characteristics of AFSCs, they provide rather limited coverage on sustainability issues. Moreover, there are interesting books that address GSCM in general. We envision this new book to synthesize policies, practices, technologies and solutions offering a comprehensive, interdisciplinary, and customized paradigm. This condensed and targeted information will be of significant added value to leading executives and practitioners in the field, as well as researchers and interested academics.

Notes

1 http://www.euractiv.com/specialreport-prods-green-planet/cutting-food-waste-greening-diet-news-513731

2 http://www.grant-thornton.co.uk/en/Publications/2013/Hunger-for-growth--Food-and-Beverage-looks-to-the-future/

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1
Sustainable Agrifood Supply Chain Management

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1.1 Introduction – Agrifood Supply Chain Management

The agrifood sector is one of the most regulated and protected sectors worldwide, with major implications for sustainability such as the fulfillment of human needs, the support of employment and economic prosperity, the environmental impact, the tackling of poverty, and the creation of new markets (Humphrey and Memedovic, 2006). Indicatively, the European Commission (EC) is promoting significant reforms to its Common Agricultural Policy (CAP) in order to respond to the plethora of internationally emerging agrifood supply challenges (EC, 2010; Scheherazade, 2014). Growing environmental, social as well as ethical concerns, and increased awareness of the impact of food production and consumption on the natural environment have led to increased pressures by consumer organizations, policy-makers, and environmental advocacy groups on agrifood companies to manage social and environmental issues across their supply chains (SCs) from “farm-to-the-fork” and along products’ life cycles (Courville, 2003; Weatherell and Allinson, 2003; Ilbery and Maye, 2005; Maloni and Brown, 2006; Vachon and Klassen, 2006; Welford and Frost, 2006; Matos and Hall, 2007; Grimm, Hofstetter, and Sarkis, 2014).

In this context, designing appropriate effective global strategies for handling agrifood products to fulfill consumers’ demand, while responding to ever-increasing changes of lifestyle and dietary preferences, has become quite a complex and challenging task. Specifically, adverse weather conditions, volatile global food demand, alternative uses of agricultural production and fluctuating commodities’ prices have led to a volatile supply of agricultural products that is expected to exceed its capacity limit in the forthcoming years. To that effect, developed countries have been increasing their agricultural production in agrifood supply chain (AFSC) operations in order to respond to the projected rise of 70% on global food demand by 2050 (FAO, 2006, 2009; Nelson *et al.*, 2010). At the same time, the value of family farms and the development of local food SCs is clearly recognized for both the developing and developed countries (FAO, 2014).

One of the most critical bottlenecks in agrifood production and distribution is the complexity and cost-efficiency of the relevant SC operations. Modern, global agrifood networks require multi-tier supply chain management (SCM) approaches due to the increased flows of goods, processes, and information both upstream and downstream the value chain. These increased requirements are related to the modern, emerging model of agrifood retailers (i.e., grocery retailers, fast-food and catering services’ providers, etc.), the need for vertical and horizontal integration along the

AFSCs, the plethora of differentiated product offerings, the market segmentation, the dominance of multinational enterprises in the food processing and retailing sectors, the need for limiting food waste and overexploitation of natural resources, as well as the branding of firms (van Roekel *et al.*, 2002; Chen, Chen, and Shi, 2003; Mena *et al.*, 2014).

Furthermore, SCM has been recognized as a key concept for the agrifood industry competitiveness. The rapid industrialization of agricultural production, the oligopoly in the food distribution sector, the advancement of Information and Communication Technologies (ICT) in logistics, customer concerns, and a divergence of governmental food safety regulations, the establishment of specialized food quality requirements, the emergence of modern food retailer forms, the increasing importance of vertical integration and horizontal alliances, as well as the emergence of a large number of multinational corporations, are just a few of the real-world challenges that have led to the adoption of SCM in the agrifood sector (Chen, 2006). To this end, SCM embraces the challenge to develop and deploy efficient value chains tailored to the specifications of the modern, uncertain environment, subject to the constraints of local and cross-regional conditions, with respect to logistics means and infrastructure, access to land and water resources, allocation of harvesting areas and the various processing and storing facilities, innovative and sustainable good-practice methods, regulatory and techno-economic environments, and rapid changes of food market characteristics.

