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EXECUTIVE SUMMARY

The Vision-of-the-Future of Brazilian Agriculture

The *Vision-of-the-Future of Brazilian Agriculture* platform gathers and synthesises structural analyses of the food, fibre and bioenergy production environments considering a long-term horizon. Embrapa counts on these inputs for decision-making and elaborating strategic planning. Players in Brazilian agriculture use it for guiding their actions. It is coordinated by Embrapa's Secretariat of Intelligence and Strategic Affairs and is the fruit of the efforts of more than 300 specialists and leaders in Brazilian agriculture, and the analysis of 126 documents and discussions from 37 events. The results are organised into eight megatrends. This Executive Summary is but a synopsis so it is important to consult the complete version of the document available at www.embrapa.br/visao-de-futuro

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Sustainability

The pressure for sustainable and integrated processes includes demands for a lower carbon footprint, water conservation, soil nutrient maintenance, the controlled use of antimicrobials and pesticides, loss and waste mitigation as well as adequate conditions of employment and income in the field. Digital solutions, robotics and automation are vital in creating and promoting sustainable processes and services. The bio-economy, combined with the green economy and the circular economy, are the basis for the key technological developments, in particular with solutions for the production of biological inputs (biofertilisers and biopesticides) for the development of the circular economy and for use by the waste agroindustry. This is in addition to other initiatives that might emerge to exploit the potential of Brazilian biodiversity. Environmental compliance aspects of rural properties, the valuation of agro-environmental services and the evolution of the social, environmental and corporate governance (ESG) agenda intensify and follow. This megatrend is transversal and is the foundation for others.

Challenges

- Foster sustainable models and technological development for the conservation of natural and forest resources and biodiversity.
- Accelerate and intensify the process of decarbonization of agriculture, in the face of international pressure to establish a carbon neutral economy (commitment assumed by Brazil to be implemented in 2050).
- Foster traceability that allows consumers to access information about the production process.
- Increase assessment and payment mechanisms for environmental services.
- Foster the growth in the bioinput industry of plant, animal and microbial origin and the reduction of the use of fossil products.
- Reduce food losses and food waste in all food production chains.
- Reach animal welfare standards in order to provide comfort and observe new national and international laws and market rules.
- Promote the development of the green economy as a competitive advantage.
- Add value to organic products, improving organic and agroecological production practices beyond the food market (cotton, for instance).

Adaptation to climate change

Investment in research and developing technology associated with production systems more resilient to climate change needs to be part of decision-making in Brazil immediately and strategically in the long term. The commitments adopted at the national and international levels strengthen this and embrace the reduction of social, environmental and economic impacts, guaranteeing food security and the competitiveness of Brazilian agriculture. All this in addition to staying in line with the Sustainable Development Goals (SDGs), especially SDG 13: Take urgent action to combat climate change and its impacts. The challenges for, and impacts on exercising agricultural activity in

the tropical regions will increase over the coming decades. Stabilising the temperature at a level of 1.5 °C requires drastic efforts and global engagement in addition to immediate investment in priority technological development until 2030.

Challenges

- Adapt the Brazilian tropical agriculture to compete with countries (in particular the most developed nations) located in temperate regions, which may have better technologies and climatic conditions related to global warming.
- Invest heavily in research for the development of technologies that allow the agricultural sector, under tropical conditions, to develop activities with lower GHG emissions.
- Reduce biodiversity loss by developing sustainable practices of production and management of soil, water, inputs and energy.
- Enforce international agreements related to climate change, in order to ensure the best image of Brazilian products in foreign markets.

Agrodigital

Several forces of information and communication technology are spurring a revolution in the field and characterising Agrodigital. This process is based on the use and development of digital technology such as modelling and simulation, artificial intelligence, machine learning, internet of things (IoT), augmented reality, robotics, sensors, 3D and 4D printing, ubiquitous connectivity, digital twins, blockchain, 5G, quantum computing and big data, to name a few. Digital transformation also affects financial and educational operations in rural areas and enhances the opening of new markets and opportunities previously considered unimaginable. Digital technology became a determining factor behind decision-making, production value adding, the optimisation of inputs and natural resources, production process traceability and transparency, as well as for increasing profitability, efficiency and competitiveness in both the national and international market.

Technology allowing the generation of new cultivars in line with consumer demands includes practices and inputs for more sustainable agriculture. These practices include discovering new molecules to control pests and diseases in order to replace traditional pesticides, expanding technical assistance and rural extension to small producers through digital platforms and distance training. Value adding to agricultural production through traceability and certification, collecting huge quantities of data on soil characteristics, climate, humidity and precipitation to support producers' decision-making and shortcutting supply chains through marketing platforms that connect the rural producer to the consumer are other examples. Startups known as agritechs are increasingly providing solutions for agribusiness and are among the leading protagonists generating this technology. This megatrend is also transversal like the first.

