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

Sustainable Development Goal 15

LIFE ON LAND

CONTRIBUTIONS OF EMBRAPA

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Chapter 3

Conservation, recovery, and sustainable use of ecosystems

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Introduction

This chapter presents contributions of the Brazilian Agricultural Research Corporation (Embrapa) to achieve target 15.1 of the Sustainable Development Goal 15 (SDG 15) (United Nations, 2018): "By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and dry lands, in line with obligations under international agreements".

This target relates to deliberations of the *United Nations Conference on Environment and Development*, held in Rio de Janeiro in 1992, which definitely established the theme "sustainable development" as a global public agenda. After this conference and the Intergovernmental Panel on Climate Change – IPCC (created in 1988 and which set the global goals for reducing greenhouse gas emissions), the Convention on Biological Diversity (CBD) and the Convention on Climate Changes were established. These, combined with the Ramsar Convention, adopted in 1971 to protect wetlands, and the Convention to Combat Desertification, adopted in 1994 to fight desertification, form the basis to achieve target 15.1. Rules established in these agreements resulted in a series of governmental actions that motivated projects in Embrapa. Embrapa main actions to comply with these agreements are described below.

Convention on Biological Diversity and biodiversity promotion

Biological diversity is the variety of genes, species, and ecosystems on Earth. Ensuring its conservation, its sustainable use, and the fair distribution of benefits from the use of their genetic resources are the objectives of CBD, which came into force in December 1993, and was ratified by 186 countries, including Brazil.

The core of Embrapa work is within the scope of CBD. In addition to establishing rules for in situ and ex situ conservation and the sustainable use of biological diversity, CBD addresses research, training, education and technological and scientific cooperation and recognizes that investing in knowledge of the biodiversity for the benefit of different sectors such as agriculture, energy, health, and the environment is essential. Actions on research, innovation, education, and training developed at Embrapa revolve around these themes and aim to learn about, conserve, and promote the sustainable use of biodiversity to promote health and social and environmental well-being (Figure 1).

Photo: Fernanda Muniz Bez Birolo

Figure 1. Biotechnology laboratory of Embrapa Semiarid, in Petrolina, PE.

In situ and ex situ conservation of genetic resources

Research for increasing knowledge on and developing technologies using genetic resources from animals, plants, and microorganisms is conducted in most of Embrapa Research Units including not only thematic units (devoted to the advance of knowledge) and regional units (devoted to researching different

Brazilian biomes), but also product units (which seek to develop technical solutions for specific crops or for animal husbandry). All these research studies are focused on the main demands of society.

Embrapa maintains, in its germplasm banks, herbaria, museums and data banks on plants, animals and microorganisms, a large pool of genetic resources for real or potential use, mainly for agriculture and livestock. This collection is available for consultation, exchange, and technological business prospection in Alelo Database. New accesses are added daily after new collections in agricultural areas and natural ecosystems are conducted; subsequently, the characterization and/or bio-prospecting of genes and bioactive molecules are performed. Internally and externally financed projects are focused on the valuation of these resources by developing technologies for human nutrition and for food, phytosanitary, biofertilizer, biofuel, medicine and cosmetic industries, among others (Figure 2).

Thus, new varieties of cultivated plants and improved animal races for increased productivity and resistance to pests, diseases, and abiotic factors such as drought and high temperature are developed. Such technologies support Brazilian agriculture in producing more in smaller areas, thus ensuring the maintenance of native vegetation in most of the national territory. Research on biofuels, biological

Photo: Vivian Chies

Figure 2. Laboratorial research of microorganisms for agro-energy.

control of pests, diseases, and invasive plants sustainably using biodiversity resources contributes to reducing the use of environmentally harmful or polluting agricultural inputs and practices.

Embrapa also conducts research on traditional knowledge in partnership with indigenous peoples, traditional communities, and family farmers aiming at preserving and valuing this knowledge for future generations, as agreed on in CBD (Figure 3).

Photo: Priscila Viudes

Figure 3. Researcher and indigenous person in ethno-knowledge and bio-prospecting identification activities.

Conservation and use of pollinators in agriculture

The fast disappearance of bees around the world before researchers have an extensive knowledge about the environmental services provided by native bees in Brazil has caused concern and discomfort. Great efforts are underway worldwide to conserve the important ecosystemic service of pollination. Joining CBD initiatives, Embrapa supported the creation of the Iniciativa Brasileira de Polinizadores (Brazilian Initiative of Pollinators – BIP), together with the Ministry of Environment (MMA), and the University of São Paulo (USP) in 2000, under the facilitation of the Food and Agriculture Organization of the United Nations (FAO). The purpose was to conduct research on the service provided by pollinators for their conservation and sustainable use (Figure 4).


