SUSTAINABLE DEVELOPMENT GOAL 2

ZERO HUNGER

CONTRIBUTIONS OF EMBRAPA

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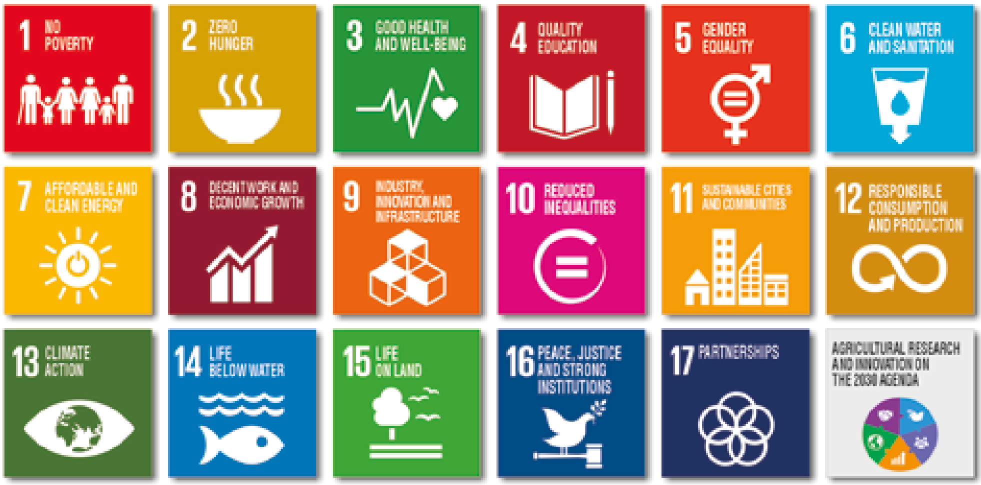
Technical Editors



Embrapa

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

Sustainable Development Goal 2

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Foreword

Launched by the United Nations (UN) in 2015, 2030 Agenda for Sustainable Development is powerful and mobilizing. Its 17 objectives and 169 goals seek to identify problems and overcome challenges that affect every country in the world. The Sustainable Development Goals (SDG), for their interdependent and indivisible character, clearly reflect the steps towards sustainability.

Reflecting and acting on this agenda is an obligation and an opportunity for the Brazilian Agricultural Research Corporation (Embrapa). The incessant search for sustainable agriculture is at the core of this institution dedicated to agricultural research and innovation. Moreover, sustainable agriculture is one of the most cross-cutting themes for the 17 goals. This collection of books, one for each SDG, helps society realize the importance of agriculture and food in five priority dimensions – people, planet, prosperity, peace and partnerships –, the so-called 5 Ps of 2030 Agenda.

This collection is part of the effort to disseminate 2030 Agenda at Embrapa while presenting to the global society some contributions of Embrapa and partners with potential to affect the realities expressed in the SDG. Knowledge, practices, technologies, models, processes and services that are already available can be used and replicated in other contexts to support the achievement of goals and the advancement of 2030 Agenda indicators.

The content presented is a sample of the solutions generated by agricultural research at Embrapa, although nothing that has been compiled in these books is the result of the work of a single institution. Many other partners joined in – universities, research institutes, state agricultural research organizations, rural technical and extension agencies, the Legislative Power, the agricultural and industrial productive sector, research promotion agencies, in the federal, state and municipal ranges.

This collection of books is the result of collaborative work within the SDG Embrapa Network, which comprised, for 6 months, around 400 people, among editors, authors, reviewers and support group. The objective of this initial work was to demonstrate, according to Embrapa, how agricultural research could contribute to achieve SDGs.

It is an example of collective production and a manner of acting that should become increasingly present in the life of organizations, in the relations between public, private and civil society. As such, this collection brings diverse views on the potential contributions to different objectives and their interfaces. The vision is not homogeneous; sometimes it can be conflicting, as is society's vision about its problems and respective solutions, a wealth captured and reflected in the construction of 2030 Agenda.

These are only the first steps in the resolute trajectory that Embrapa and partner institutions draw towards the future we want.

Maurício Antônio Lopes
President of Embrapa

Preface

The eradication of hunger in the world is one of the greatest challenges to the ethics of every human being, and conveniently diluted when placed as the responsibility of humanity. It is difficult to understand why this challenge is not overcome, since the volume of food production is certainty not a determinant of hunger, but rather its poor distribution, which is exacerbated by the asymmetrical distribution of income among and within nations, which makes evident the lack of world political desire to effectively eradicate hunger.

Proposed by the United Nations (UN), 2030 Agenda for Sustainable Development presents a set of 17 Sustainable Development Goals (SDG). They constitute a list of challenges to be overcome by everyone and around the world; in summary, they seek to make life better on this planet, as well as preserving it for future generations.

In this agenda, the eradication of poverty and hunger contained in the SDGs 1 and 2, undoubtedly constitute challenges of the first magnitude, closely intertwined, and which require a great effort and willingness of the world community for its overcoming.

Brazil has engaged in this effort and seeks to implement SDG in all regions of the country and in its various sectors. In 2016, the National Committee for the Sustainable Development Goals was created, which is the national coordination body for the achievement of 2030 Agenda of the United Nations goals.

Embrapa, as a public company whose mission is to seek solutions for sustainability of Brazilian agriculture, has a direct connection with food production and, therefore, with the eradication of hunger in Brazil. This publication addresses the contribution of Embrapa to implement SDG 2: "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", which can be summed up as "zero hunger and sustainable agriculture".

Five targets quantify SDG 2[1]. Chapter 3 – Food Security and Healthy Food for All – of this publication addresses the first two targets:

> 2.1 By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food for all year round.

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[1] Available at: <https://www.un.org/sustainabledevelopment/hunger/>.

> 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

Target 2.3 is the theme of Chapter 4 – Contribution to Production Improvement in Family Farming, Indigenous Peoples and Traditional Populations:

> 2.3 By 2030, double the agricultural productivity and income of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.

Target 2.4, the subject of Chapter 5 – Sustainable Food Production, foresees:

> 2.4 By 2030, ensure sustainable food production systems and implementing resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.

Finally, target 2.5 encompasses the theme addressed in Chapter 6 – Genetic Diversity and the Eradication of Hunger:

> 2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.

This publication presents a sample of the work developed by Embrapa in its contribution to SDG 2, Zero Hunger, and what the perspectives and obstacles are to progress in overcoming the serious problem of hunger and malnutrition, as well as the reduction of the impacts caused by agricultural activity on the environment. The space is certainly insufficient for the work of all the teams engaged in the theme presented, but it gives an idea to society of the effort of Embrapa and commitment to the transformation of the current reality and the overcoming of it, which is one of the greatest challenges of our century.

Technical Editors

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Chapter 1

Food production and eradication of hunger

João Carlos Costa Gomes
Carlos Alberto Barbosa Medeiros

Global contextualization

The persistence of hunger in the world for centuries reveals the complexity of the challenge posed by its eradication. Despite the significant technological advance of modern society, the continuity of the problem shows that only the technological approach, although necessary, is not enough to achieve food sovereignty and security for millions of people. The elimination of this social menace requires a systemic approach supported by policies, such as the distribution of wealth. In addition, there is a need to strengthen mechanisms that promote citizenship and social inclusion, which will enable society to overcome this serious problem.

Data from the UN annual report on food and nutrition security, published in September 2017 (El estado..., 2017), are worrying. The report reveals that, after a decade of continued reduction in world hunger monitoring rates, these indicators are on the rise again. According to the report, in 2016, hunger reached 815 million people, representing 11% of the world's population. In Latin America and the Caribbean, hunger reached 6.6% of the population, or 42 million people. Although the document identifies conflicts as one of the main factors contributing to the increase in hunger in the world, climate change has also played a significant role, either aggravating conflicts or directly interfering with food production, as in the case of prolonged droughts and other climatic phenomena. The report mentions that:

> Given the relationship between climate crises, the collapse of agricultural and livestock prices, and the appearance of conflicts, the adoption of agricultural practices and subsistence strategies that support adaptation to climate change should be promoted. (El estado..., 2017, p. 72, our translation).

In addition, it mentions that:

> Agriculture is the pillar of subsistence for the majority of people living in situations of fragility, protracted crises, and conflicts.

> It underscores the importance of prioritizing and supporting agricultural development, in contexts of contribution and recovery, creating resilient livelihoods and improving food security and nutrition, as the cornerstone of peaceful and inclusive societies. (El estado..., 2017, p. 77, our translation).

The recommendations of the report refer to UN Objective of Sustainable Development 2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations, 2018), particularly in its targets to "[...] ensure access by all [...] to safe, nutritious [...] food [...]" (United Nations, 2018), and those that identify the need to

> implement [...] practices that increase productivity and production, [...] strengthen capacity for adaptation to climate change, extreme weather, [... and] maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals [...] (United Nations, 2018).

It should be noted, however, that when it comes to food and nutrition security, two other issues should also be considered. The first is that hunger is not the result of the scarcity of food; it is, however, due to food poor distribution. Food production today would be enough to radically reduce or even eliminate world hunger if food were adequately distributed. A study by the United Nations Food and Agriculture Organization (FAO) published in 2016 shows that:

> world food production is sufficient to meet the demand of the 7.3 billion people who inhabit the earth. Despite this, approximately one in nine of these people still face the reality of hunger (Iandoli, 2016, our translation).

The problem is so serious that the United Nations Children's Fund (Unicef) presented in 2017 a study indicating that 1.4 million children from four African countries – Nigeria, Somalia, Yemen and South Sudan – are at imminent risk of starvation (Iandoli, 2016). "The research questions the whole international policy to combat chronic malnutrition put into practice in the last decades" (Iandoli, 2016, our translation). In addition, the structuring of the world food system and its main dynamics are under the hegemonic control of a small number of corporations, where private logic prevails (Maluf, 2012).

The other relevant issue is that of inequality and poverty resulting from the asymmetrical distribution of wealth on the planet. The gap between the rich and the poor has been widening in recent years. According to the British NGO Oxfam, in 2010 the wealth of the 62 richest people in the world was equal to the poorest half. By 2016, this number has fallen to the eight richest people who had wealth equivalent to the 3.6 billion people making up the poorest half on the planet (BBC Brazil, 2017). Even worse, wealth accumulated by the wealthiest 1% of the world's population now equals, for the first time, the wealth of the remaining 99%, which has prompted a need for politicians and policymakers to take actions to reduce inequality in the world (BBC Brasil, 2017).

SGD 2 also highlights the priority of "[...] ensure sustainable food production systems and implement resilient agricultural practices that [...] help maintain ecosystems [...]" (United Nations, 2018). Since the first *United Nations Conference on the Human Environment* took place in Stockholm in 1972, the old idea that nature is an inexhaustible source of resources begins to be overcome. Over the last few years, the awareness of society regarding the conservation of natural resources has been increasing. The analysis of the planet panorama shows the concern of the world with the rising of food production, but at the same time, the connection of this production with the guarantee of sustainable use of natural resources, particularly soil, water and biodiversity is clear. The expansion of the agricultural frontiers to increase production results on environmental impacts, which means that the rise in production requires the increase of the efficiency of this process, reducing energy consumption and input dependence, guaranteeing sustainable use of natural resources.

The sustainable use of natural resources can be exemplified through two concepts: virtual water and water footprint. Virtual water is the water required to produce a product, and is transported with it without having the exact notion of its volume. Considering only corn, wheat and sorghum produced in the United States and exported to Mexico, these three products carry 7 billion cubic meters of water per year, which would be enough to cover the whole United Kingdom with 4 cm of water (Smith, 2011). The water footprint is an environmental indicator that serves as a tool to calculate the annual volume of water used directly (drinking, cooking, hygiene, etc.) or indirectly to produce goods and services (food, clothing, etc.). The concept was introduced by Hoekstra and Hung (2002) quoted by Bleninger and Kotsuka (2015) as an indicator to map the impact of human consumption of fresh water as a global resource that is a right of all. For example, water consumed in rice, soy and corn production in Rio Grande do Sul would support the water footprint of 34 million people in Brazil (verbal information)[1]. The examples reflect only the pressure on water, not considering other environmental impacts. The pressure on natural resources is on a scale that is sometimes difficult to measure, indicating the need for change in the technological formats that support world agriculture.

Eradication of hunger in Brazil

The important position of Brazil as a food producing country is well known, as well as, at the national level, the production and availability of food for consumption by the population do not constitute a risk to food and nutrition security. However, regional disparities lead to a dangerous imbalance in food access. If, on the one hand, food production in some regions raises the country to worldwide levels, there is still a significant part of the population in a situation of food insecurity, which shows that the volume of food production is not configured as a determinant of hunger (O estado..., 2014).