Challenges

- Expand the range of connectivity, under threat of increasing the gap between the most technical producer and the one unable to adhere to this new model.
- Provide alternatives that, based on the increase of connected devices and data in IoT networks, allow greater interoperability, broader geographic distribution, real-time interaction,

support for large-scale sensor networks and the availability of new energy and storage sources.

- Map and propose the implementation of alternatives in digitization and automation in agriculture.
- Train small and medium-scale producers, agronomists, extension workers and agricultural technicians in digital technologies aiming digital inclusion and agricultural sustainability.
- Develop processes based on business intelligence, seeking to understand and coming up with solutions comprising great heterogeneity and complexity of information.

Technological intensification and concentrating production

Significant production map changes has tended towards productive specialisation and an increase in agricultural exports in terms of both quantity and value. Other factors are present like the strengthening of the food-nutrition-health relationship – one of the consequences of the pandemic, shortening the distances between production and consumption (short chain), the progressive reduction of the population in the countryside and the consequent scarcity of manpower, progressive automation and the demand for trained professionals. Moreover, there is higher concentration on production and on income in rural areas, and more concern over employment levels, costs of labour and the environment.

Challenges

- Propose market diversification goals, with productivity growth combined with strengthening and sustainable intensification.
- Add value to the technological framework applied to agribusiness, aiming at maximizing domestic production for domestic supply and export purposes.
- Systematize and make public to the general consumer information on agricultural value chains.
- Provide better livelihoods to rural producers, especially to the small-scale farmers.

Rapid transformation in consumption and value adding

The chief global trends in food consumption are sustainability, healthiness, food safety and increasing market segmentation. The evolution of digitalisation has allowed the traceability of products, by reading information contained in a quick-read bar code (QR Code) and radio frequency identification (RFID), which are related directly to the consumption trend associated with safety, reliability and food quality.

The search for sustainable production processes has been consolidating towards convenience and practicality, with more direct shopping and use of digital channels. The higher concern about social and environmental issues favours the growth of market niches, such as alternatives to meat products (plant-based), “green” products and those based on insects and algae. A growing trend towards vegetarianism and veganism offers a greater opportunity to markets for plant-based foods or meat-alternative proteins. Flexitarianism

(reducing, though not replacing meat consumption) is also increasing and reinforcing new market opportunities. The consumer has been considering some factors in their purchasing, such as environmental preservation, human health, animal health and welfare, and fair labour conditions. The search for healthier foods also continues, with fewer additives, preservatives, sodium and sugar. The nexus between food, tourism and gastronomy is gaining value and products derived from native species of Brazilian biomes contribute to a greater awareness of the authenticity, thus increasing their value in national and international markets. Conversely, the world faces a food and nutrition security crisis. On the one hand, there is an increase in the number of people facing hunger and food insecurity while on the other there are problems related to obesity and malnutrition as a result of poor diet with unhealthy foods. Finally, the covid-19 pandemic intensified food vulnerability, which in turn also changed consumption habits towards low-quality diets and more people overweight.

Challenges

- Reinforce actions related to products with higher added value, such as functional foods rich in bioactives, antioxidants, probiotics and prebiotics.
- Intensify food production with lower energy density and higher nutritional and protein density.
- Develop processes and products for target-audiences with individual dietary needs such as new protein sources, plant proteins, lab-grown meat, algae, co-products, insects.
- Optimize the utilization of agro-industrial coproducts to obtain compounds and materials of interest.
- Provide technologies that allow traceability of products, adding safety and reliability to production chains.
- Improve public policies to face food and nutrition security crisis.

Bio-revolution

In agriculture, progress in biological science, associated with the accelerated development of information and communication technology have stimulated achievements in productivity, pest and disease control, and the generation of new energy sources amongst others. The bio-based technology and genetic resources emerging through advanced biotechnology techniques are synthetic biology, varied studies of plant, animal and microorganism genomics and phenomics, gene editing, development of biomolecules, not forgetting other biosystems. This applies especially for gene editing with its potential to develop more productive plants and animals better adapted to biotic and abiotic stresses. New biological applications are already being used to address global challenges, including climate change and pandemics.

Bio-inputs as essential tools for crops to adapt to climate change contribute to the mitigation of greenhouse gas emissions and must incorporate certified practices accruing carbon credits. With the launch of the National Bio-inputs Program (Programa Nacional de Bioinsumos), in May 2020, public policies must stimulate the adoption of these inputs in the country even more. The use of bio-inputs in conjunction with the

manipulation of microbiomes like the plant rhizosphere or the animal digestive system is promising in the development of sustainable strategies for food production. Brazil seeks independence from its notorious reliance on external fertilizer supplies and this has led to bio-fertilizers achieving greater prominence. Nanotechnology tools could result in significant developments in agricultural practices given the appropriateness of their inputs and products, thus potentially revolutionising and strengthening Brazilian agriculture. These developments would allow Brazil to consolidate itself as the main exporter of healthy foods produced with sustainable technology focused on environmental preservation.

