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Smart Innovation in Agriculture

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Preface

This book is devoted to the topic of agriculture, which is studied from three perspectives. The first perspective is agricultural economics. This book has a vivid multidisciplinary character. Agriculture is considered not only from the positions of agricultural disciplines but also from the positions of economics and management in agriculture, regional economics (in Part Three, agriculture is connected in connection to the regional economy), state management (economic policy), management of innovations, and ICT (as a sphere of technical sciences).

The second perspective is sustainable development. The book elaborates on the priority of agriculture for implementing SDG 2, i.e., provision of food security. The book also pays a lot of attention to SDG 9 in the aspect of the importance of post-industrialization (transition to Industry 4.0 in the process of the Fourth Industrial Revolution), high-tech infrastructure, and smart innovations for the development of agriculture and provision of food security.

The agricultural economy is also considered in this book as a source of economic growth, and thus, attention is paid to SDG 8. Provision of food security is studied not only as a macro-mission of the agricultural economy but also as a micro-mission of the subjects of agricultural entrepreneurship. As shown in the book, this micro-mission is implemented through corporate social and ecological responsibility, which draws a connection between this book and SDG 12.

In this book, the technologies of agricultural (farm) production are improved for their adaptation to climate change, so the book is connected to SDG 13. Protection of the environment and ecological agriculture is considered in several chapters, which ensures the book's connection with SDG 14 and SDG 15. The book elaborates and analyzes the experience and problems of food security provision in developing countries, due to which the book contributes to SDG 10 (offering recommendations for the reduction of countries inequality in the development of the agricultural economy and level of food security).

In Part Three, agriculture is considered in the connection to the regional economy and treated as a source of the region's growth and economic (food) security. The authors determine perspectives and offer recommendations for the development of

rural territories based on smart technologies in agriculture (transition to digital agriculture). Thus, the book has a clear connection to SDG 11. Other SDGs are also considered in the book.

The third perspective (perspectives are enumerated by the order, not by importance in the book) is smart innovations. Smart innovations, cyber-physical systems, and digital technologies in agriculture are the main message of this book. It demonstrates that agriculture must not stand aside from the Fourth Industrial Revolution. The agricultural economy must receive a digital impulse for development and perform a transition to Agriculture 4.0. However, this requires special (adapted to the specifics of agriculture) smart innovations, systems, and technologies, which are developed in this book. Organizational and economic and managerial recommendations for their implementation are offered in this book.

The significance of the given topic is very high since agriculture is under bilateral pressure, which stimulates its digital modernization. On the one hand, the growth of global demand for food and unfavorable change of climate, which reduces the efficiency of agricultural production, increase the deficit of food and aggravate the problem of food security provision.

On the other hand, the Fourth Industrial Revolution is gathering pace and already covers most spheres of the economy and most countries of the world. The result of the described pressure is the "institutional trap" of preservation of the third technological mode in agriculture. Low susceptibility/inclination for innovations in agriculture and deficit of financing (government subsidies and private investments) leads to its isolation from the Fourth Industrial Revolution.

Delayed technological development of agriculture (compared to other spheres of the economy) further reduces its attractiveness for private investors, which deprives it of resources for innovations. The intense growth of demand and deficit of food leads to the forced increase of government financing for the artificially (by the government's initiative) started digital modernization of the agricultural economy. Here, sample/standard (not innovative) and/or borrowed from other spheres of economy (not adapted to the specifics of agriculture) technologies are used.

With the existing approach, digital modernization of the agricultural economy is very slow, has low effectiveness, and does not allow solving the problem of food security provision (making a small contribution to sustainable development). Rural territories fall into decline and are peculiar for the reducing quality of life. The novelty of this book consists in offering, elaborating, and describing an alternative approach to the transition to Agriculture 4.0, which envisages the following:

– use of the leading technologies and implementation of smart innovations in agriculture;
– use of not conventional but adapted to the specifics of agriculture (or developed especially for it) digital technologies.

The advantage of the new approach is, first, allowing overcoming the "institutional trap" of the agricultural economy and ensuring its quick technological leap, which will allow for the following: (1) complex and complete solution of the problem of food security; (2) significant increase of the agricultural economy's contribution to

implementing the SDGs; (3) provision of high investment attractiveness of the agricultural economy in the long-term. Second, the new approach allows achieving rapid development of rural territories and the reduction of their underrun (inequality) from urban territories, which, in the long-term, could start the trend for de-urbanization, as well as the development of rural tourism.

Unlike other existing publications, this book studies—in a systemic manner—the prospects of transition to Agriculture 4.0. From the positions of economics, the book provides a scientific view of digital agriculture. From the positions of management, the book describes the organizational and managerial foundations of implementing smart innovations in agriculture. From the positions of regional economics, the book determines the contribution of the transition to Agriculture 4.0 for the regional economy and development of rural territories. From the positions of state management, this book offers recommendations in the sphere of economic policy for implementing smart innovations in agriculture. From the positions of agriculture, management of innovations, and ICT, the book provides case examples, considers international experience, and offers smart innovations and digital frameworks—which are ready for implementation—for agriculture.

This book contains the leading developments in the sphere of using smart innovations in the agricultural economy from various spheres of scientific knowledge. The book is aimed at (highest to lowest priority):

1. Scholars who study the agricultural economy from positions of various disciplines: economics and management in agriculture, regional economics, state management (economic policy), management of innovations, and ICT (as a sphere of technical disciplines): They will find in the book the fundamental inventions and results of empirical research in the sphere of the prospects for implementing smart innovations in agriculture based on a new approach to regulating the agricultural economy;
2. Practitioners who deal with the agricultural economy: They will find in the book the analysis of international experience and the leading scientific and practical developments in the sphere of state and corporate management of implementing smart innovations in agriculture;
3. Educational process, in which materials of the book could be used for such disciplines as “Agriculture,” “Agrarian economics,” “Management in agriculture,” “Corporate economics,” “Regional economics,” “Management of innovations,” “Public administration,” etc.