The document published by FAO in 2014 highlighted that Brazil has significantly reduced hunger, malnutrition and malnourishment in recent years (O estado..., 2014). The document attributes this reduction to income transfer programs, as well as to structuring public policies, such as the strengthening of family farming. It makes sense to invest in policies for this segment, given the published data of the last census of agriculture, which shows that family farming produces more than 70% of food consumed in the country (IBGE, 2009).

Concerning public policies in support of family farming, the Programa de Aquisição de Alimentos da Agricultura Familiar (Family Farming Food Acquisition Program – PAA) deserves being highlighted. It was launched in 2003, when family farmers were facing a chronic problem: the lack of markets for small-scale production. The Programa Nacional de Alimentação Escolar (School Food National Program – Pnae) deserves being equally highlighted for its double importance. It contributes to the reduction of child malnutrition in school stage, and has a positive impact on family farming, since it establishes that public schools, as of 2009, should allocate at least 30% of its resources provided by the federal government for the direct purchase of food from family farmers.

[1] Information provided by researcher Adilson Luis Bamberg of Embrapa Clima Temperado, based on calculations made by him in 2017, but not published.

The sustainability of production systems has also been the target of public policies, such as the Plano Nacional de Agroecologia e Produção Orgânica (National Plan of Agroecology and Organic Production – Planapo), for the period 2013–2019. It has produced positive impacts by promoting not only sustainable production, but also the use and conservation of natural resources, and stimulating teaching and research focused on ecologically based agriculture. Embrapa has been involved in the construction and execution of Planapo, and is responsible for carrying out a series of activities related to research and technology transfer for ecological production systems.

Role of Embrapa

In response to society's demand for safe food production and to improve the nutritional status and quality of life of the population (SDG 2 targets), Embrapa public notices have stimulated the development to technological solutions focused on these issues. Further, it established managerial figures to analyze the evolution of these themes in its research, development and innovation (R&DI) agenda, and to identify technological gaps to be filled and the strategies to be followed for the induction of research projects that meet the already mentioned society demands. These figures are specifically the Portfólio Alimentos Nutrição e Saúde (Nutrition and Health Food Portfolio) and Portfólio Alimentos Seguros (Safe Food Portfolio), which manage projects in these areas, strengthening initiatives and stimulating the search for solutions for the production of safe food and food fortification strategies, which may constitute the technical basis of an integrated national food and nutrition security agenda.

In the same context, Embrapa has stimulated actions that promote the social and productive inclusion of family farmers, traditional peoples and communities, through the valorization of products derived from the management of agrobiodiversity, traditional agricultural, cultural, local know-how and of natural resources products. It is one of the objectives of the Portfólio Inovação Social na Agropecuária (Social Innovation in Agriculture Portfolio).

The escalation of the adoption of sustainable production systems is fundamentally due to the increase, in recent years, in the society awareness of the need to produce food with low impact techniques for agroecosystems and that have as one of the requirements the concern for the health of farmers and consumers. This alternative scenario is related to changes in consumption pattern, lean diets, green products, more conscious consumers, new role of family farming, new rural-urban social pact, new and segmented markets. This implies socially constructed qualities that respect the "know-how", the local knowledge and knowledge that is sponsored by participatory processes that lead to the empowerment of people in the place where they live. There is a whole paradigm shift to be able to make this alternative scenario feasible, which includes the production of knowledge.

This new standard in agriculture and agricultural research has already been a segment of Embrapa with the support of several Brazilian universities and organizations that have been making efforts to consolidate the agroecological approach as a scientific basis for sustainable agriculture. This means valuing the autonomy of farmers, diversifying the production matrix, consolidating new technological formats, and pursuing sustainability. Not only sustainability, but also the durability or durable processes to contribute to food and nutritional security, for the generation of resilience and the production of socially constructed wealth. This is what lies behind and feeds the so-called agro-ecological paradigm.

In this scenario, it is well known that Embrapa is advancing research conserning knowledge and technologies aimed at improving and consolidating sustainable production systems, with the incorporation in the programming of research projects and technology transfer focused on sustainability. The creation, in 2012, of the Portfólio Sistemas de Produção de Base Ecológica (Ecological Based Production Systems Portfolio), indicated this progress, which represents an opportunity to strengthen research actions in this area, insofar as it allows the prioritization, induction and coordinated execution of projects focused on an ecological agriculture. As stated institutionally:

> the increasingly evident need to consider the conservation of natural resources and the well-being of the population as fundamental aspects, has been demanding from Embrapa new approaches that will guarantee its protagonism as a research institution (Marco..., 2006, our translation).

Target 2.5 of SDG 2 refers to the importance of "[...] maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals [...]" (United Nations, 2018), ie agrobiodiversity, and "[...] promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed" (United Nations, 2018).

Agrobiodiversity is a result of management systems, environmental conditions and genetic characteristics of the various populations of living beings. Local knowledge and culture are integral parts of agrobiodiversity because it is human activity that shapes and conserves biodiversity (FAO, 1999). In this case, it can be used the concept of socio-biodiversity, which covers agrobiodiversity and the strategies used in its management for various purposes. Traditional knowledge associated with biodiversity is all knowledge, innovation or practice, individual or collective, of indigenous peoples and local communities, associated with the properties, uses and characteristics of biological diversity, inserted in socio-cultural contexts proper to these peoples; it consists of practices, empirical knowledge and customs passed on from parents to children living in direct contact with nature (Santilli, 2003). Traditional knowledge ranges from natural resource management techniques, hunting and fishing methods, knowledge on various ecosystems, pharmaceutical, food and agricultural characteristics of species, to the very categorizations and classifications of species of flora and fauna used by traditional populations (Santilli, 2003).

Considering the possibilities and knowledge accumulated so far, it can be said that biodiversity is one of the most promising fields for agricultural research and its interfaces with chemistry, biochemistry, botany and other fields of scientific knowledge. The study of new uses, including nutraceutical and functional properties, the so-called green chemistry, are still relatively recent. The ability of some plant species to contribute to agriculture as phytoprotection is a path to be overcome in order to reduce dependence on inputs over which there is no control on technological or scientific routes.

Final considerations

The analysis of the world and Brazilian context presented in this chapter shows that overcoming hunger is a global challenge, but it also requires local strategies. It represents a challenge for science and technology public institutions, as Embrapa and other state organizations. In the case of Embrapa, strengthening research on more sustainable production systems, valuing agriculture and socio-biodiversity, developing value-added mechanisms and generating income, including for young people and women, must contribute for the composition of the institutional agenda. At the national level, the definition of adequate strategies and the strengthening of the articulation between State and society represent an enormous potential to contribute to the reduction of the serious problem represented by hunger.

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Chapter 2

Eradication of hunger: solutions developed by Embrapa

Carlos Alberto Barbosa Medeiros
Ynaiá Masse Bueno
Tatiana Deane de Abreu Sá

Introduction

The resurgence of hunger in the world ignites the warning signal for the Brazilian situation, in which the indexes show a worrying panorama. In this scenario, the responsibility of Embrapa increases, which, as a public agricultural research corporation, directly connects with food production, making a significant contribution to the eradication of hunger in Brazil. The advancement of knowledge and the development of technologies promoted by Embrapa since its creation have contributed decisively to the improvement of production systems, with increased productivity and production, which has direct consequences on food availability.

Food and nutritional security

The concern about food insecurity is growing worldwide given recent statistical data showing the worrying increase in hunger in several regions of the world. In 1996 the United Nations Food and Agriculture Organization (FAO) issued a guiding concept on the subject, placing the need to ensure access to food for all and at all times, in sufficient quantity and quality to ensure a healthy and active life (Declaração..., 1996). This concept highlights three dimensions of food security: availability, access and utilization.

Undoubtedly, we find the greatest volume of contributions of Embrapa regarding availability. Its actions aimed at the improvement of different productive systems of species of importance for the Brazilian population diet. Taking into account the regional characteristics and always striving for a better balance with environmental, economic and social issues, food production has received the contribution of important technological solutions for the creation and evaluation of genetic material appropriate to each environment, as well as the development of inputs and practices that combine efficiency, low cost and low environmental impact.

Although Embrapa is more involved with the productive aspects associated with availability, access to food has been the focus of specific programs developed with partner institutions that both focus on social aspects and support public policies on the issue. The utilization of food, with all indicators linked to its quality, particularly those associated with contamination from the production system itself, where pesticide residues are crucial points, has also had important place in the research, development and innovation (R&DI) agenda of Embrapa Units. On the other hand, the ongoing change in the characteristics of foods demanded by society, with the valorization of foods that meet higher standards on nutritional and functional requirements, is a unique opportunity, and has been also the object of numerous research projects carried out at Embrapa. It is important to highlight biofortification, an improvement aimed at nutritional enrichment, which has an important role in the fight against the deficiencies that characterize the diet of the most vulnerable segments of the population.

Agricultural productivity of small-scale food producers

Target 2.3 of Sustainable Development Objective 2 (SDG 2), "[...] double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers [...]" (United Nations, 2018), is particularly challenging. In implementing this target, the role of women (in particular for the segments addressed) should be considered, given the limitations in policies of land, technical assistance and rural extension, financing and production insurance, among others, in the contrasting and complex realities of Brazilian biomes.

The distribution of Embrapa Units throughout the country, with its various ecoregional centers of products and services, and other types of research and technology transfer structures, with its multidisciplinary teams, has played a relevant and growing role to improve agricultural production and sustainability for the different segments of the agricultural sector, including those mentioned in target 2.3.

Particularly in the last 2 decades, Embrapa and partners have made available an expressive number of research results to family farmers. The topics were closely related to agricultural, livestock, aquaculture and forestry production. Studies with indigenous and traditional peoples have also been growing gradually at Embrapa, as a way to meet demands of public policies and civil society representatives. These outcomes are the result of the work of multidisciplinary research and technology transfer teams that seek, with local partners, complementary skills to develop actions with traditional peoples and communities. This complementarity is fundamental for broadening the understanding of the worldview of communities and minimizing cultural, social and political differences in an effort to bringing tradition and innovation together.

Sustainable systems of food production

The analysis of the world panorama shows the concern of the world with the increase of food production, and, at the same time, the connection of this production with the guarantee of sustainable use of natural resources, particularly soil, water and biodiversity. The increase in production due to the expansion of the agricultural limits is questioned because of the consequent environmental impacts, which evidences the need to evolve the productive process with improved efficiency, reducing energy consumption and the use of non-renewable source inputs. Nowadays, it is known that the adoption of high impact management systems has led to an increasing degradation of environmental quality, which shows the unsustainability of these practices.

In this scenario, target 2.4, described in SDG 2, is the great challenge posed to short and long-term agricultural research.

> By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality (United Nations, 2015).

In accordance with the UN target, around 40% of Embrapa Decentralized Units have strategic objectives associated with themes such as innovative and sustainable production systems and organic and agroecological farming systems, which are capable of inducing the development of technologies that meet the need of food production with less environmental impact. Contributions of Embrapa to achieve this goal are significant, always seeking a more favorable environmental balance for agriculture and livestock.

There are many solutions developed that combine productivity with less impact on natural resources, including techniques for preserving water resources and the conservation and sustainable use of agrobiodiversity, development of biological inputs, low carbon technologies, and agricultural practices that prioritize the maintenance of the biological activity of the soils. Aware of the importance of integrated productive systems, in which association of crops and animal husbandry confer greater sustainability and stability to production, investments in research in this segment have been expressive, producing knowledge that has contributed to the structuring of these systems. However, there is a need to refine research on more complex systems, given the lack of information and the insufficiency of knowledge generated until the present, which requires knowledge of the dominant ecological processes in these agroecosystems in order to enhance them to benefit production.

Genetic resources

To ensure the sovereignty and food and nutritional security of the world's population, it is vital that genetic resources are conserved and available to farmers, indigenous peoples and traditional communities. A series of human interventions – such as the replacement of traditional varieties with improved ones, change from diversified cropping systems to monoculture, deforestation for livestock farming, among others –, associated with climatic intemperies – such as high temperature and precipitation variations – result in a significant loss of genetic diversity and, consequently, a huge risk to the maintenance of production systems resilient to climate change.

To minimize these risks, target 2.5 of SDG 2 challenges countries to maintain the genetic diversity of seeds, cultivated, farmed and domesticated animals, and their respective wild species, including through diverse and well-managed seed and plant banks at national, regional and international levels. It also challenges them to ensure access and fair and equitable sharing of benefits arising from the use of genetic resources and associated traditional knowledge as internationally agreed.