Challenges

- Increase efforts in the search for plant species and populations adapted to the Brazilian biomes as well as in the identification of genes and metabolic routes to be incorporated into commercial lines/cultivars.
- Increase efforts, including the proposition and/or evaluation of public policies, in the development of bioinputs for the adaptation of agricultural cultures to climate change.
- Develop nanotechnology tools for advances in sustainable agricultural techniques and applicability of its inputs and products.
- Encourage actions to reduce dependence on imported chemical fertilizers.
- Intensify efforts in research on the use of microorganisms that mobilize soil nutrients and on plant genetic improvement regarding greater efficiency in fertilizer use.

Integration of knowledge and technology

In order to resolve complex problems and propose innovative solutions capable of meeting the needs of a global society, there is a trend is towards a new convergent, integrative research approach with transdisciplinary teams, counting on collaboration between different organisations and fields of specialisation, pooling resources and knowledge. Scientific collaboration networks are thus expanded both from a geographical and thematic point of view. Agricultural research progresses towards internationalisation, seeking to share data, processes and research structures in the development of multidisciplinary projects to resolve challenges. Agriculture must be regarded as interconnected and systemic since the problems in one production chain may affect several others. There should be even greater cooperation between public and private sectors and between science and stakeholders.

Tax incentives and simplifying the rules and regulations are fundamental in boosting the establishment of public-private partnerships in food and agriculture research. From the farm to the consumer, artificial intelligence systems are the basis of processes in all the stages of the main agricultural production chains, with intensification of digitalisation and automation channels in agriculture, prescriptive intervention (data integration, computational tools and modelling systems) and good management practices. The Fourth Industrial Revolution expands simultaneously and promises to transform practically all sectors of the economy, including agro-food systems, starting with the fusion of tools to

exploit the limits of the physical, digital and biological spheres.

The phenomenon of convergence is also a social process so its impacts are not only in the scientific and productive scope but also in social organisation. The expansion of the integration and convergence of technology and knowledge is, for example, well demonstrated by the global rise of the One-Health concept, which demonstrates the inseparability of human, animal and environmental health. This highlights the growing importance of the transdisciplinary and multisectoral approach necessary to face the huge challenges related to health and food both today and in the future – a crucial theme of the United Nations 2030 Agenda.

Challenges

- Implement an integrated RD&I agenda in scientific organizations focused on environmental safety and society health.
- Promote culture change in S&T organizations by encouraging scientists to collaborate with stakeholders through a transdisciplinary vision.
- Invest in staff and multidisciplinary teams, attracting professionals from non-agricultural areas for development of projects.
- Prepare new generations of students to address the challenges of agriculture and food and their connections with society, economy and environment.
- Anticipate measures related to ethical, legal, socioeconomic and political aspects of human action, coordinating the collaboration between multidisciplinary teams and institutions to address integrated and convergent research.
- Foster the prevention of zoonotic diseases and communicable diseases that negatively affect the livelihood, trade and economic growth of nations.

Increase in governance and risks

The recognition of Brazil as an agricultural power requires a more robust governance architecture between players, requiring clear interpretation of movement in the institutional ambit. This is true not only for the agricultural players but also of those who influence all production chains such as the financial, services and industrial sectors and the consumer market who represent the sector ever more incisively. Value-adding on products and services from Brazilian biomes must incorporate environmental and social values, as local production and exploitation are collaborating with the maintenance of carbon stock, biodiversity, water resources and the traditional knowledge associated with their use or agricultural practice.

Investigating the characteristics and limits of natural resources and environmental services are fundamental to sustainability. This requires efforts to capture data and generate reliable information to allow risk monitoring and modelling. Supporting efforts to consolidate the social, environmental and governance (ESG) set of standards and best practices are essential. Risk management will evolve in order to better define co-responsibilities between the public sphere, economic agents and producers with regard to the normal risks involved in production, price and climate variations,

catastrophic events and agricultural business, and their implications.

Challenges

- Increase the interaction and intertwining of agricultural, livestock and forestry agendas.
- Work on studies concerning risk analysis in the Brazilian agricultural sector.
- Invest in animal and plant health defense.
- Propose training and act preventively in response to health threats in geographical areas where they are likely to emerge.
- Anticipate risks arising from greater interdependence between the links of food systems and increased pressure on natural resources and landscapes.
- Develop and implement strategies to combat the increased threat of emerging infectious diseases and environmental pollution.
- Expand interconnected risk management capability.