This book is aimed to be a practical guide for implementing smart innovations in agriculture and starting its technological transitioning to Agriculture 4.0. We hope this book will be in demand not only in developed countries but especially in developing countries, which face the problems of agriculture that are studied in the book and require smart innovations for the agricultural economy. We also hope that this book will be a significant contribution to sustainable development.

On behalf of the editors and authors of this book, we would like to express gratitude to the editors of the series "Smart Innovation, Systems and Technologies"—Prof. Robert J. Howlett (KES International) and Prof. Dr. Lakhmi C. Jain (Founder KES International)—for supporting our idea and helping with its successful implementation.

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Introduction

Technological progress in recent decades has had a particular impact on agriculture. The formation of market relations in agriculture has led to the contradictory nature of the model of its development. On the one hand, agricultural enterprises received complete independence from the state. Due to this, private, including venture investments, became available to them.

On the other hand, in the agricultural sector, there are some "market failures" that reduce the efficiency of market relations and hinder the innovative development of this industry. One of the "market failures" is the strategically significant non-profit mission of agriculture associated with its important contribution to food security. The fulfillment of this non-profit mission contradicts the commercial interests of agricultural entrepreneurship, whose investments in sustainable development—corporate social and environmental responsibility—often do not pay off due to insufficient effective demand.

Simultaneously improving the quality and maintaining food security at a high level while ensuring its mass quantitative and price accessibility are directly opposite entrepreneurial tasks, since the first of them is associated with an increase in costs and, accordingly, food prices, and the second task requires fixing or even reducing prices. Without government support, agricultural enterprises cannot fulfill their mission in the field of sustainable development or find themselves on the verge of breaking even.

Another "market failure" is the inflexibility of the agribusiness value-added chain. Agricultural enterprises are at the beginning of this chain and operate in a highly competitive environment due to low market entry barriers. However, enterprises located at the next stages of the value-added chain—food production enterprises and enterprises of wholesale purchasing of agricultural products—operate in conditions of much less concentration of markets with their monopolistic or oligopolistic structure.

The high bargaining power of buyers in B2B food markets and, accordingly, the low bargaining power of sellers—agricultural enterprises—do not allow them to influence market prices and limit their opportunities for technological development and innovation. The difficulty in overcoming this "market failure" lies in the fact that

enterprises at the stages of the value-added chain following agriculture are characterized by a natural (forced) monopoly/oligopoly, since an artificial increase in the number of market players is associated with high risks of reducing the quality and safety of food and therefore contradicts the idea of ensuring food security.

The "market failures" also include the continuing high dependence of productivity (efficiency) and quality of agricultural products on natural and climatic factors. This leads to high entrepreneurial risks and low investment attractiveness of agriculture in comparison with other sectors of the economy.

The described "market failures" are insurmountable in the current technological order. But the transition to a new fourth technological order opens up new opportunities for the development of agriculture. Firstly, smart agricultural innovation can improve quality and safety while maintaining or even lowering food prices, as well as increasing sharply productivity by overcoming food shortages. Due to this, based on "smart" innovations, it is possible to significantly increase the contribution of agriculture to sustainable development and harmonize the commercial and non-commercial interests of entrepreneurship.

Secondly, advanced technologies such as blockchain (distributed ledger) and ubiquitous computing (UC) enable food products to be tracked along the entire agribusiness value-added chain. This makes it possible to overcome the natural monopoly/oligopoly in the next stages of the value-added chain after agriculture and increase the bargaining power of agricultural producers. This will allow them to be more flexible and more innovative.

Thirdly, climate smart innovation in agriculture makes it possible to make it sustainable or even independent of natural and climatic factors. In this case, entrepreneurial risks are reduced many times and the investment attractiveness of agriculture increases. Consequently, "smart" innovations make it possible to ensure the high efficiency of the market mechanism in agriculture—to maintain its independence from government regulation and funding and at the same time maximize its (non-profit) contribution to sustainable development.

This is a more preferable path compared to the current practices of tightening state regulation of agriculture and expanding its state subsidies, which undermine the foundations of the market mechanism and consolidate subsidies as an integral characteristic of agriculture. However, despite the urgent need for smart innovation, agriculture is the sector of the modern economy that is least involved in the Fourth Industrial Revolution and embraced by advanced technologies.

In this regard, the problem of studying the accumulated experience of digital modernization of agriculture and the development of scientific, methodological, and practical recommendations to accelerate this modernization in the interests of mass introduction and intensification of the use of "smart" innovations in agriculture is urgent. This book is designed to solve the problem posed and aims to study the existing experience and prospects for the introduction of "smart" innovations in agriculture. The book answers the question of why "smart" innovations are spreading at a slow pace in agriculture and how to accelerate their diffusion. The book contains five parts.

The first part identifies the importance of smart innovation in agriculture for modern economic and ecological systems and provides an overview of advanced technologies, including artificial intelligence (AI) and deep learning. The second part of the book is devoted to a review and analysis of international and regional empirical experience in the implementation of smart innovation in agriculture, with special attention to the experience of Russia and the Kyrgyz Republic.

The third part is devoted to promising directions and guidelines for the development of smart innovation in agriculture according to the priorities of modern economic and ecological systems. In the fourth part, policy and management implications for the development of smart innovation in agriculture in modern economic and ecological systems are proposed and substantiated. Among the proposed recommendations are the Agriculture 4.0 model based on deep learning, as well as applied solutions for creating vertical farms based on hydroponics, deep learning, and AI as smart innovations in agriculture.

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