In order to develop competitive and sustainable AFSCs, there are a few critical issues that have to be first recognized:

1. the unique attributes of AFSCs that differentiate them from other SC networks;

2. the decisions that should be made on the strategic, operational, and tactical levels;
3. the necessary policies to ensure sustainability of the agrifood chains; and
4. the appropriate innovative interventions, which are required to foster major advances and competitiveness within the evolving AFSC context.

Therefore, more frequent changes in AFSC designs are necessary and strategic actions should be taken to foster sustainability (Halldorsson, Kotzab, and Skjøtt-Larsen, 2009), and thus to achieve higher efficiency in logistics' operations performance and resource usage (e.g., Gold, Seuring, and Beske, 2010; Carter and Easton, 2011).

In general, an AFSC is encompassing a set of operations in a “farm-to-the-fork” sequence including farming, processing/production, testing, packaging, warehousing, transportation, distribution, and marketing (Iakovou *et al.*, 2012). These operational echelons have to be harmonized in order to support five flow types, namely:

1. physical material and product flows;
2. financial flows;
3. information flows;
4. process flows; and
5. energy and natural resources' flows.

The aforementioned operations, services, and flows are integrated into a dynamic production–supply–consumption ecosystem of research institutions, industries, producers/farmers, agricultural cooperatives, intermediaries, manufacturers/processors, transporters, traders (exporters/importers), wholesalers, retailers, and consumers (van der Vorst, 2006; Matopoulos *et al.*, 2007; Jaffee, Siegel, and Andrews, 2010). Moreover, the continuous evolution of AFSCs, and the overall complexity of the agrifood environment along with global market trends further highlight the need for integration of individual SCs into a unified AFSC concept. In such a structure, strategic relationships and collaborations among enterprises are dominant, while these organizations are further required to secure their brand identity and autonomy (Van der Vorst, da Silva, and Trienekens, 2007). A conceptual configuration of AFSCs is depicted in Figure 1.1.

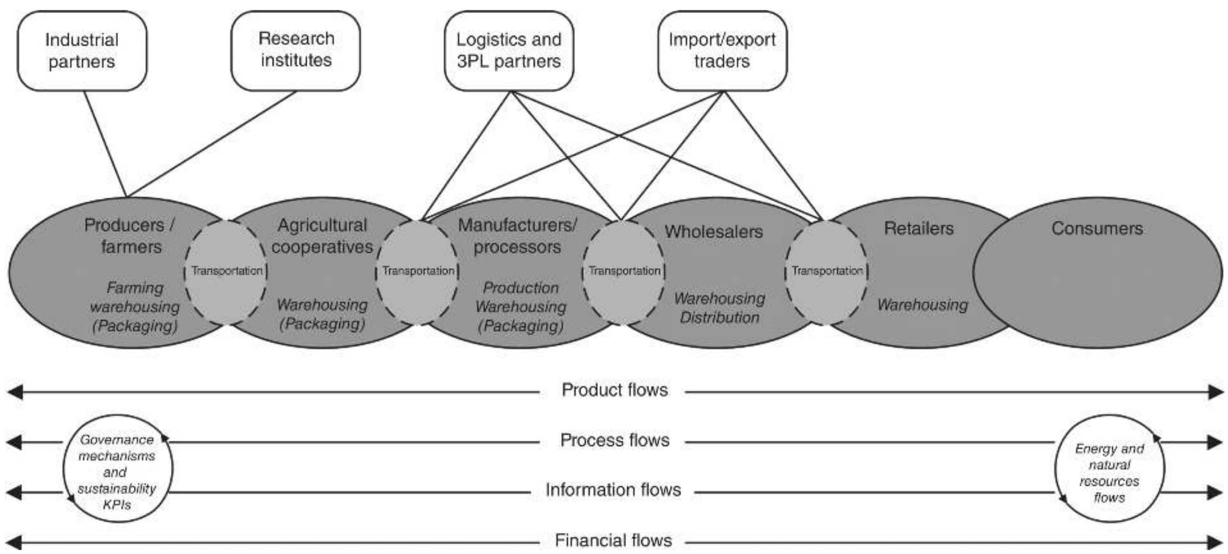

Figure 1.1 A typical agrifood supply chain.

Adapted from Tsolakis et al., 2014a.