Photo: Viviane Pires

Figure 4. Bee (*Apis* sp.) pollinating a cotton flower (*Gossypium hirsutum*).

Research networks, co-sponsored by Brazilian funding agencies, were formed to research on diversity, management, and conservation of stingless bees in different biomes and agroecosystems, and to evaluate the impact of pollination service in productivity of native species, such as Brazilian nuts (*Bertholletia excelsa*), and crops as cotton (*Gossypium hirsutum*), tomato (*Solanum lycopersicum*), melon (*Cucumis melo*), and apple (*Malus domestica*).

Subsequently, Embrapa set the theme as a priority by approving the project Conservação de Recursos Genéticos de Insetos Polinizadores (Conservation of Genetic Resources of Pollinating Insects), aiming to preserve, maintain, and enrich the genetic resources of pollinating insects in the Northern, Northeastern, and Southeastern regions of Brazil. Six Embrapa Units work together to maintain conservation cores of 41 species of stingless bees and 4 species of solitary bees. In situ and ex situ conservation actions by means of an insect tissue bank are planned (Motta Maués, 2002; Freitas; Pereira, 2004; Imperatriz-Fonseca et al., 2006; Polinização…, 2013).

Conservation and use of microorganism culture collections

Embrapa coordinates and maintains microorganism collections, including viruses, bacteria, fungi, and protozoans, collected in wetlands, *Caatinga*, *Cerrado*, and Atlantic Forest. In general, collections are organized according to functionalities of microorganisms (such as soil nutrient fixation, bioindication, growth promotion, biological control, antibiotic action, and dye production) or according to their use (such as in rice cultivation and biofuel industry). In addition, there are multifunctional microorganisms of agricultural and environmental importance. These collections are constantly enriched, researched, and prospected so as to promote innovation for agricultural sustainability (Melo; Azevedo, 2008; Mattos et al., 2011; Mattos, 2015).

One of the most emblematic cases is that of co-inoculation of soybean, bean, and sugarcane crops with nitrogen fixing bacteria of the genera *Rhizobium* and *Azospirillum* (Reis Júnior; Mendes, 2007; Schultz et al., 2012; Hungria et al., 2014). These technologies have resulted in reduction of nitrogen fertilizer use, significant increments in productivity and increased resistance to water stress (Figure 5).

Photo: Ana Lucia Ferreira

Figure 5. Nodules of bacteria *Rhizobium* sp. on root of beans (*Phaseolus* sp.)

Biological control

Biological control is an ecosystemic service performed by natural enemies to maintain the balance of populations in natural and managed ecosystems, such as agroecosystems and urban environments, where it is adopted for suppressing animals, plants, and microorganisms regarded as pests, which are harmful to human activities. Natural enemies such as predators, parasitoids, parasites, competitors, and pathogenic microorganisms maintain under control insects and mites that cause damages to crops, as well as plant pathogens and weeds (Figure 6). Biological control allows production of healthier food in a more sustainable way, and the conservation of natural habitats.

Photo: Erika Sevilha

Figure 6. Predatory wasp (*Vespa* sp.) capturing a beetle pest.

Research on biological control is carried out in several Embrapa Units, from North to South of Brazil. Two project portfolios group these research studies: Controle Biológico: Ciência a Serviço da Sustentabilidade (Biological Control: Science in the Service of Sustainability) and Sistemas de Produção de Base Ecológica (Eco-based Production Systems). Examples of technologies developed by Embrapa in this area are products based on entomopathogenic bacteria *Bacillus thuringiensis* for the control of dengue- and malaria-transmitting mosquitoes, and several caterpillar pests of crops such as maize (*Zea* sp.), soybeans (*Glycine* sp.), and cotton (*Gossypium* sp.) (Monnerat et al., 2017).

Cartagena Protocol on Biosafety

The 2003 Cartagena Protocol establishes procedures for the transboundary movement of organisms resulting from modern biotechnology aiming to ensure that the transport, transfer, handling, and use of these organisms have no adverse effect on the conservation and sustainable use of biological diversity, also considering human health. The Brazilian Biosafety Law (11,105 of 2005) and normative rules of the Comissão Técnica Nacional de Biossegurança (National Biosafety Technical Commission – CTNBio) guide the Cartagena Protocol implementation in Brazil.

Before the implementation of the Protocol, in the 1990s, Embrapa already aimed at reaching a suitable level of safety in its projects with genetically modified organisms (GMOs) and contributed with technical inputs for discussions on the development and approval of Brazil's first law on biosafety at the Brazilian House of Representatives, in 1995. The current law replaced this Law in 2005. Since then, Embrapa experts act at CTNBio and take part in international negotiations of the Cartagena Protocol providing a specialized technical contribution to the Ministry of Foreign Affairs.