The main strategies of Embrapa for promoting the conservation of genetic diversity are ex situ and on farm conservation. Ex situ conservation actions consist mainly of the collection, documentation and conservation of genetic resources in germplasm banks of the institution, which can serve for genetic improvement and for the restitution to farmers, peoples and traditional communities of varieties lost or missing varieties. In relation to in situ conservation, Embrapa performs biological inventories and geographic analysis for conservation planning; evaluation and development of management techniques for the sustainable use of biodiversity; ecological restoration in degraded landscapes; analysis and promotion of conservation of genetic resources by local communities and farmers. It also contributes effectively to the strengthening of on farm conservation strategies in several Brazilian regions with family farmers, indigenous peoples and traditional communities, through seed banks and houses, seed fairs and agrobiodiversity guardians, subject also discussed in Chapter 6, on genetic diversity.

Final considerations

The contribution of Embrapa to the eradication of hunger in Brazil is undeniable, with all the effort allocated in the development of solutions for agriculture. It is important to emphasize the complexity of the work carried out, which involves, in addition to a large number of species of importance for human consumption, the cultural diversity of each region, the characteristics of the productive systems and the environments in which they are inserted, aspects that give an indication of the magnitude of the research challenge to increase food production. However, the eradication of hunger is not only a problem to be faced with technological solutions. Based on this premise, there is a need for an increasing commitment by Embrapa to the development of subsidies and support for good quality public policies that minimize asymmetric income distribution and support sustainable food production, particularly for those segments lacking public support.

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Chapter 3

Food security and healthy food to all

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Introduction

The purpose of this chapter is to present contributions of Embrapa to targets 2.1 and 2.2 of the Sustainable Development Goal 2 (SDG 2) (United Nations, 2018):

> By 2030, end hunger and ensure access by all people, in particular, the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
>
> By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.

Food is the most basic need of human beings, essential for them to develop in every way, and it goes beyond the plate of food on the table at lunchtime in many families' home. In 2014, Brazil reported that 3% of the population consumes fewer calories than those recommended by the Food and Agriculture Organization of the United Nations (FAO) and left the Hunger Map for the first time (El estado..., 2017). However, about 20 civil society entities wrote a report presented in July 2017, concerning to the Brazilian performance in complying with the 17 SDG. The report warns that there is a risk that Brazil will return to the next Hunger Map due to a combination of socioeconomic factors that have arisen from 2015 to 2017, such as high unemployment, poverty alleviation, cut of beneficiaries of Bolsa Família Program and freezing of public spending for up to 20 years (Luz..., 2018).

Although many gaps have been identified, the work developed has significant importance for the food and nutritional security of the Brazilian population, and this chapter represents only a small sample of all the work performed by Embrapa and its partners.

Food security

On August 25th, 2010, the Política Nacional de Segurança Alimentar e Nutricional (National Policy of Food and Nutritional Security – PNSAN) was established with the general objective of promoting food and nutritional security, under article 3 of Law 11,346/2006 (Brasil, 2006), as well as ensuring the human right to adequate food (HRAF) throughout Brazil. PNSAN has as its guidelines the promotion of universal access to adequate and healthy food – particularly for families and people in situations of food and nutritional insecurity – and the promotion of the supply and structuring of sustainable and decentralized systems, based on agroecology, production, extraction, processing and distribution of food. The implementation of the Sistema Nacional de Segurança Alimentar e Nutricional (National System of Food and Nutritional Security – Sisan) is based on the principles of promoting food and nutritional security to ensure HRAF. The Conselho Nacional de Segurança Alimentar e Nutricional (National Council for Food and Nutrition Security – Consea), an advisory body to the Presidency of the Republic, is integrated with Sisan for social control and participation of society in the formulation, monitoring and evaluation of public policies on food and nutritional security (FNS), to promote the progressive implementation of HRAF in collaboration with the other Sisan bodies.

In this context of broad promotion of FNS associated with increasing risk factors, it is clear that, currently, access to food is gradually distancing itself from the logic of quality and entering into the logic of the market. It is considered as assumptions in FNS and its promotion that social determinants affect the way people feed themselves, the means by which they access food, and which foods they access (Giordani et al., 2017). Thus, the proposal of alternatives and the constant search for guarantees of access to quality food and in sufficient quantities for the population should be a duty of the State in order to promote actions directed to this end.

In this sense, in April 2016, the Ministry of Science, Technology, Innovations and Communications (MCTIC) and the Ministry of Foreign Affairs (MRE) launched a Global Network for Teaching, Research and Extension in Nutrition, Sovereignty, Food, and Nutrition Security (Rede Global NutriSSAN) (Rede Nutri, 2016), with 69 institutions represented, being Embrapa among these. Its objectives are to promote and strengthen global nutrition commitments, bring together governments from various countries and various sectors of civil society to accelerate progress towards global nutrition goals, activate a global network for knowledge exchange and construction, technology transfer and generation and analysis of public policies related to food and nutrition sovereignty and security. These actions are carried out in particular through a technological platform for communication and cooperation with the potential to interconnect a wide range of actors committed to the FNS, through the creation of Web Conferences and Special Interests Groups (SIGs), among other modalities of work. In August 2017, SIG Alimentos Seguros (Safe Food) was created at Embrapa, which discusses topics such as: specific strategies focused on safe food; risk analysis in food – Codex alimentarius; integrated production as a quality management system and food security in the primary segment; impacts of mycotoxins on food; perception of society in safe food – socioeconomic view, among several others.

Embrapa has also sought to present strategies for productive inclusion, food security, employment and income in various territories in Brazil. Embrapa active participation in the Brasil Sem Miséria (Brazil Without Misery) Plan as of 2011, with the objective of increasing the productive capacity of family farmers and promoting the entry of their products into the consumer markets (Campello et al., 2014) is noteworthy. In the Territory of Borborema, Paraíba state, about 4 thousand families were benefited from actions to promote the diversification of fruit production systems (banana, mango and cashew) and animals (cattle, goats, sheep, pigs and alternative poultry); agroecological farming systems of potatoes and meliponiculture; production of organic cotton, sisal and castor oil; peanut and sesame production; training and organization of local farmers' networks. In Vale do Guaribas Territory, Piauí state, participatory innovation initiatives are carried out with technologies to strengthen family farming, such as the construction of integrated systems for the production of grains and vegetables (cowpea and cassava) and animals (hens and goats); production and management of alternative inputs (biodigesters and composting); water catchment and use system that benefit approximately 5 thousand families. Still in the Valley of the Guaribas River and the Canindé River, Piauí state, actions to revitalize garlic crops have been conducted in more than 16 municipalities with the use of Embrapa technology to produce garlic free of viruses. In the Alto Oeste Potiguar Territory, Rio Grande do Norte state, food production actions are carried out with emphasis on fruit production (production of seedlings, grafting), hen and meliponiculture; good agricultural and manufacturing practices in fruit and dairy cattle breeding; good manufacturing practices in craft cheeses; good agricultural and processing practices for cassava and sesame; medicinal plants with the management and production of herbs that benefit almost 3 thousand families. In the Territory of Irecê, Bahia state, through shared knowledge learning, more than 4 thousand families are benefited with technologies such as integrated systems of food production, with emphasis on fruit production, olericulture, sheep and goat husbandry and hen production; good practices in the manufacture and processing of food, with full use of cassava plants for animal and human nutrition; and forage plant production system. Another example of action to guarantee access to quality food that benefits more than 6 thousand families is carried out in the Territory of Velho Chico, Bahia state, with transfer of technologies on the use of integrated food production systems, with emphasis on cassava culture, hen, sheep and goat husbandry, fruit production and meliponiculture; good manufacturing practices and food processing, with full use of cassava plants for animal and human nutrition and processing of native fruits.

Healthy food

At the end of 2014, the Ministry of Health launched the new *Guia Alimentar para a População Brasileira* (*Dietary Guidelines for the Brazilian Population*), which reports the care and the ways to achieve a healthy, tasty and balanced diet (Guia..., 2014). The guide indicates that food is based on fresh (fruit, meat, vegetables) and minimally processed (rice, beans and dried fruit) foods, as well as avoiding the ultraprocessed ones (such as instant noodles, packet snacks and soft drinks) with the intention of promoting health and good nutrition, fight malnutrition, and prevent illnesses on the rise, such as obesity, diabetes and other chronic diseases such as stroke, heart attack and cancer.

Micronutrient deficiencies such as iron and zinc and vitamin A are serious public health problems in developing countries. Studies point to anemia as one of the most important nutritional problems in Brazil (Batista Filho et al., 2008). As a way to improve the diet of Brazilians, especially the poorest, the BioFORT project, responsible for the biofortification of food in Brazil, coordinated by Embrapa, focused on the conventional genetic improvement of basic foods in the diet of the population, such as rice, beans, cowpea, cassava, sweet potatoes, corn, pumpkin and wheat. The aim of the BioFORT project is to reduce malnutrition and ensure greater food security by increasing iron, zinc and vitamin A levels in the diet of the poorest population by crossing plants of the same species, generating more nutritious cultivars, by the method known as biofortification.

Scientific research seeks to offer alternatives for access to quality food and safe food for the population, especially in situations of vulnerability. Fortification or enrichment of food represents one of the strategies for combating iron deficiency anemia and has been used by several countries, whether mandatory or not. In

January 2000, the Ministry of Health and the Pan American Health Organization (PAHO), with the support of the Micronutrient Initiative, prepared a project proposal for the development of a strategy to control micronutrient deficiency in Brazil. Embrapa, as a partner of this proposal, was responsible for technically subsidizing the implementation and guaranteeing the quality of iron fortification procedures of wheat and corn flour. This study led the Ministry of Health to mandatory iron fortification since 2004, which included the addition of folic acid along with iron. The technology can also be used for the fortification of cassava flour and in particular benefits those affected by iron deficiency anemia and society in general, with a reduction in annual health costs of around BRL 126 million.

Another example of a contribution of Embrapa was the development of Banana BRS SCS Belluna cultivar, naturally biofortified, rich in fiber and with lower carbohydrate content and calorific value than other commercial cultivars (Embrapa, 2018b). It has four times more resistant starch than 'Grande Naine' and twice as much as 'Prata-Anã'. It is indicated for both in natura and processed consumption, especially in the form of flour, chips and raisins (dehydrated banana). The average productivity is around 30 tons per hectare per year, and can reach 40 tons per hectare per year.

Tested and recommended by Embrapa and partners, the Beauregard biofortified sweet potato (Embrapa, 2018a), developed in the United States, has 10 times more carotenoids (pro-vitamin A) than its main competitors; its production varies between 23 and 29 tons per hectare. The orange coloring of the Beauregard potato is due to the high amount of beta-carotene, which turns into vitamin A in the body.

Another opportunity that has been worked on and that should be further explored is the stimulus to food diversification with the inclusion of species with high nutritional value. It is known that changing eating habits is extremely complex. However, it has been much easier to recover food habits, such as working with traditional vegetables, better known in academia as Non-Conventional Food Plants.

Traditional vegetables are species that have been almost abandoned because of changes in society. Disseminating information through publications, transfer actions (lectures, workshops, courses and events) and the strengthening of community banks as seed and seedling multipliers have been used as strategies for working with these traditional vegetables. The loss of the reference of productive and diversified yards, whether in rural or urban areas, and with the development of large-scale agri-food systems with powerful productive chains resulted in a dangerous concentration of the Humanity food base in a few species. Talking to gastronomy professionals is another strategy that has been used as an efficient tool for valorization and promotion of the consumption of unconventional vegetables, always interested in innovative ingredients and/or with strong cultural appeal. Some species have distinctive taste, such as mangarito (*Xanthosoma riedelianum*), jambu (*Spilanthes acmella*), ora-pro-nóbis (*Pereskia aculeata*), vinegar (*Hibiscus sabdariffa, H. acetosella* and *H. cannabinus*), azedinha (*Rumex acetosa*), bertalhas (*Basella alba* and *B. rubra*), taioba (*Xanthosoma taioba*), peixinho (*Stachys Byzantine*), major-gomes or carirus (*Talinum triangulare* and *T. paniculatum*), muricato (*Solanum muricatum*), physalis (*Physalisperuvianum, P. maculata* and *P. pubescens*), capuchin (*Tropaeolum majus*), among others.

It is important to emphasize that the work of rescuing non-conventional vegetables aims to diversify the local diet with the communities involved in order to improve health, due to the good nutritional characteristics of these species, in close dialogue with nutrition professionals. As an outstanding example, ora-pro-nóbis and moringa (*Moringa oleifera*) can be mentioned, with high levels of protein, iron and calcium; carurus (*Amaranthus* spp.), also very rich in protein; taioba and bertalha and mignonette vine (*Anredera cordifolia*), rich in iron; the capuchin, very rich in lutein; and araruta (*Maranta arundinaceae*), with high quality starch and high digestibility. Thus, investing in the production and consumption of traditional vegetables is great to coping with the effects of climate change, since these species present remarkable resilience, being easy to grow, often perennial or spontaneous growth size, and even less demanding in inputs and more tolerant to pests, diseases and bad weather.