The actors involved in the AFSC system can be generally partitioned into public authorities and private stakeholders. The former category includes mainly national governments and the associated ministries, administrative authorities (regional, district, urban), as well as international organizations (e.g., Food and Agriculture Organization), while the latter encompasses individual farmers/growers, cooperatives, research institutes and innovation centers, chemical industries, agro-industries and processors, food traders, logistics providers, transporters, supermarket chains and food stores, as well as financial institutions (Jaffee, Siegel, and Andrews, 2010). In this context, highly concentrated agro-industrial enterprises and retailers have recently morphed into dominant players in the agrifood field, while the public sector has emerged as a key-governance actor (Bachev, 2012).

Furthermore, AFSCs exhibit a set of unique characteristics that differentiate them from classical supply networks and raise an imperative need for customized managerial capabilities. According to Van der Vorst (2000, 2006), AFSCs are characterized by:

1. the unique nature of their products as in most cases they deal with short life-cycle and perishable goods;
2. high product differentiation;
3. seasonality in harvesting and production operations;
4. variability of quality and quantity on farm inputs and processing yields;
5. specific requirements regarding transportation, storage conditions, quality and safety, and material recycling;
6. a need for complying with national/international legislation, regulations, and directives regarding food safety and public health, as well as environmental issues (e.g., carbon and water footprints);
7. a need for specialized attributes, such as traceability and visibility;
8. a need for high efficiency and productivity of expensive technical equipment, despite often lengthy production times;
9. increased complexity of operations; and

10. the presence of significant capacity constraints.

The remaining of this chapter provides an in-depth examination of AFSCs and the related decision-making across the involved operations. Specific focus is provided on the three dimensions of sustainability, that is, economic, social, and environmental (Beske, Land, and Seuring, 2014) that modern, competitive AFSCs need to accommodate.

1.2 Why Sustainable Agrifood Supply Chain Management

The world has encountered and is expected to face even greater volatility and related challenges in the future, including economic crises, social exclusion, and climate change, with direct impact upon business activities (Validi, Bhattacharya, and Byrne, 2014; Brorström, 2015). The design and adoption of sustainability strategies throughout business operations has emerged as a meaningful intervention to accommodate such challenges (Shaw, 2013). Interestingly enough, the concept of sustainability cannot be easily defined and is, in fact, determined by academicians and decision-makers alike (Parr, 2009). Initially, researchers and practitioners were solely focused on environmental aspects to accommodate corporate needs and drive shareholder value (Caniato *et al.*, 2011). Nonetheless, in the contemporary global contextual framework, sustainability transcends the environmental dimensions and further relates to market competition, availability of raw and virgin materials, access to energy sources and increasing global population (Bajaj, Jha, and Aggarwal, 2013). Hence, the concept of the “Triple Bottom Line” (Kleindorfer, Singhal, and van Wassenhove, 2005) or the “Three Pillars” (White and Lee, 2009) of sustainability has been introduced to highlight the need for a balanced approach to the three P’s, namely people, profit, and planet. The aforementioned dimensions provide corporate growth opportunities emanating from the adoption of sustainable good practices (Byrne, Ryan, and Heavey, 2013; Sezen and Turkkantos, 2013).

The value proposition of linking research to sustainable development is strongly acknowledged. This is further affirmed in the most recent research and development policy documents of the European Union (EU). Specifically, the European Research Area (ERA) vision 2020 calls for a focus on societal needs and ambitions toward sustainable development. The three “Key Thrusts” identified by the European Technology Platform on the “Food for Life” Strategic Research Agenda 2007–2020 meet all of the criteria required to stimulate innovation, to create new markets, and to meet important social and environmental goals. These “Key Thrusts” are:

- Improving health, well-being, and longevity.
- Building consumer trust in the food chain.
- Supporting sustainable and ethical production.

While, the topic of “sustainability” is inherent to SCM (Ahi and Searcy, 2013; Pagell and Shevchenko, 2014), it is only during the last two decades that sustainability in SCM has attracted increased academic and business interest, further reflecting the fact that SC operations are a field where most organizations can and actually implement green strategies (Kewill, 2008; Seuring, 2013). Indicatively, Seuring and Muller (2008) present a comprehensive literature review of almost 200 relevant papers while further outlining the major research directions in the field. Moreover, in the work of Gupta and Palsule-Desai (2011), the existing sustainable SCM literature is classified under four broad categories related to decision-making, namely strategic considerations, decisions at functional interfaces, regulation/government policies, and decision support tools. Similarly, Seuring (2013) reviews papers that tackle the issue of sustainable SCs with a focus on the application of quantitative models. More recently, Ahi and Searcy (2014) conducted a structured review of 445 articles and provide an analysis of 2.555 unique metrics employed in assessing green and sustainable SCM.