Embrapa trained specialists on biosafety to do research and work with public policies as part of two (a national and an international) major projects. By technically training professionals and students from several Brazilian institutions, methodologies to assess environmental and food risks of GMOs were developed and improved; currently, they are widely used in Brazil and abroad by research, inspection, customs control, monitoring and public policy planning authorities.

Embrapa was the first public company in the world to develop and certify the safety of genetically modified transgenic crop varieties: beans resistant to the golden mosaic virus and soybeans tolerant to herbicides from imidazoline group.

Nagoya Protocol on Access to Genetic Resources

Approved in 2014, the Nagoya Protocol establishes rules for sharing benefits arising from the use of genetic resources and associated traditional knowledge of indigenous peoples, traditional and local (*quilombola*, *caiçara*, and rubber tapper) communities, and family farmers.

Brazil is home to the largest biodiversity on the planet, with more than 20% of all species on Earth, which corresponds to about 1.8 million varieties of plants, animals, and microorganisms. This biodiversity, known as genetic heritage

(GH), generates countless benefits to humanity as a source of food, fuel, fibers, medicines, and raw material for industrial products. It is the raw material for bio-economy that is of enormous importance in this century. Biological richness is within these organisms or on their barks, leaves, roots, hairs, feathers, skins, etc. It is also in substances produced by them such as resins, latex, poison, and chemical substances. This valuable Brazilian heritage is protected by Law 13,123/2015 (Brasil, 2015a) and ruled by the Conselho de Gestão do Patrimônio Genético (Genetic Heritage Management Council – CEGEN).

To comply with the objectives of CBD, Brazil adopted a provisional measure in 2001 to regulate the access to genetic resources. Since then, Embrapa experts have been playing a main role in debates on the theme within decision-making bodies, such as technical committees, and acting as counselors in CEGEN, by offering technical input. Law 13,123/2015, developed with Embrapa researchers active involvement, substituted the provisional measure. Furthermore, these researchers contributed in international negotiations within the Nagoya Protocol.

Nagoya Protocol covers all genetic resources but acknowledges the autonomy of the International Treaty on Plant Genetic Resources for Food and Agriculture (IT PGRFA), developed within the framework of FAO. Most research studies developed at Embrapa are within the scope of IT PGRFA, but many projects must also meet the requirements of the Nagoya Protocol and the Brazilian Law on Access to the Genetic Heritage (Brasil, 2015). Such research studies involve accessing the genetic heritage, such as using genetic information contained in samples of plants, animals, microorganisms or substances extracted from them to study what they are made of, to test what they are useful for or to develop marketable product or process, such as medicines, perfumes, and cosmetics (Figure 7). The result of these studies contributes to developing new products, many of which are patented. The marketing of these products results in benefits that should be shared with genetic resource providers, that is, the Brazilian State representing the people in general or traditional and local peoples and communities who are holders of traditional knowledge.

Between 2010 and 2016, Embrapa maintained a major project to implement regulations of access to genetic heritage. Workshops were organized in different Embrapa Research Units to train technicians and researchers in order to raise their awareness and enable them to duly and correctly follow the law.

At the same time, genetic resource collections belonging to other institutions and kept by Embrapa in its germplasm banks, conservation nuclei, and biological