These and other examples of knowledge and use of genetic resources are critical to ensuring food security for present and future generations. The greater the interest in diversifying and adding value to agriculture in the form of new foods, fibers, biomaterials and other raw materials, the better it will be for biodiversity.

Final considerations

This chapter outlined some of the ongoing actions at Embrapa capable of expanding production capacity and facilitating access to safe, high-quality and high nutritional value food. Healthy eating requires sustainable production systems, free of pesticides and contamination. It is also important to diversify food, respect food culture and agricultural seasonality. In addition to encouraging initiatives to promote diversified production systems, it is important to consider the research needs along the productive chains as a way to avoid losses and food waste.

The government's role is to foster public policies that guarantee the population food security and sovereignty, considering the environmental challenges caused by climate change, desertification, soil degradation and water resources reduction. It is essential to increase investments in research, which minimize the impacts on food production and contribute to sustainable rural development.

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Chapter 4

Contribution to the improvement of production concerning family farming, indigenous peoples and traditional populations

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Introduction

Actions that are representative of the contribution of Embrapa to the achievement of target 2.3 of Sustainable Development Objective 2 (SDO 2) are addressed in this Chapter. Target 2.3 is:

> By 2030 double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and nonfarm employment (United Nations, 2018).

The agricultural production of the social segments contemplated in this chapter – family farmers, indigenous peoples and traditional populations – has characteristics, meanings and challenges distinct from the other productive segments of the Brazilian agricultural sector. They demand adequate diagnoses and reflections on their meaning in different economic, social, political, cultural and environmental realities, in order to be able to approach strategies to increase production.

Currently, in the Embrapa project portfolio, there is an expressive set of projects that directly or indirectly contribute to the achievement of target 2.3 of SDG 2, in particular with regard to the increase in agricultural productivity and income of family producers, and which are sheltered in different arrangements and portfolios.

Family farming, indigenous peoples and traditional populations

Depending on the region, different categories of family farmers are considered, related to socio-environmental contexts (Vieira et al., 2014), technological trajectories (Costa, 2015) or other attributes. The categories of family farmers make up segments that have historically been excluded from the benefits offered by the agricultural policy, especially in relation to farm loan, minimum prices and production insurance (Mattei, 2014).

In general, the public policies for the rural area favored the most capitalized sectors, especially those associated with the production of commodities focused on the foreign market. Only in the early 1990s, in response to the mobilization of rural social actors, there was an effort to create a national policy focused on meeting the specific needs of family farmers, resulting in the creation of the Programa Nacional de Fortalecimento da Agricultura Familiar (National Program for Strengthening Family Farming – Pronaf), in 1996. However, from a legal point of view, they were recognized as a productive segment only in 2006, when Law 11,326/2006 (Brasil, 2006), the Family Farming Law, was enacted, being the first to set guidelines for the sector, one of the most fragile in terms of technical capacity and market insertion (Rosa, 1998; Mattei, 2014). Since then, a broad set of public policies focused on the family farming sector has emerged including, among others, the creation of the Ministry of Agrarian Development (MDA), the Programa de Aquisição de Alimentos (Food Acquisition Program – PAA) and, more recently, in 2012, the Política Nacional de Agroecologia e de Produção Orgânica (National Policy on Agroecology and Organic Production – Pnapo). One of the general principles of these iniciatives is equity in the application of resources in ethnic, generational and gender terms. As of 2016, this situation tends to change again, with the extinction of the MDA and the dismantling of policies aimed at family farming, which will have significant negative impacts in the segment (Mattos, 2017).

In 2007, Decree 6,040 created the Política Nacional e Desenvolvimento Sustentável de Povos e Comunidades Tradicionais (National Policy and Sustainable Development of Traditional Peoples and Communities – PNPCT) with an emphasis on the recognition, strengthening and guarantee of territorial, social, environmental, economic and cultural rights and respecting and valuing their identities, their forms of organization and their institutions (Brasil, 2007). In politics, traditional peoples and communities (TPCs) are defined as culturally differentiated groups that recognize themselves as such, have their own forms of social organization, occupy and use territories and natural resources as a condition for their cultural, social, religious, ancestral and economic reproduction, using knowledge, innovations and practices generated and transmitted through tradition. This policy indicates to public institutions the need to support TPCs in initiatives related to the sustainable development of their territories, respecting their cultural characteristics.

TPCs hold millenarian knowledge about food production practices that are transmitted from parents to children for many generations. In general, its agriculture is characterized by clearing, burning and slash-and-burn, by systems of cultivation with wide biological diversity, by the multiple use of natural resources and by management practices that reflect the constant observation of nature. Empirical experimentation by local researchers/experimenters over thousands of years has resulted in land use systems appropriate to the diversity of cultures and realities. Some of these experiences, such as those of agricultural systems in Negro River, have already been recognized as intangible heritage (Eloy et al., 2010).

Participation of Embrapa

Historically, Embrapa has followed up the demands of specific policies in the broad context of family farming and its TPC segment, and even subsidizing such demands with its knowledge base. In this way, it assists in the construction of policies and specific plans in support of productive activities for family farming and its PCT segment. Embrapa has also expanded its portfolio of research and technology transfer projects with the exchange and construction of knowledge among this public. It initiated a series of participations in instances related to the construction of specific public policies for PCT and its implementation. It participated in 17 workshops on ethnodevelopment of indigenous peoples and the *Fórum Nacional para Elaboração da Política Pública Nacional de Segurança Alimentar e Nutricional e Desenvolvimento Sustentável dos Povos Indígenas do Brasil* (National *Forum for the Elaboration of the National Public Policy on Food and Nutrition Security and Sustainable Development of Indigenous Peoples of Brazil* (Neumann, 2006); the preparation of the Indigenous Project Portfolio and its technical committee, the subcommittee on sustainable development of traditional peoples and communities (Condraf). It is currently a member of the Inter-Sectoral Committee on Indigenous Health (Cisi/MS), the Permanent Committee for Indigenous Food and Nutrition Security (CP6) of the National Council for Food and Nutrition Security (Consea), the subcommittee on socio-biodiversity of the National Committee for

Agroecology and Organic Production (Cnapo), among others. These instances have discussed many topics related to the promotion of productive activities with TPC. In addition, Embrapa has maintained a General Cooperation Agreement with the Fundação Nacional do Índio (National Indian Foundation – Funai) for 20 years, which is currently being rediscussed.

With participation and influence in the national scenario of public policy construction, Embrapa has encouraged the expansion of research actions and the availability of technologies for family farmers, indigenous peoples and traditional populations. Especially since 1980, in several of its research centers, teams that worked in experimental fields began to work alongside this productive segment and progressively expanded their activities with these producers. Some examples: the research experience and intervention projects carried out between 1987 and 1997 in four regions of the Northeastern Semiarid region with rural communities, under a cooperation project between Embrapa Semiarid Agriculture and La Recherche Agronomique Pour le Développement (Cirad) (Leite, 2002); the experience of cooperation between Embrapa Temperate Agriculture and Empresa de Assistência Técnica e Extensão Rural do Rio Grande do Sul (Company of Technical Assistance and Rural Extension of Rio Grande do Sul – Emater-RS) (Gomes et al., 2011); the study focused on soil conservation in areas of family farming in the northeast of Pará state, conducted at the then Center for Agricultural Research of the Humid Tropic (currently Embrapa Easter Amazon), in cooperation project with the German Technical Cooperation Agency (GTZ) (Burger, 1986); and the project focused on farming systems in family farming in the Amazon carried out at Embrapa Easter Amazon, in cooperation with Cirad (Tourrand; Veiga, 2003). Sousa (2006) gathered a sample of results of research and technology transfer projects implemented by Embrapa focused on family farming, at the beginning of this century, by topic and by ecoregion.

In fact, one of the milestones of Embrapa's institutional effort for family farming was the creation in 2003 of Macroprogram 6 (MP6): Support for the Development of Family Farming and the Sustainability of the Rural Environment. The MP6, during its 14 years of existence, has stimulated and strengthened dozens of projects aimed at initiatives for the sustainable development of family farming and traditional communities with a territorial approach as a priority to add value. It promoted the convergence of multi-institutional and interdisciplinary efforts in the network of partnerships that supported it. Embrapa has also studied economic aspects associated with the environment and environmental services applied to family farming, traditional populations and indigenous peoples (Mattos; Hercowitz, 2011; Dias et al., 2016a).

Various arrangements and portfolios of Embrapa have projects related to the increase of productivity and income of family farmers, traditional peoples and communities. This is the case, for example, of the Ecological Base Production Systems, Social Innovation in Agriculture, Climate Changes, and Native Forest Resources portfolios, and of the project arrangements Strengthening of Family Agricultural Systems Rain Dependent in the Brazilian Semi-Arid; Agroecological Innovation: construction and knowledge exchange with family farming in the Northeast region of Brazil; Agroecological Systems as an Alternative for the Development of Family Farming in the Midwest Region; and Fire-Free Agriculture in the Amazon. The arrangement approved in 2017, Construction and Knowledge Exchange for the Sustainable Development of Traditional Peoples and Communities (ConPCT), aims to organize, strengthen and stimulate projects primarily with PCT public.

Several projects are focused on increasing the productivity and income of small-scale food producers with a focus on family farming, considering their ethnic and generational approaches, such as: Synergy and Insecticide Potential Evaluation of Essential Oils from the Brazilian Amazon (Sineroil); Technologies for Rational Cultivation of Acai (*Euterpe oleracea* and *E. precatoria*) Production for the Production of Fruits in the Amazon Region (Açaitec); Techniques for the Recovery of Degraded Pastures in the Amazon (Repasto); Soil Conservationist Management in Family Production for Low Carbon Agriculture in the West of the State of Acre, Juruá Produces (Juruapro); Management of the Soil and Culture of Pineapple for Family Farming of the State of Acre (Abac); Utilization of Essential Oil of *P. aduncum* L. (Piperaceae) on Citrus Psilidus Control (Diaphoroil); Geotechnology for the Management of Tropical Forests in the Amazon (Geoflora); Optimization of Brazilian Nut (*Bertholletia excelsa*) Drying Processes for Value Aggregation in Extractive Production Units (Secast); Adjusting Brazilian Cashew Drying Technologies for Adoption in Family Units of Extractive Production; and Quality of Raw Material, Acai and Coffee Processing and Management of Family Agroindustries of Acre (Fortalece).

Embrapa, in its Amazon Units, has also worked in partnership with other institutions in research, development and technology transfer projects, focusing on family farmers in new projects or on strengthening existing enterprises linked to associations and cooperatives representing that public. These are small agroindustrial enterprises that aim, in general, to add value to the products of extractivism and agriculture practiced in rural communities. A noteworthy example was the Farinha de Cruzeiro do Sul project: strengthening of family farming and geographical indication of Território da Cidadania [citizenship territory] of Vale do Juruá, which aimed to develop the necessary basis for family farmers to request the geographical indication of the Território da Cidadania of Vale do Juruá, Acre, for cassava flour, with the objective of improving the living conditions of the producers of that region (Souza et al., 2016).

Embrapa develops a series of projects with indigenous peoples and traditional communities (Udry et al., 2015; Dias et al., 2016a). It works together with the Krahô indigenous people of Tocantins, where an action of enrichment of yards and related training in the format of field days in the villages made the diversification of production possible by planting 20 thousand seedlings of fruit trees in 20 villages, contributing to the increase of production (Figure 1). Of these 20,000 seedlings, about 6,000 corresponded to dwarf cashew varieties (Dias et al., 2015).