The issue of sustainability is even more vital for the food industry which is dominated by a growing demand for sustainably produced food as consumers today are highly cognizant of the manner in which the food is produced, processed, and distributed (Beske, Land, and Seuring, 2014). In general, AFSCs are dynamically evolving over time in order to follow the persistent changes within the broader agrifood environment and to further accommodate the continued introduction of new environmental and food safety legislation from both European and international directives (Glover *et al*., 2014). In the forthcoming years, modern AFSCs will have to cope with a plethora of major challenges that are underway, encompassing amongst others: rapid urbanization, growth and liberalization of domestic/global factors and markets, decrease of public sector funding, dominance of global SCs, concerns for food quality and safety, changes in technology, weakness of regional rural populations to comply with the requirements posed by dominant enterprises, climate change effects on farming, and the adoption of corporate social responsibility (CSR) practices. Therefore, the recognition of the most critical issues that need to be addressed by all AFSCs' stakeholders toward an integrated decision-making process emerges as a prerequisite for designing and managing such complex, multi-tier SCs and ensuring their overall efficiency and sustainability.

Furthermore, societal stakeholders demand corporate responsibility to transcend product quality and rather extend to areas of labor standards, health and safety, environmental sustainability, non-financial accounting and reporting, procurement, supplier relations, product life cycles, and environmental practices (Bakker and Nijhof, 2002; Waddock and Bodwell, 2004; Teuscher, Grüninger, and Ferdinand, 2006). Therefore, sustainable SCM expands the concept of sustainability from a company to the SC level (Carter and Rogers, 2008) by providing companies with tools for improving their own and the sector's competitiveness, sustainability, and responsibility toward stakeholder expectations (Fritz and Schiefer, 2008). In addition, the principles of accountability, transparency, and stakeholder engagement are highly relevant to sustainable SCM (Waddock and Bodwell, 2004; Teuscher, Grüninger, and Ferdinand, 2006; Carter and Rogers, 2008). More specifically, in response to pressures for transparency and accountability, agrifood companies need to measure, benchmark, and report environmental sustainability performance of their SCs; whilst on the other hand, policy-makers need to measure the sectorial performance within the SC context for effective target setting and decision-making interventions.

Particularly, as dictated by the third "Key Thrust" that ERA articulates, food chains need to operate in a manner that exploits and optimizes the synergies among environmental protection, social fairness, and economic growth. This would ensure that the consumers' needs for transparency and for affordable food of high quality and diversity are fully met. Progress in this area is expected to have important benefits for the industry in terms of reduced uses of resources, increased efficiency, and improved governance. An overview of emerging global trends, policy developments, challenges, and prospects for European agri-futures, points to the need for novel strategic frameworks for the planning and delivery of research. Such frameworks should address the following five challenges:

- *Sustainability*: facing climate change in the knowledge-based bio-society.
- *Security*: safeguarding European food, rural, energy, biodiversity, and agri-futures.
- *Knowledge*: user-oriented knowledge development and exchange strategies.
- *Competitiveness*: positioning Europe in agrifood and other agricultural lead markets.
- *Policy and institutional*: facing policy-makers in synchronizing multi-level policies.

Addressing these challenges could usher the European agrifood sector to the knowledge-based bio-economy, while ensuring that the sector (and food retailers) remains globally competitive further addressing climate change and sustainable development concerns, such as the maintenance of biodiversity and prevention of landscape damage. Meeting these multi-faceted sustainable development challenges facing the agrifood sector worldwide, will require a major overhaul in the current agriculture research system. Recent foresight work under the aegis of Europe’s Standing Committee for Agricultural Research (SCAR), has highlighted that in the emerging global scenario for European agriculture, research content needs to extend to address a diverse and often inter-related set of issues relating to sustainable development, including food safety/security (Keramydas *et al.*, 2014), environmental sustainability, biodiversity, bio-safety and bio-security, animal welfare, ethical foods, fair trade, and the future viability of rural regions. These issues cannot simply be added to the research agenda. Rather, addressing them comprehensively and holistically in agriculture research requires new methods of organizing research, in terms of priority-setting, research evaluation and selection criteria, and in bringing together new configurations of research teams, as well as managing closer interactions with the user communities and the general public in order to ensure that relevant information and knowledge is produced and the results are properly disseminated.

