Information and Communication Technologies

and their relations with agriculture

Silvia Maria Fonseca Silveira Massruhá
Maria Angelica de Andrade Leite
Ariovaldo Luchiari Junior
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Technical Editors

Embrapa

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Brazilian Agricultural Research Corporation
Embrapa Agricultural Informatics
Ministry of Agriculture, Livestock and Food Supply

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Foreword

The Brazilian Agricultural Research Corporation (Embrapa) is a participant member of the Cooperative Program for Agrifood and Agroindustry Technological Development of the Southern Cone (Procisur), a joint initiative of the National Institutes for Agricultural Research of the Southern Cone aimed at fostering their cooperation, alongside other global actors in the fields of science, technology and innovation, to help improve the productivity, competitiveness and sustainability of natural resources, food safety, rural land development and social equity in regional agriculture. The countries represented at Procisur are: Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay.

Procisur is organized into Regional Platforms aiming to coordinate and integrate the various public and private actors of a specific sector in cooperative ventures, thus fostering technological development and innovation in common interest areas. Embrapa Agricultural Informatics coordinates the Information Technology Applied to Agriculture work team within the sphere of the Regional Platform for the Use of Emerging Technologies.

Aiming to foster knowledge exchange and establish the participation of new technologies in regional agriculture competitiveness and sustainability, Embrapa Agricultural Informatics took the initiative of organizing the production of this book addressing the use of information and communication technologies and their relations with agriculture. It is the result of a joint effort with the National Institute of Agricultural Technology (Inta Argentina), the National Institute for Agricultural Research (Inia Chile), the National Institute for Agricultural Research (Inia Uruguay) and the Inter-American Institute for Cooperation on Agriculture (IICA-Procisur).

Readers will have the chance to keep abreast of the main findings in the areas of computational biology and bioinformatics, automation and precision agriculture, information and knowledge management, modeling and simulation, high performance processing, market, technology transfer, and future prospects for the use of ICT applied to areas such as natural resources, climate change, phytosanitary safety, and solutions involving spatial data. Initially, we expect to disseminate the current status regarding the use of ICT in agriculture in the southern cone. In addition, it is a starting point to establish a foundation for future debates, allowing us to exchange experiences, strengthen partnerships and foster the sustainable development of agriculture production chains in the Southern Cone. The expected outcome is the establishment of incentives that will increasingly enhance the role of ICT in boosting agricultural growth and enhancing social, environmental and economic conditions in the rural domain.

Maurício Antônio Lopes
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Preface

This book is the result of an ongoing effort by the Information Technology Applied to Agriculture work team, within the sphere of the Regional Platform for the Use of Emerging Technologies of the Cooperative Program for Agrifood and Agroindustry Technological Development of the Southern Cone (Procisur). At the team's last meeting in July 2013, in Montevideo, Uruguay, Embrapa Agricultural Informatics, alongside representatives of the National Institute of Agricultural Technology (Inta Argentina), the National Institute for Agricultural Research (Inia Chile), the National Institute for Agricultural Research (Inia Uruguay), the Paraguayan Institute of Agrarian Technology (IPTA Paraguay), and the Inter-American Institute for Cooperation on Agriculture (IICA–Procisur) identified an opportunity to disclose and consolidate, in a document, what the participant institutions have been discussing on the challenges and opportunities for development related to the use of Information and Communication Technologies (ICT) in the field of agricultural research.

ICT have been globally viewed as the third pillar of scientific inquiry, alongside theory and experimentation. Advances in ICT play a strategic and political role in all economic production chains, including agriculture.

The new challenges of achieving greater productivity and efficiency in agriculture by optimizing the use of natural and environmental resources increasingly require the need to apply different types of information technology. The integration of ICT enables the development of solutions in mechanization, phytosanitation, animal welfare, traceability and food safety, biofuels development, precision agriculture, agricultural risk management, impact assessment and mitigation of climate change, and reproduction and biotechnology.

New developments such as simulation, modeling, knowledge management (ontology, semantic web), expert systems, artificial intelligence, wireless networks, mobility, and image processing combined with open systems for better information exchange foster increasing progress in research and innovation, offering solutions that benefit agriculture.