Photo: Ubiratan Piovezan

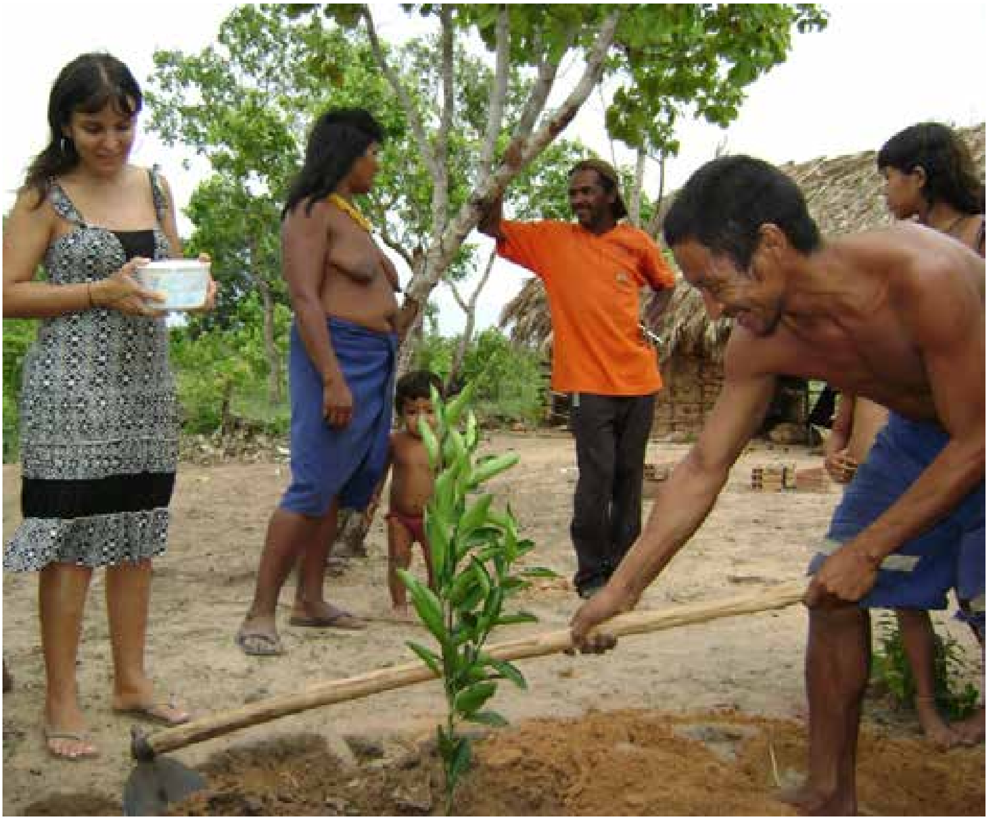

Figure 1. Enrichment of yards with fruit trees in Macaúba village.

In this territory, it also promoted the collection, multiplication and reintroduction of 24 rice varieties, with an increase in local production (Rangel; Dias, 2016). In addition, Embrapa has supported indigenous peoples, in partnership with Funai and other institutions, in the organization of important seed fairs (Dias et al., 2014), with the expansion of collective awareness of the value of agricultural diversity to increase production, income generation and appreciation of the local culture.

In the state of Amapá, the Acai, Banana e Citros (ABC) Project of the Family Cultivation of the Indigenous Communities of Oiapoque has carried out interchange of technologies in fruit culture and formed multiplier agents that have appropriated lasting, replicable technologies, interactively, ethically and collectively (Figure 2). This has contributed to increased production and income in communities (Santos, 2016)."

Embrapa's Units in different regions of Brazil, with their different mandates and competencies, tend to offer different actions regarding the public contemplated and the nature of the theme. Thus, in Roraima, the state with the

Photo: Jackson Santos

Figure 2. Field day on banana cultivation, in Manga village (BR-156), Karipuna indigenous land, October 2013.

highest percentage of indigenous lands, in relation to the total area, the actions of Embrapa are focused on the availability of technologies related to cassava cultivation and support to the production of watermelon by the indigerous peoples, especially the Macuxi and Wapichana, which are the largest producers of this fruit in the state. In the Federal District, a partnership between Embrapa Units, Funai and indigenous and indigenist organizations has provided courses in the form of agroecological dialogues, addressing contents related to the conservation of agrobiodiversity and indigenous food security (Dias et al., 2016b).

According to Dias et al. (2016b), a series of actions are carried out with traditional communities, such as: a) mangabeiras, in the state of Pará – the mapping of 227 mangaba (*Hancornia speciosa*) natural occurrence sites; survey of 80 extractive communities and the analysis of the role of these communities in the conservation of natural areas and related knowledge; b) Brazilian nut, in the state of Acre – establishment of a participatory sustainable forest management model, georeferencing of matrices, creation and strengthening of socio-environmental education practices; c) babassu (*Attalea* ssp.), in the state of Maranhão – promoting exchanges between groups of extractivists; d) artisanal fishing, in the states of Tocantins and Sergipe – studies of traditional knowledge; e) mangrove-crab (*Ucides cordatus*), in the states of Piauí, Maranhão and Ceará – participatory research for fishing management and characterization of the productive chain, among others.

It is worth mentioning, in addition to the action of the Núcleos de Estudos Agroecológicos (Agroecological Studies Centers – NEAs) implemented in several Embrapa research units, also the figure of regional arrangements of projects focused on agroecology, which aim to ensure articulations and expand the contribution of the institution to family farming. In the context of the TPC segment, the ConPCT arrangement counts on the participation of 17 Embrapa Units and several related projects. The arrangement aims to promote innovation actions among traditional peoples and communities that contribute to identify, characterize and value traditional systems of use, management and conservation of natural resources that contribute to food and nutritional security with a territorial focus, guaranteeing sustainable ways of life.

Final considerations

An analysis of the actions carried out and the results achieved in relation to the improvement in production with family farming, indigenous peoples and traditional populations makes it evident that, especially during the last 2 decades, there has been a significant advance in this sector, especially in family farming, result of the support provided by more inclusive public policies, in which the work of Embrapa is expressive, through its multidisciplinary teams spread through its Units in all Brazilian regions.

Despite the relevance of the productive segments mentioned in this chapter, for their contribution to food security and sovereignty in Brazil, including their own territories, there is concern about the drastic changes that have been implemented in the public policies addressed to these segments, which includes Embrapa's agenda. The experience accumulated by Embrapa teams that has contributed to the advancement of knowledge, including the adoption of methodologies of exchange and collective construction of knowledge along these productive segments. There should be actions in partnership with other governmental institutions and governmental organizations to improve food security and sovereignty in Brazil and beyond, through increased agricultural productivity, and access to productive resources, inputs, knowledge and value-added opportunities, as outlined in SDG 2 target 2.3.

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Chapter 5

Sustainable production of food

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Introduction

The purpose of this chapter is to present contributions of Embrapa to target 2.4 of Sustainable Development Goal 2 (SDG 2):

> By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality. (United Nations, 2018).

Anthropogenic action has led to the development of technological agroecosystems, highly dependent on inputs produced from non-renewable resources, making them vulnerable due to their low sustainability. There is little concern about the conservation and recycling of nutrients, which makes these systems highly affecting to the environment (Feiden, 2005). In this scenario, it is fundamental to develop sustainable food production systems that address not only productivity but also incorporate social and environmental aspects of sustainability. The preservation of ecosystems producing food with greater efficiency in the use of inputs and energy is fundamental to guarantee the conservation of natural resources. The challenge is to generate knowledge and technologies that guarantee the stability of agroecosystems, and that promote and increase their capacity for self-regulation and resilience.

This chapter represents a small sample of the work developed by Embrapa, with the fundamental contribution of its partner institutions, in search of an agriculture that meets the growing demand of society for safe technologies related to environment and human health.

Sustainability in the production of food

The development of sustainable food production systems is based on basic pillars, such as the genetic adequacy of the propagating materials used, the efficiency and origin of the inputs used, and the management practices used and their relationship with the environment and socioeconomic impacts.

Sustainable agricultural systems require genetic materials that present productivity within species patterns and greater resistance to stresses, particularly biotic ones, although tolerance to abiotic stresses in certain environmental conditions is relevant. This chapter presents a logic that is contrary to the green revolution perspective, in which genetic materials of high productivity, but with low rusticity were selected, highly responsive to the application of synthetic fertilizers, but extremely dependent on phytoprotectants.

The sustainability of productive systems is closely associated with the characteristics of the inputs used: the logic is to reduce dependence on inputs from non-renewable sources. It is shown the high correlation between the genetic materials used and the level of input utilization, in which the highest rusticity of propagation material corresponds to a lower contribution of inputs. In this sense, the importance of bioinputs increases, in which the potential of biological assets is placed at a new level of significance for sustainable production systems.

Sustainable production systems also highly depend on: a) management practices that contribute to the maintenance of agrobiodiversity, without which sustainability is compromised; b) stimuli of positive biotic interactions that contribute to the maintenance or improvement of soil characteristics and water preservation and to the expression of the productivity potential of the genetic material in use. As a classic example, there is the use of legumes in green manure systems, which provide nitrogen for subsequent crops and stimulate the biological activity of the soil.

In this context, this chapter selects practices and technologies generated by Embrapa that contribute in some way to the sustainability of agricultural systems in all their economic, social and environmental aspects, and that, in the last analysis, have played a relevant role in increasing the resilience of agroecosystems.

The development of production systems on an ecological basis has guided the research agenda of Embrapa Units, in response to the growing demand from society for the production of safe food with low environmental impact. Because of these research actions, there are countless organic production systems, developed with partner entities, with different species of importance for human consumption.

In this sense, the systems of organic production of grains, such as rice, corn, coffee, fruit trees (citrus, banana, pineapple), vegetables and roots and tubers (cassava and potato) can be mentioned (Embrapa, 2008, 2017, 2018b). There are significant contributions in the animal segment, such as the development of technologies for the production of organic milk, chicken meat and pork, as well as the production of organic eggs (Embrapa, 2014, 2016). The viability of organic production or ecological base in this segment is based on the installation of diversified production systems, integrating animal production to annual and perennial polycultures, as opposed to the management adopted in conventional systems that generally emphasize monoculture and confined systems. These systems combine the production of food with the conservation of natural resources, focused on preserving the farmers' and consumers' health, for not using pesticides.

Genetics and sustainability

Sustainability has been impaired in many productive systems by the genetic erosion that has occurred over the years. The selection and dissemination of genetic materials with high dependence on inputs caused a drastic reduction in the availability of genotypes characterized by rusticity and high resistance to biotic and abiotic stresses. This erosion shows its most perverse side to family farming, subtracting from this segment the possibility of using materials more adapted to less-technified systems. In view of this problem, Embrapa research agenda has as one of its priorities the development of cultivars that are more efficient in the use of natural resources and less dependent on the use of inputs.

This study focused on the generation of cultivars of different species of importance for agricultural food production systems, such as the corn cultivars BRS Caimbé, BRS Caatingueiro, BRS Gorutuba, BRS 4103 and BRS 4104; the black bean cultivar BRS Paisano; the potato cultivars Epagri 361-Catucha, Cristal, BRS Ana and BRS Clara; the onion cultivar BRS Sustentare; the pumpkin cultivar BRS Tortéi (Figure 1); and the carrot cultivar BRS Planalto (Embrapa, 2016, 2017). Concearning fruit growing, the variety of passion fruit for the *Caatinga*, BRS Sertão Forte and the varietal diversification in the citrus fruit cultivation is highlighted, important for the phytosanitary sustainability of this productive segment (Embrapa, 2017).

In the animal production segment, the preservation of Crioula Lanada sheep is highlighted for the adaptation to the climatic conditions of the southern fields and the ex situ conservation of *curraleiro pé-duro* cattle, resistant to the difficult conditions of the semi-arid region (Embrapa, 2017).

Photo: Paulo Luiz Lanzetta Aguiar

Figure 1. Pumpkin cultivar BRS Tortéi.

Agricultural inputs – paths to sustainability

Agriculture begins to undergo a transition process, based on the gradual substitution of the use of some inputs considered critical for reasons of economic nature, by inspiration of environmental order or by public health problems. In the logic of reducing input use, integrated production systems represent an advance towards the sustainability of agricultural production. These meet the requirements of good agricultural practices (GAPs) by emphasizing the importance of environmental preservation, production of safe food for human health, social adequacy and economic viability and working conditions that must predominate in the production system. Embrapa, in a study in partnership with other research entities, has developed integrated production systems for different grain species, such as beans, corn, soy and wheat, and for an expressive number of fruit species, such as pineapple, cashew, citrus, coconut, apple, mango, melon, strawberry, peach, grape, and annonaceae, such as sweetsop, also known as *ata* or *pinha*, and also graviola, cherimoia and atemoia (Embrapa, 2008, 2009, 2010, 2013, 2014, 2016, 2017, 2018b). In the animal area, the Agricultural Integrated Production System (Sapi) of Caprine Milk (Embrapa, 2014) stands out.

In order to replace impacting inputs, the development of bioinputs as a support to plant protection and nutrition, which the biological component is responsible for increasing efficiency and reducing the environmental impact of the final product, is an irreversible trend. Under this approach, the contribution of Embrapa has been significant for advancing the sustainability of production systems, generating solutions that combine productivity maintenance and environmental preservation. Concerning plant protection, the development of Baculovirus-based biopesticide is one of the examples of alternatives to the use of chemicals in caterpillars control, in a safe, efficient, low cost and low environmental impact form (Embrapa, 2017). As a contribution to biological insecticides, among other results, there is the scientific evidence of the possibility of using neem leaf extract (*Azadirachta indica*) as an insecticide for the control of the fall army-worm (*Spodoptera frugiperda*) in corn cultivations (Embrapa, 2010).