Furthermore, in order to unleash value, it is important to exploit the potential of utilizing agrifood waste and the associated by-product biomasses for energy recovery and nutrient recycling, to mitigate climate change and eutrophication (Kahiluoto *et al.*, 2011). To that end, biomass has emerged as a promising option, mainly due to its potential worldwide availability, its conversion efficiency, and its ability to be produced and consumed on a CO_2-neutral basis. Biomass is a versatile energy source, generating not only electricity but also heat, while it can be further used to produce biofuels (Verigna, 2006; Watanabe *et al.*, 2014; Toka *et al.*, 2014). Iakovou *et al*. (2010) provide a critical synthesis of the state-of-the-art literature on waste biomass SCM. Agrifood biomass is usually free of toxic contaminants and is determined spatially and temporally by the respective local/regional profile of the pertinent activities.

It is well documented that 31% of the greenhouse gas (GHG) emissions and more than 50% of eutrophication are related to food chains, thus highlighting the need to intervene in the AFSC to ameliorate its impact on the environment (CEC, 2006). In order to promote “green” AFSCs and elaborate agrifood biomass operations on a large scale, the application of appropriately designed innovative policies and systems is necessary (Van der Vorst, Tromp, and van der Zee, 2009; Negro, Hekkert, and Smits, 2007). Green SCM is one of the top two strategic priorities for global corporations (McKinsey, 2011). The benefits of going green are substantial, as green SCM cannot only reduce an organization's carbon footprint but it can also lead to reduced costs, improved reputation with customers, investors, and other stakeholders, thus further leading to a competitive edge in the market and increased profitability. Indicatively, a case study for the new business model for agricultural material sourcing of Nestle, a leading food company (Goldberg and Fries, 2012), summarizes a set of trends that are valid for most food companies.

Indeed, the post-2009 recession period has further underlined the need to turn the business focus, across the world, not only to profitability, but to sustainability as well. Today, one of the key priorities in corporate strategic design for an organization is to emerge as socially responsible and sustainable. Companies are structuring their sustainability reports to disclose their strategy to address the growing concerns of environmental degradation and global warming. Today, 93% of the global Fortune 250 companies release their annual sustainability report (KPMG, 2013), up from 37% in 2005 (Singh, 2010). As a focal part of sustainability initiatives, green SCM has unequivocally emerged as a key discipline that can provide competitive advantage with substantial gains for the company's bottom line. In designing green SCs, the intent is to adopt, comprehensively and across business boundaries, best practices right from product conception to the end-of-life recycling stage. In this context, green initiatives relate to both tangible and intangible corporate benefits. Sustainability reports of many companies indicate that the greening of their SCs has helped them to reduce their operating costs with increased sustainability of their business.

Additionally, modern AFSCs are exposed to a wide variety of natural, technological, and man-made risks, such as weather related risks and extreme weather events (e.g., hail storms, floods, and droughts), natural disasters (e.g., earthquakes, volcano eruptions), biological and environmental risks (e.g., livestock diseases), production risks (e.g., yield uncertainties), human resource risks (e.g., seasonal personnel unavailability), management and operational risks (e.g., forecasting errors), logistical, infrastructural, and technological risks (e.g., uncertainty of new technologies adoption), price and market risks (e.g., price volatility of inputs and outputs), financial risks (e.g., disruptions of farm business financing), policy, institutional, and regulatory risks (e.g., uncertainties of tax and fiscal policies), and political risks (e.g., political and/or social instability) (Jaffee, Siegel, and Andrews, 2010). These risks may inhibit normal operations of AFSCs and could provoke deviations, disruptions, or shutdowns to the SC's fundamental flows. Furthermore, they may have a dramatic impact on cost, efficiency, and reliability of the included activities and operations.

The associated core risk-related decisions refer to: (i) the selection of appropriate risk governance modes; and (ii) the implementation of suitable risk mitigation strategies. The first set of decisions explores the options of the market, private and public risk governance along with the relevant intervention levels. The second set refers to the nature of the applied risk mitigation policy including technology development and adoption, enterprise management practices, financial instruments, investments in infrastructure, policy and public financial support schemes, and private collective actions (OECD, 2009).