We are witnessing a transition from the industrial society to the information society. Within this concept, ICT are a set of tools with great potential for technology dissemination and transfer. The new channels and means of mass communication are heralding a new era of the information revolution. It is essential that Latin-American countries prioritize development in science and technology, in innovation, and especially in infrastructure and ICT-qualified human resources.

This book reveals how the member countries of Procitur are using ICT to solve problems related to agriculture production systems. Specifically in relation to Brazil, it charts developments in the field of ICT in the last five years, featuring the research projects that Embrapa Agricultural Informatics has been developing in partnership with the 46 Embrapa Research Centers. Its objective is to provide resources to reflect on the main technological prospects of ICT for the coming years, alongside the other participant countries of Procisur.

To this end, the book has been divided into seven parts describing the current scenario of ICT in various areas. Part I gives an overview of the possibilities for technological innovation afforded

by ICT tools and their applications (AgroICT) in agriculture, besides charting the insertion of ICT in rural environments.

Part II mostly focuses on the role of ICT in biotechnology, classified into four chapters on genomics, bioinformatics, computational biology, and the role of computing in plant phenotyping.

Part III addresses the role of ICT within the scope of natural resources and climate change. The chapters range from ICT use in agrometeorology, climate risk zones, and climate change to applications involving geospatial data.

Part IV discusses the role of ICT in production chains. The first chapter addresses the use of ICT in phytosanitary safety. The remaining chapters address the topic of automation and precision agriculture. These chapters draw on the experience and expertise of researchers of the Faculty of Zootechnology and Food Engineering (FZEA-USP), of the São Carlos Engineering School (EESC-USP), and Embrapa Instrumentation.

In Part V, the goal is to discuss certain ICT tools and technological development in the area of ICT design for agricultural applications (AgroICT). To this end, it was divided into five chapters ranging from storage and high performance/high volume data processing to data, information and knowledge management to a discussion of data modeling, simulation and mining.

Part VI covers the generation of technology and AgroICT application and transfer. It starts by describing AgroICT applications and their markets, as well as a few case studies of technology transfer to AgroICT products. Next, a few emerging technologies are described, followed by a presentation of the future prospects of technological evolution in AgroICT.

Part VII features experiments being developed in the areas mentioned in the previous chapters in other member countries of Procisur, such as Chile, Argentina and Uruguay.

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Part 1

The role of ICT in agriculture

Photo: Neide Makiko Furukawa

Chapter 1

New challenges and opportunities for Information and Communication Technologies in agriculture (AgroICT)

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1 Introduction

Nowadays we are experiencing a moment of transformation involving a major dichotomy. On one hand, people live in extraordinary times of great prosperity, long and healthy lives, available technologies providing access to information and knowledge, and higher levels of education. On the other, they face several risks to the planet, high levels of poverty, diseases, and the need to improve the quality of education.

This contemporary and globalized world urges all of us to search for a more sustainable and equitable economy, in which bioeconomy gains importance and visibility, since sustainability has definitely entered the list of society's priorities. Within the sphere of this study, bioeconomy is considered as a field of human activity which promises to bring together all sectors of the economy employing biological resources (living beings) to offer coherent, efficient and tangible solutions to huge challenges such as climate change, replacing fossil raw materials, food safety, and population health (EMBRAPA, 2014).

In this context, which focuses on health, quality of life and well-being, technological progress will play an increasingly strategic and political role in Brazil and worldwide. The report commissioned by the US National Science Foundation, Converging Technologies for Improving Human Performance Nanotechnology, Biotechnology, Information Technology and Cognitive Science, points to the synergy between nanotechnology, information technology, biotechnology and cognitive science as the greatest future potential for humanity in the next 20 years (ROCO; BAINBRIDGE, 2002).

For several decades, information and communication technologies (ICT) have been making significant contributions to the various fields of knowledge, enabling the storage and processing of great volumes of data, process automation, and exchange of information and knowledge. Their major potential lies in their transversality to bring added value and benefits to various sectors of business, market, agriculture and environment.

Some of the most recent innovations in ICT promise to enhance agricultural research, generating new AgroICT. In this study, AgroICT is defined as a set of specific applications for agriculture that use ICT-based tools, such as geographic information systems (GIS), systems based on knowledge, decision-making supporting systems, and models incorporated into new technologies