Still in relation to the bioinputs, the work of Embrapa with the biological nitrogen fixation (BNF) (Figure 2) contributes to the reduction of the impact of agricultural activity on the environment, mainly by the reduction of greenhouse gases emission and fossil fuels use in the manufacture of nitrogen fertilizers. In this sense, it is worth mentioning the increase of the productivity of the cowpea, with

Photo: Ana Lúcia Ferreira

Figure 2. Biological nitrogen fixation (BNF) – nodules in bean roots.

gains of up to 40%, from the inoculation of the seeds with the specific rhizobium BR 3267, BNF promoter. This result has a high positive impact on the cultivation of cowpea, a traditional subsistence crop in the North and Northeast regions of Brazil, which is the main source of protein for family farmers in the semi-arid region (Embrapa, 2018b).

The process of replacing agricultural inputs with high-impact on public health and on the environment requires biological control, defined as "the use of living organisms to suppress the population of a specific pest, making it less abundant or less harmful" (Embrapa, 2018a, our translation), a theme on which Embrapa has generated significant volume of knowledge. The biological control of citrus larvae (*Phyllocnistis citrella*), one of the main pests of citrus orchards, using the parasitoid *Ageniaspis citricola* and the studies that have successfully allowed the use of the Trichogramma wasp in the control of *Spodoptera frugiperda* in the cultivation of corn, and also against a new pest, the caterpillar *Helicoverpa armigera*, in which other techniques have not been efficient to avoid damages to the farmers (Embrapa, 2014, 2016, 2017).

One of the critical points for scaling up organic or sustainable production systems is the availability of fertilizers that meet the requirements of low environmental impact, efficiency and adequate cost. Embrapa has made important contributions in this segment, such as the development of granulated phosphate organomineral fertilizer, from poultry litter, a technological solution from an agronomic point of view, but also environmental, not only by the destination of waste, but also by the contribution to reduce the emission of greenhouse gases due to the superficial application of organic residues (Embrapa, 2018b). Also, the pig farming project Agrosuíno, conducted by Embrapa and partners, developed the process of treatment of swine manure and subsequent granulation of this material, resulting in easy application granulated organomineral fertilizer (Embrapa, 2018b).

Sustainable agricultural practices of social reach

With a significant contribution to sustainable food production, Embrapa, in various regions, has developed practices that aim to meet the society demand for cleaner agricultural technologies, which combine productivity and the preservation of natural resources and public health. In this context, some examples of such practices will be described.

The traditional agriculture of the Amazon, based on the practice of slashing and burning, has become the target of criticism due to the damages caused to the environment. As a solution, there is the Tipitamba System, a sustainable practice that makes possible family farming without burning. The system consists of a technological, socioeconomic and environmentally sustainable alternative for family farming with a focus on reducing the use of fire and deforestation, mitigating the environmental impacts of agriculture in the Amazon region (Embrapa, 2012, 2014).

Considering the growing demand for low-cost and wide-ranging social technologies that could alleviate the existing chronic malnutrition, mainly in the North and Northeast, Embrapa developed the integrated small-scale production system called Sisteminha Embrapa, which consists of the integration of pisciculture with other small animal breedings and the staggered production of edible plants. To reuse discarded water from fish farming and use the nutrients contained in it, the system integrates activities such as hydroponic and conventional vegetable cultivation, irrigation of small grazing areas for small ruminants and poultry, and the creation of earthworms for production of humus from the solid waste generated in the fish and poultry farming (Embrapa, 2014, 2018b). As another example of integrated production involving fish farming, it is also worth highlighting the use of the desalination concentrate of the water from underground wells for the tilapia culture, and the use of effluent from this breeding for the cultivation of saltbush, resistant to salt, whose mass is used for the production of hay for feeding goats, sheep and cattle (Embrapa, 2018b).

Still in the aquaculture segment, other sustainable practices stand out, such as the development of a method for capturing, storing and transporting live crabs with low waste indexes, reducing the discard of values from around 55% to around 5% (Embrapa, 2018b). Also worthy of mention is the so-called “bioremediation of oysters in aquaculture”, which consists in the placement of “pillows” for the creation of oysters in the drainage channel or in sedimentation tanks in shrimp farms, reducing the volume of nutrients from the drainage water, and consequently the potential of eutrophication of the water bodies that receive the effluents, being yet another source of income for the commercialization of oysters produced (Embrapa, 2018b).

Another important action of Embrapa is the colonial poultry project for family farming in the South of Brazil, which employs accessible technologies, with little use of labor and low investment needs (Embrapa, 2017). The activity contributes to the subsistence and the generation of complementary income for the families of farmers living in situations of social and economic vulnerability, through the commercialization of meat and eggs.

Quintais Orgânicos de Frutas (Organic Fruit Yards) is an Embrapa action with significant contribution to food security and social, economic and environmental sustainability that also benefits public in situation of vulnerability and social risk. With more than 2 thousand units installed in about 200 municipalities in the South region, the yards are the cultivation of a set of fruit species, vegetables and grains for human consumption (Embrapa, 2017). A similar action is developed in the Semiarid with the implantation of Quintais Produtivos (Productive Yards), where different species of fruits and vegetables are cultivated using simplified irrigation systems, with the use of rainwater collected in cisterns. Yards are an important source of food for families of farmers, with an important contribution to their subsistence (Embrapa, 2017).

Usually used for the recovery of degraded areas, agroforestry systems (SAFs), consortia of agricultural crops with tree species (Figure 3), also represent a sustainable form of food production.

Photo: Diva da Conceição Gonçalves

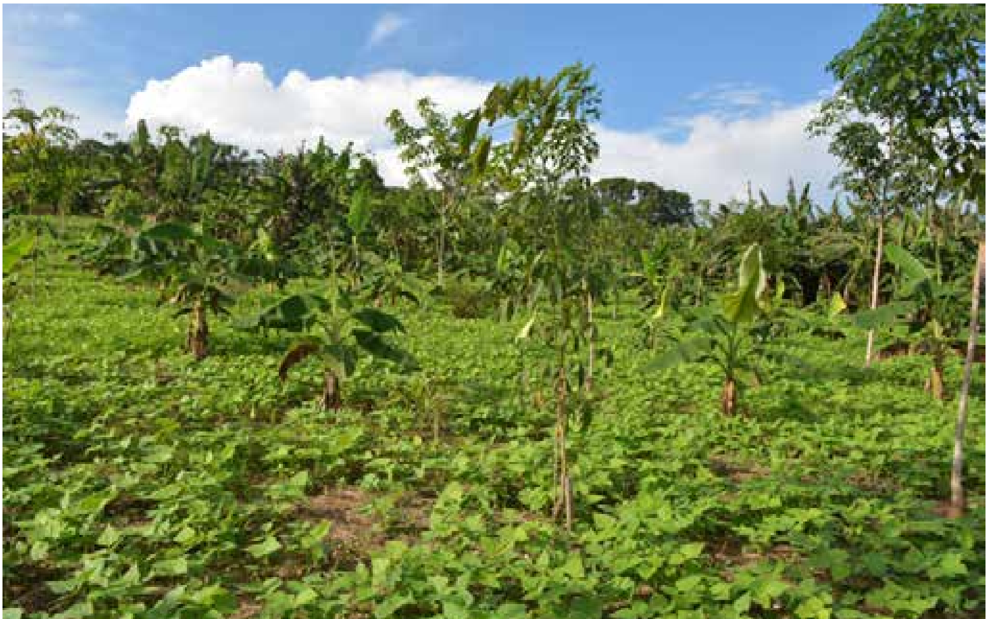

Figure 3. Agroforestry system with bean cultivation (*Phaseolus vulgaris*), banana (*Musa* sp.) and rubber tree (*Hevea brasiliensis*). Extractive Reserve Chico Mendes, Brasileia, Acre state, Brazil, 2017.

Embrapa has developed a series of research actions aimed at identifying, in different ecosystems, the potential for synergism between tree species and food producing species, seeking the structuring of SAFs, which, besides providing an environmental service, also promote the increase in income for farmers. In addition, the actions integrated with the partner institutions, including farmers' organizations, to validate and popularize SAFs in different biomes, and their contribution to the inclusion of this type of system in public policies should be highlighted (Embrapa, 2017).

The challenge of climate changes

Climate change poses a major threat to the sustainability of agriculture, the potential impact on productivity and the risk of change in the incidence of pests and diseases, which may ultimately have negative impacts from an economic and environmental point of view.

Institutionally, Embrapa has addressed the issue through actions directly associated with the generation of knowledge and technologies towards the mitigation of the impacts of climate change on food production. One of these actions is represented by the creation of the Unidade Mista de Pesquisa em Genômica Aplicada a Mudanças Climáticas (Joint Research Unit on Applied Genomics for Climate Change), which joins efforts of Embrapa and the State University of Campinas (Unicamp) to develop plants better adapted to climate change. Another important institutional action was the structuring of the Climate Changes Portfolio, a management figure of projects organization, whose objective is to subsidize the actions of Embrapa in search of solutions to prevent global warming and the consequent increase in the frequency of occurrence of events that can reduce drastically the food supply to the population.

In this scenario, the actions of Embrapa aimed at the decarbonization of agriculture deserve special mention. Embrapa has joined global efforts to reduce greenhouse gas emissions (GHGs), which places Brazilian agriculture in a leading position in the international scenario regarding the sustainability of agricultural production systems.

Being the result of Embrapa's partnership with other institutions, Crop-Livestock-Forest integration systems (ICLFS) involve the production of grains, fibers, wood, energy, milk or meat in the same area (Figure 4). The contribution of the system to the decarbonization of agriculture and consequently to the reduction of

Photo: Karina Pulrolnik

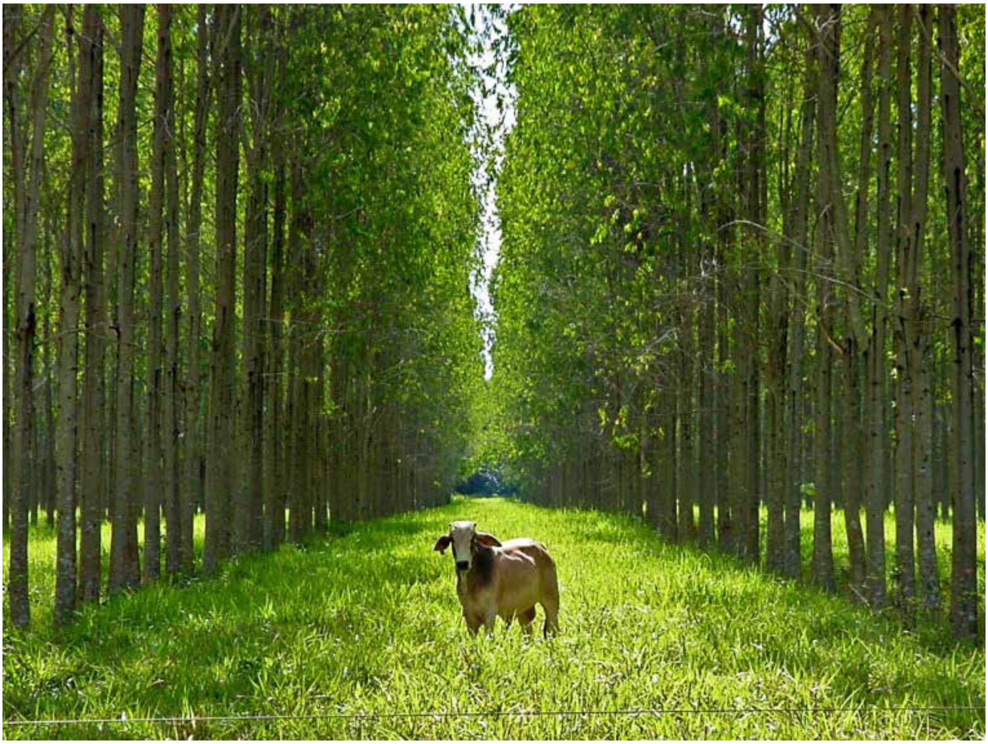

Figure 4. Crop-Livestock-Forest Integration Systems (ICLFS), Embrapa Cerrados, Planaltina, DF.

GHG emissions is considerable, due to the large deposition of vegetal residues, promoting the fixation of carbon in the soil. In the same context, the development of the "Carbon Neutral Meat" brand concept aims at attesting that the beef produced in integrated forest-animal husbandry systems originates from animals that had enteric methane emissions (GEEs) compensated during the production process, by the growth of trees in the system (Embrapa, 2018b).