The existing research has focused only on few critical aspects of the agrifood risk management concept including cross-border transaction risks (Ameseder *et al.*, 2009), chemical and biological risks (Bachev, 2011), agricultural contracts (Ligon, 2003), catastrophic/disaster risk management (Antón, Kimura, and Martini, 2011; RPDRM, 2012), income risk management (OECD, 2000), climate risk management (Wall, Smit, and Wandel, 2004), and insurance schemes (Bielza Diaz-Caneja *et al.*, 2009).

To sum up, the nature of the overall decision-making process in sustainable AFSCs is purely dynamic, as it unfolds in real-time within an uncertain environment that changes continuously bringing new challenges and opportunities. Consequently, the decisions along with the associated implemented strategies should be continuously evaluated and reconsidered in order to ensure the long-term efficiency and sustainability of an AFSC.

1.3 Hierarchy of Decision-Making for AFSCs

Designing, managing, and operating AFSCs involves a complex and integrated decision-making process. This is even more accentuated when AFSCs deal, for example, with fresh, perishable, and seasonable products in the context of high volatility of supply and demand. In general, the design and planning of sustainable AFSCs needs to address a wide range of issues including crops planning, harvesting practices, food processing operations, marketing channels, logistics activities, vertical integration and horizontal cooperation, risk and environmental management, food safety, and sustainability assurance.

1.3.1 Strategic Level

The strategic decisions involve all stakeholders that are interested in participating in a sustainably driven SC network of agricultural goods. Thus, decisions at the strategic level of the hierarchy span the following aspects: selecting the appropriate farming technologies, SC partnership relations, design of SC networks, establishment of a performance measurement system along the AFSC, and finally, quality assurance. Below, these decisions are further discussed, while a synthesis of the relevant and up-to-date research efforts is provided.

1.3.1.1 Selection of Farming Technologies

Today's trends toward diversified crops, quality standards, increased environmental concerns, biological and weather implications, and safety regulations dictate the need for a careful selection of the farming technologies to be employed (Søgaard and Sørensen, 2004). To this end, farming technologies range from traditional farming machinery to sophisticated information technology (IT) and precision agriculture (PA) applications; the latter are recognized as a major contributor to increased farming efficiency and environmentally sustainable farming practices (Aubert, Schroeder, and Grimaudo, 2012; Bochtis, 2013).

The main decisions involved in the selection process of the farming technologies relate to:

1. the determination of the capital requirements and expenditure on farming equipment;
2. the development of cooperative schemes in the utilization of farming machinery; and
3. the adoption of innovative farming applications.

In terms of capital expenditure and cooperative actions, the optimum solution must be investigated with relevance to the type of planting, tillage practices, harvesting methods, ownership costs, operating costs, labor costs, and timeliness costs. In terms of innovation and performance, the factors that affect the selection of farming technologies can include, indicatively, the size of the yielded production, the required quality of the agricultural products, and the volatility of weather and soil conditions.

Farming technologies ensure the uninterrupted supply of adequate goods so that a particular AFSC can respond to market demand over the strategic horizon. In the literature, there are well documented quantitative models that deal with the optimal mechanization level of farms with regard to the capital expenditure, economic efficiency, and capacity utilization (e.g., Glen, 1987; Godwin *et al.*, 2003; Søgaard and Sørensen, 2004; Sørensen, Madsen, and Jacobsen, 2005; Pandey, Panda, and Panigrahi, 2006; Katalin *et al.*, 2014). Moreover, many researchers stress the importance of cooperative schema in machinery utilization, especially in the case of small- and medium-scale farms, which are characterized by common agricultural factors such as the cultivated crop varieties, farm size, soil type, environmental impact, and labor employability (e.g., de Torro and Hansson, 2004; Aurbacher, Lippert, and Dabbert, 2011; Abebaw and Haile, 2012; Dai and Dong, 2014). Today, modern research deals with the incorporation of innovative approaches into applied farming technologies. Robotics and IT applications toward production automation, image analysis, and quality sensing are only a few of the radical advances that have been developed for vegetable propagation, picking, trimming and packaging, robotic milking, and livestock monitoring (Wrest Park History Contributors, 2009). Finally, the utilization of PA technologies (i.e., satellite imagery and geospatial tools that allow the selective treatment of a field as a heterogeneous entity) has emerged as a viable intervention to promote farming efficiency and foster environmental sustainability though drastic