Still in relation to the reduction of GHG emissions, the work of Embrapa on the indication of no-till planting to increase carbon sequestration and improve the chemical and physical quality of the soil deserves special mention.

> [...] The No-Till Planting System (SPD) is a conservationist practice of cultivation and soil management that provides many technical, economic, environmental and social benefits, constituting one of the main technological solutions for sustainable agriculture in the tropics (Embrapa, 2018b, our translation).

The SPD is included among the technologies considered as Brazilian voluntary commitment to reduce greenhouse gas emissions. In addition to reducing energy consumption, particularly fossil fuels, other recognized benefits provided by this technology have led to a large number of studies concerning its applicability to a diversity of production systems and the cultivation of different plant species of importance in food production, such as rice, beans, corn, wheat, vegetables, and pastures (Embrapa, 2018b).

Final considerations

One of the important components of productive systems to determine their degree of sustainability is the genetics of the materials used, which highlights the importance of genetic improvement in structuring sustainable production. Once the genetic material is defined, the concern is for the inputs to be used. In this component, the research has worked on several fronts: a) in the development of phytoprotectants, in which the bioinputs represent an important alternative; b) in the search for efficient fertilizers from renewable sources; c) in the organization of integrated production systems, in which the rational use of inputs and good agricultural practices are fundamental requirements.

Embrapa has acted intensely, not only in these segments, but also in others of significant importance for the sustainability of agricultural systems. However, in the quest for sustainability, other frontiers are beginning to be explored and, in the coming years, must have significant knowledge contributions. The advancement and consolidation of a biologically based agriculture, where natural resources are preserved and the environment not very impacted, should occupy a prominent place in the agenda of research institutions such as Embrapa. Climate change and its implications for sustainable agricultural production are also a major challenge for research, whose overcoming will require intensified efforts in the coming years. However, perhaps one of the greatest challenges to be faced in advancing and refining the sustainability of agricultural systems is the organization and articulation of existing knowledge, as well as of knowledge to be generated. In this aspect, it is fundamental to build knowledge exchange networks, in which the interaction between its different actors allows eliminating steps and shortening paths for technological advancement in search of sustainability, so demanded by society today, but which will become a mandatory issue for agriculture in the very near future.

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Chapter 6

Genetic diversity and the eradication of hunger

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Introduction

This chapter addresses the contributions of Embrapa to target 2.5 of Sustainable Development Goal 2 (SDG 2):

> By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed. (United Nations, 2018).

The modernization model of agriculture based on agricultural mechanization, the use of industrial inputs and genetic uniformity led to the substitution of varieties adapted to traditional farming systems by varieties, which meet the needs of intensive agriculture. This has contributed to the disappearance or loss of genetic variability of species that coevolved with the environment and with the cultural diversity of peoples for hundreds of years.

According to the statements of Zakri Abdul Hamid in 2013, quoted by Alisson (2013, our translation), about 75% of the genetic diversity of agricultural crops has been lost in the last century. According to Hamid:

> [...] there are 30,000 species of plants, but only 30 crops are responsible for providing 95% of the energy supplied by foods consumed by humans. Most of them (60%) are rice, wheat, corn, millet and sorghum.

Regarding the animals, the author states "approximately 22% of the bovine breeds in the world are in danger of extinction by the lack of recognition of their quality to meet the current demands of cattle breeders" (Hamid, 2013 quoted by Alisson, 2013, our translation). However, many of these native breeds are means of subsistence for many poor families in the world, since their management and maintenance are simple when compared to genetically improved breeds. The diversity of these agricultural and livestock species is important for breeding programs and local production because of their adaptation to unfavorable environmental conditions, being more resistant to droughts, extreme heat and tropical diseases. In this way, they are more appropriate to deal with climate change.

In the context of the diversity of agricultural and breeding systems, agrobiodiversity is a broad term that includes all the components of biodiversity that constitute the agroecosystem and are relevant to agriculture and food. Associated with agrobiodiversity is a range of knowledge of indigenous peoples and traditional communities that, through selection, domestication and acclimatization of native species in various socio-historical contexts, allows local and global adaptation of genetic resources to environmental adversities. The conservation of genetic resources and the promotion of the sustainable use of agrobiodiversity are crucial strategies for ensuring the eradication of hunger.

Concerned with the challenge of conserving the genetic diversity of domesticated and non-domesticated farm plants and breeds, and also with the fair and equitable sharing of benefits arising from the use of these genetic resources and associated traditional knowledge, Brazil has signed and ratified important international treaties, such as the Convention on Biological Diversity (CBD) (Convention on Biological Diversity, 1992) and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (Tratado..., 2009).

The CBD defines two strategies for biodiversity conservation: ex situ and in situ/on farm and it is based on three pillars: conservation of biological diversity, sustainable use of components of biological diversity and fair and equitable distribution of benefits arising from genetic resources use.

In accordance with CBD, ITPGRFA aims at the conservation and sustainable use of plant genetic resources for food and agriculture, as well as the fair and equitable sharing of the benefits derived from its use. It recognizes the sovereignty of States over their plant genetic resources and establishes a multilateral system for facilitated access and sustainable use of these resources. It also recognizes the right of farmers and the contribution of local communities, indigenous peoples and farmers in all regions to the conservation and development of plant genetic resources, which form the basis of food and agricultural production throughout the world.

Embrapa carries out several actions that contribute to the implementation of these international agreements in Brazil. In relation to the CBD, Embrapa has been operating since 2002 with several programs linked to the agricultural sector related to agrobiodiversity, the conservation of pollinators and the Cartagena protocol on biosafety. Regarding ITPGRFA, the Company developed a project that resulted in a strategic action plan to promote food security in a context of climate change for crops of rice, corns, beans, wheat and cassava in Brazil, Paraguay and Uruguay. This action plan was financed by the Benefit-Sharing Fund of the International Treat and built by the Latin American Network for the Implementation of the International Treaty on Plant Genetic Resources for Food and Agriculture (Laniit) (Strategic..., 2016).

Regarding the fair and equitable sharing of benefits from the use of genetic resources and associated traditional knowledge, the focus of both international agreements, CBD and ITPGRFA, Embrapa has contributed since 1997 to national and international discussions and the implementation of Law 13,123/2015 (Brasil, 2015) of Genetic Heritage Access and of Decree 8,772/2016 (Brasil, 2016), which regulates, at the national level, the access and use of native genetic resources and associated traditional knowledge and guarantees the fair and equitable sharing of benefits.

All the initiatives carried out by Embrapa aiming at the implementation of international agreements added to the strategies adopted to promote research, exchange and knowledge construction actions, supporting public policies, contribute to the achievement of SDGs, but especially to target 2.5. We highlight some initiatives related to the conservation of plant genetic resources and the sustainable use of agrobiodiversity that contribute to the food and nutritional security of populations.

Ex situ conservation of genetic diversity

The conservation ex situ of genetic diversity relates to the maintenance of genetic resources outside their place of origin, being preserved in the short, medium or long term. It includes enrichment activities (by collection or exchange), documentation and conservation of these collections. It guarantees germplasm for genetic improvement programs and for the restitution of traditional varieties lost or missing from local farming or breeding systems (Figure 1).

Photo: Paulo Luiz Lanzetta Aguiar

Figure 1. Genetic diversity.

Embrapa is the main responsible for ex situ conservation in Brazil and maintains the ninth largest collection of genetic resources in the world. There are about 140 germplasm banks of different products and a collection of about 200 thousand accesses of more than 700 species of cultivated plants and their wild relatives. These genetic resources are being conserved in 29 Units of Embrapa, including the Base Collection (Colbase), in Embrapa Genetic Resources and Biotechnology, which has about 110 thousand accesses and 1,019 species. The largest banks are: rice (about 30 thousand accesses); beans and soy (about 18 thousand each); wheat (about 15 thousand); and sorghum (7,200). Functional microorganisms are also maintained in this system and there are about 33 thousand accesses.

In relation to animal genetic resources, the ex situ conservation bank has 85,000 semen samples and 450 embryos. In general, the most productive animals used today in national livestock are the result of work developed by breeders, often associated with researchers. Throughout the selection process, many lineages are discarded by breeders, and Embrapa manages to preserve them in the form of frozen semen and embryos at 196 °C below zero. These lineages may prove important for future breeding programs. In addition to this strategy, animal diversity is also maintained in conservation centers, in partnership with associations, universities and other institutions.

It is important to emphasize that all these materials are documented and arranged in the Sistema Alelo which is a portal of information on plant, animal and microbial resources that enables the exchange and use of germplasm between institutions in different countries.

In situ/on farm conservation of genetic diversity

It covers the conservation, management and restoration of species populations and of its associated ecosystems. In situ conservation is also included on farm conservation, related to populations of species under cultivation, generally domesticated, as well as ethnovarieties (local varieties) conserved in agricultural areas (Clement et al., 2007). In situ/on farm conservation ensures that natural evolutionary processes and changes resulting from interaction with the landscape and cultural environment are maintained, allowing the accumulation of genetic variability, adapted to environmental and social changes.

Embrapa has developed several actions related to in situ conservation, such as biological inventories and geographic analyzes for conservation planning; evaluation and development of management techniques for the sustainable use of biodiversity; ecological restoration in degraded landscapes; and also to the analysis and promotion of the conservation of genetic resources by local communities and farmers. Emphasize the actions with the indigenous peoples, in which Embrapa operates in different territories, such as: Krahô, in Tocantins; Kaxinawá and Kulina, in Acre; Kayabi, in Mato Grosso; Tumukumaque, Oiapoque, in Amapá; Guarani and Kaigang, in Rio Grande do Sul, where there are activities with corn, cassava, fava beans, peanuts, beans, pumpkins, acai and even native bees.

One relevant experience refers to the support given by Embrapa to the farmers who conserve and use the Sementes da Paixão (seeds of passion, name given to the creole seeds in the state of Paraíba). Several participatory trials have been carried out to evaluate and select traditional varieties, aiming to compare their quality to other materials from breeding programs. In addition, research has contributed to improve seed production and to identify storage techniques that extend its shelf life (Santos et al., 2012).

Related to the strategies to promote in situ/on farm conservation, we highlight the banks or seed houses, the agrobiodiversity guardians and the seed fairs, actions that have been supported by Embrapa for more than 20 years.

Seed houses and socio-culturally territorialized genetic collections are local strategies for the dissemination of agrobiodiversity performed in learning spaces where families have access to new species and varieties. Seed houses are directly related to local farmers associations or technical schools. Embrapa has been an important partner of these actions by providing seeds that are included as part of the collection of these houses and are used in agroecological systems of local production.

Agrobiodiversity guardians are farmers and breeders who maintain a range of species and varieties in their farming and breeding systems, thus contributing to their conservation and adaptation to climate change. Embrapa participates in guardians' networks composed of family farmers, *quilombolas* and indigenous people in partnership with other institutions. In some cases, it supports participatory genetic improvement, training farmers and technicians, and thus strengthening the autonomy of communities. Only in Rio Grande do Sul, more than 230 individual or organized guardians were identified, and a significant part of the agrobiodiversity conserved by them was inventoried (Bevilaqua et al., 2014). These initiatives, which also include the network of junior guardians, have achieved international recognition by being nominated as a "sustainable practice" by the Food and Agriculture Organization of the United Nations (FAO) in 2016.

Agrobiodiversity fairs or seed fairs aim to foster community management, enable access to locally missing components of agrobiodiversity, introduce new crops into local systems, and promote the exchange of experiences. They are also spaces for the commercialization of family farming products. Embrapa has been supporting numerous fairs, especially in indigenous territories (Dias et al., 2015). The Krahô indigenous land, for example, has already held 10 agrobiodiversity fairs (Figure 2), which had 6,000 farmers from more than 20 ethnic groups (Dias et al., 2014). The initiative has multiplied to other indigenous territories such as Xerente, Pareci, Kayapó, indigenous peoples of Roraima and of Médio Purus, in Amazonas, and has been incorporated into public policies. Along with other publics, Embrapa supported, in Rio Grande do Sul, the holding of 12 fairs in 2017, with the participation of more than 10 thousand people.

Among the experiences of rescue and repatriation of genetic resources from the germplasm banks, there are 4 varieties of indigenous corn, 12 of sweet potato,

Photo: Terezinha Dias

Figure 2. *Krahô Fair of Traditional Seeds*: indigenous farmer exposes seeds for exchange.

27 of rice for the indigenous people Krahô (TO); several corn varieties for the Xavante (TO), Guarani (RS) and Maxacali (MG); fava beans for the Xavante (TO); and wheat varieties that resulted in the distribution of seeds to family farmers in Chapada dos Veadeiros (Dias et al., 2013; Rangel; Dias, 2016).

An important action was carried out from seeds of open pollinated varieties, mainly provided by the Germplasm Bank of Vegetables (Embrapa Vegetables), which allowed the reproduction of the seeds of the varieties selected locally by farmers. Through training activities and field days, more than 20 community local banks of traditional vegetable seeds were established along with farmers and traditional communities in the various regions of the country.

Several participatory evaluations of materials provided by germplasm banks have been carried out in partnership with farmers and local institutions, such as varieties of cassava, corn, pumpkins, peanuts and beans. In Rio Grande do Sul state, farmers' participation resulted in the transfer of 140 creole bean varieties and 30 varieties of other species through Partituras da Biodiversidade[2] – a collection of creole varieties for evaluation and possible adoption (Villela et al., 2014). Annually, 30 seed collections are available, among cultivars and creole varieties of beans, corn, vegetables and dual-purpose legumes to guardian farmers who, through a process of participatory genetic improvement, identify those with the greatest potential for selection of new varieties adapted to several social and ecological systems.

Final considerations

In close relation with target 2.5 for more than 4 decades Embrapa has been developing actions for the conservation of the genetic diversity of seeds, plants and domesticated animals and their wild relatives. Its collection and exchange actions have brought together the sixth largest collection of germplasm in the world and the largest in Latin America. Added to this, pioneering actions of genetic resources availability to society, from ex situ conserved accesses, have allowed the repatriation of scarce and locally missing materials, contributing to the strengthening of in situ/on farm conservation and to a qualified approach between the two conservation systems (ex situ and in situ/on farm). At Embrapa, several projects and initiatives to strengthen the conservation of genetic

2 Translation note: It is a mechanism for promoting biodiversity increase. It assembles creole varieties and makes them available to farmers who evaluate and select the varieties considering new uses.

resources, carried out locally by farmers, are underway, broadening the global perspective of conservation of the agrobiodiversity

This chapter has highlighted some of the initiatives that Embrapa has undertaken to promote the conservation of genetic resources and the sustainable use of agrobiodiversity. There are countless efforts by curators, breeders, researchers, family farmers, traditional peoples and communities who conserve seeds and insert them into food production systems. However, the challenge of mitigating hunger in the world requires corporations such as Embrapa to unite with government institutions and civil society in the search for joint solutions to strengthen these initiatives, either by expanding and structuring the germplasm banks of research institutions and of farmers, either by creating innovative systems for shared management or by creating and implementing appropriate public policies to achieve the goals of sustainable development.

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Chapter 7

Perspectives and challenges

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Introduction

Understanding and interpreting the changes through which our perception of agriculture, science, and society is crucial to projecting the challenges and opportunities, which the Sustainable Development Goals (SDG) give rise to. Truly, there is no way to segment the scientific and technological advances of the evolution observed in agriculture over time and their real consequences on the perceptions of society on the agriculture role and its relations with climate change, harmonious coexistence and use and efficient management of natural resources, with the food-nutrition-health connection and quality of life, with modern concepts of territoriality and, especially, with the expectations of consumers, eager for attributes of health, well-being, comfort and sustainability.

The signs and challenges that society presents us to the future require an agriculture capable not only of producing food in quantity and quality, but also of offering fiber, energy and ecosystem services from the sustainable and efficient use of natural resources, the adoption of good agricultural practices that value agronomic practices such as crop rotation, integrated pest management, no-till planting system, among others. An agriculture capable of promoting the reduction of the use of fossil fuels and the maintenance or expansion of biodiversity. These challenges and opportunities are complex and will require the articulation of robust research and innovation networks, including public and private institutions and civil society organizations, capable of transforming technological knowledge and solutions in development. For such, Embrapa and all organizations should not only provide knowledge and technology, but also contribute to the governance of productive chains, articulate innovative arrangements and contribute to the formulation of public policies linked to SDG commitments and the expectations of society.

In addition to concern about the impacts of climate change on food production, the dynamics of ecosystems and biomes and especially poorer populations, there will be increasing attention to the inefficient use of natural resources (soil, water, atmosphere, biodiversity and energy sources), as common goods, which will require innovations oriented towards the valorization of biological mechanisms and processes to the detriment of the use of external inputs. In addition, the technological solutions to be developed, in addition to being environmentally friendly, should present great capacity to generate tangible and intangible value to society.

In addition, the link between food, nutrition and health will be clearer. In this context, food will no longer be perceived as "necessary commodity", becoming understood as "promoter of quality of life, good health and well-being". Thus, the population will be more interested in the technological format with which the food is produced, its territorial origin and socio-cultural connection, as well as greater attention to the mechanisms and strategies of traceability and certification, including the adoption of good agricultural practices and use of inputs.

It is clear that this is not predicting the future, but of analyzing and contextualizing the signs that society points out to us, as well as inferring about possible developments in the agriculture role and its impacts on research, development and innovation agenda, focused on the technological and standard forms of inputs use, starting from an agriculture that until then provided food for an agricultural promotion of health and quality of life. An example of these signs is the strong concern of society regarding the use of pesticides and genetically modified organisms in agriculture, which can be interpreted as a powerful moviment that will strengthen the bases of a "third wave" in agriculture.

Although it can still be perceived almost as a utopia for the most skeptical people, the "greening" of agriculture will be increasingly imperative, due to several issues: a) pressure from society for healthier foods; b) increased cost of obtaining new synthetic molecules for use in agriculture, especially for living with pests; c) increased pest resistance to these molecules; d) expansion of investments in research, development and innovation in biological, private and public assets.

Compared to the technological formats that underpinned the green revolution and still support the adoption of integrated systems, the scientific bases of biologically based agriculture are more complex and require highly specialized knowledge in chemistry, biochemistry, physiology and ecophysiology, yet highly integrated and backed by recovery principles of agronomy and agroecology, often simply replaced by some available synthetic input.

Biological-based asset generation and the design of sustainable production systems require the mastery of complex relationships and robust transdisciplinary networks ("networks of networks"). Moreover, it requires a shift from the Cartesian to the holistic mental model, a mastery of methods and indicators of high complexity, as well as humility to "observe" what nature already "knows".

Although in our mental model tangible assets (seeds, fertilizers, inoculants, and pesticides) are often more perceptible as to their impact on the production process, recent studies show that 68% of advances obtained by Brazilian agriculture result from the incorporation of knowledge and good practices for the production system, considered intangible assets (Alves; Silva, 2013).

Sources of nutrients present in agrominerals occurring in different formations, many of which are still unknown; cultivation waste; animal waste; in addition to the products and co-products of biological processes present in nature, whose organisms (fungi, bacteria, actinomycetes and mycorrhizae) are capable of promoting plant growth, controlling pests, increasing nutrient absorption efficiency, promoting biological nitrogen fixation, among other functions, will be fundamental for the consolidation of this new agriculture, which is more intensive in knowledge, in detriment of the input of external inputs.

Undoubtedly, there is great expectation from society as to the consolidation of biologically based agriculture and its ability to produce healthy food in a scale sufficient to feed the world population, which is in direct connection with SDG 2. To this end, some challenges emerge to the consolidation of the "third wave" of agriculture, among which the following stand out:

- Review the academic curricula of agricultural and related courses, with greater emphasis on knowledge integration and holistic vision, strengthening the bases for the construction of a mental model of agriculture based on mechanisms and processes to the detriment of that based especially on inputs.
- Expansion of investments in research, development and innovation in strategic areas for the consolidation of biologically based agriculture.
- Extension of the generation of knowledge on the interaction between soil-water-plant-atmosphere-microorganisms based on ecophysiology, chemistry, biochemistry, biology and agro-geology.
- Generation of databases, information, knowledge and technologies (strategic territorial intelligence) associated with sustainable use of waste

and co-products of agro-industrial processes in agriculture on a territorial scale.

- Progress in the generation of data in order to subsidize revisions and changes in the legal and normative framework aiming at expanding the use of biological products and processes in agriculture and guarantee the right of the farmers.
- Expansion and consolidation of Innovation Networks focused on the generation of biologically based assets through public policies and public-private partnerships.

Challenges presented by SDG 2

The launching of the United Nations' Agenda 2030, comprising 17 Sustainable Development Goals (SDG), poses challenges previously known but not yet concretely addressed as an urgent need to ensure the improvement of living conditions of the world population. The SDG analysis reveals its close association with agriculture, where food production and its social, economic and environmental implications are directly or indirectly linked to a significant percentage of established targets. It is, however, under SDG 2, "end hunger, achieve food security and improved nutrition and promote sustainable agriculture" (United Nations, 2018), that agricultural production and the work developed by Embrapa present its greater connection.

In this sense, the work of Embrapa related to the target focused on food and nutritional security of SDG 2, discussed in Chapter 3 of this publication, focuses on its participation in the implementation of public policies related to the topic. Particular attention is paid to the contribution to the Plano Brasil Sem Miséria (Brazil Without Misery Plan) launched in 2011, with a significant volume of actions in the different regions of the country, aimed at increasing the productive capacity of family farming, given its fundamental importance for food production. It should also be noted that the results of the BioFORT Network projects, coordinated by Embrapa, have leveraged the issue of biofortification of food in Brazil and contributed to reduce malnutrition and ensure greater food security for the most vulnerable segments of the Brazilian population. However, it remains a challenge to combine efforts to increase the range of foods contemplated by the nutritional enrichment process, with attention to the demands associated with the food culture of the populations of different regions, given the potential of this action to mitigate the deficiencies of the diet of the poor populations.

The challenge in the SDG 2 target of increasing agricultural productivity and income of small food producers, discussed in Chapter 4, is directly associated with Embrapa's research, development and innovation (R&DI) agenda. The existence of a portfolio of projects that aims to support sustainable development initiatives in family farming and traditional communities reflects Embrapa's concern with this productive segment. However, the convergence of efforts to foster the social and productive inclusion of farmers, traditional peoples and communities, women and young people remains urgent, including, among other things, the development of simple and of easy appropriation technologies and especially the design of a strategy that recognizes the protagonism of these actors in the processes of technology transfer, exchange and knowledge construction, and that results in an effective approximation and interaction of Embrapa with these segments.

The focus on territorial development, taking into account local identity and the possibility of strengthening existing organizational initiatives as a way to achieve a social and productive repositioning, should also be considered as a future perspective in the agenda of Embrapa. Food, cultural and gastronomic diversity and landscape enhancement potential and environmental services will create new opportunities for income generation in the Brazilian countryside, which will establish a new perspective, including young entrepreneurs willing to build more sustainable bases and connections between the expertise, the production of food and the generation of value.

The maintenance of genetic diversity is another target set forth in SDG 2, for which the contribution of Embrapa has undoubtedly been fundamental, but several challenges persist. Among them, the need to promote greater coordination of actions between ex situ conservation and on farm conservation stands out. Therefore, it is fundamental to improve the governance system of germplasm collections of public institutions in order to consolidate shared management strategies that recognize the role of traditional farmers, peoples and communities in the conservation and sustainable use of genetic resources. Another challenge concerns the need to expand the capacity of germplasm banks to respond to the demands of on farm conservation, particularly associated with the recomposition of local diversity. Well-structured communication strategies can also help to disseminate information on existing accesses, expanding possibilities for reintroduction of missing varieties and introducing new varieties into the field.

Considering the impacts of climate change on food and nutritional security of populations and the importance of genetic resources to guarantee the resilience of production systems, it is of fundamental importance that Embrapa expand its research to identify and document the strategic accesses resistant to variations in temperature and in order to be incorporated into their breeding programs. The identification of climate risk areas and of greater vulnerability to the conservation of genetic resources is essential, and, in this regard, the establishment of an observatory for the monitoring of conservation of genetic resources and of agrobiodiversity is recommended, as well as the implementation of a network alert system for risk monitoring.

Ensuring sustainable food production systems and implementing resilient agricultural practices that increase productivity and production that help maintain ecosystems is another issue posed by SDG 2. The intensification and sustainability of production systems are among the mega-trends identified with a strong impact potential for Brazilian agriculture (Embrapa, 2014). The contribution of Embrapa to the generation of technologies oriented to the sustainability of agricultural production is undeniable. Major challenges, however, remain largely associated with the technological breakdown of making production systems less dependent on the use of external inputs. Likewise, the development of biodiverse systems, of greater resilience and stability under the nutritional and sanitary aspects, remains as a bottleneck to be overcome. The advance towards the structuring of systems that are more complex requires the knowledge of the ecological processes prevailing in these agroecosystems, in order to enhance them to improve productivity, given the high degree of ignorance about the most diverse interactions that occur in them. This is undoubtedly a unique scientific challenge that transcends the disciplinary approach of research and that, in order to be overcome, it must have the integrated participation of researchers working in different areas of knowledge.

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