Photo: Zineb Benchekchou

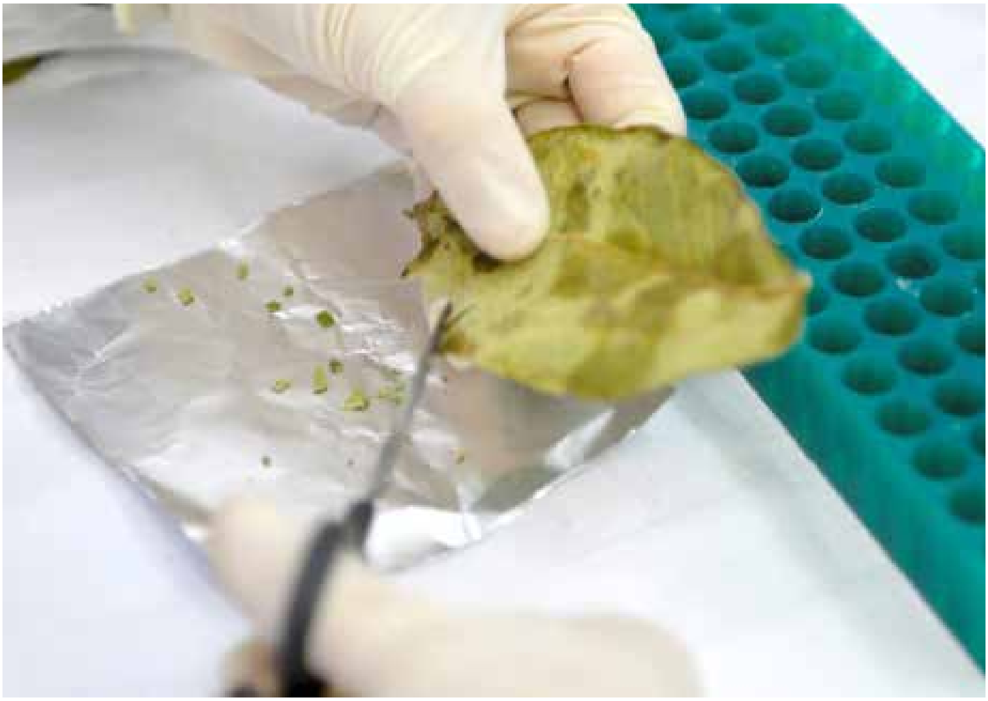

Figure 7. DNA extraction in Plant Genetic Laboratory at Embrapa Genetic Resources & Biotechnology.

collections were regularized (Figure 8). By offering training for its employees, Embrapa becomes a strong player in the regulatory environment and is able to provide expert inputs to its public-and-private-sector partners, as well as to governmental, legislative, and educational authorities, thus effectively contributing to the development, consolidation, and application of the Law on Access to the Genetic Heritage and, consequently, of the Nagoya Protocol.

Conventions on climate change and their protocols

Global mobilization to face climate changes started in 1992 when 197 countries acceded to an international treaty to combat climate changes, the United Nations Framework Convention on Climate Change (UNFCCC). Its purposes were to limit global temperature average increases and the resulting climate change and to deal with the impacts arising from them. In 1995, the countries (called Parties) adopted the Kyoto Protocol so as to strengthen the global response to climate changes.

Photo: Ronaldo Rosa

Figure 8. Plant tissue propagation in a laboratory at Embrapa Eastern Amazon.

Kyoto Protocol and Paris Agreement

Kyoto Protocol legally binds the parties of developed countries to gas emission reduction targets. The first commitment period started in 2008 and ended in 2012. The second period started in 2012 and will end in 2020. Out of 197 countries that are currently taking part in the convention, 192 ratified the protocol.

The Paris Agreement, approved in December 2015 at the *21st Conference of the Parties (COP 21)*, marks the latest steps in the development of UN's climate change regime, creating a historical momentum to make climate change one of the main focuses in the development agenda. The Paris Agreement seeks to intensify actions and investments necessary for a sustainable future, with low carbon emission. Its main purpose is to strengthen the global answer to the threat of climate change, keeping the increase in global temperature well below 2.0 °C in this century as compared to pre-industrial levels, and pursuing efforts to limit temperature rise to 1.5 °C.

Paris Agreement requires that all parties present their best efforts through nationally determined contributions (NDCs). This requires that all parties report regularly on their emissions and their implementation efforts. Most developing countries have opted to include an adaptation component in NDC, alligning their national long-term development priorities and zero-emission pathways with SDG targets.

The practices and agricultural, technological, and knowledge systems described below are examples of how Embrapa has acted to fulfill these commitments.

Good agricultural practices

Good agricultural practices (GAP) are a set of rules and standards that farmers shall comply with; in addition to making production systems more profitable and competitive, GAP ensure safe food production (Figure 9). By adopting good practices in husbandry based on recommendations of the book *Boas Práticas Agropecuárias – Bovinos de Corte* [*Good Agricultural Practices – Beef Cattle*] in Mato Grosso farms, a 25% decrease in greenhouse gas emissions from pastures and 60% from beef production were possible (SF Agro, 2016).

Embrapa and partners have being developing awareness-raising actions for farmers and training multipliers in quality control protocols for GAP. This not only

Photo: Paulo Kurtz

Figure 9. Good agricultural practice: no-till farming on straw.

results in more competitive production systems due to a consolidated domestic market and expanded possibilities to gain new markets that value high quality beef and leather, but also contributes to fulfilling Brazil's commitments within the Paris Agreement.

Integrated Crop-Livestock-Forest Systems

Embrapa developed integrated crop-livestock-forest systems (ICLF) based on the proper management of crops and pastures so as to provide a substantial increase in production, specially in cases of recovering degraded or low-production areas (Balbino et al., 2011). By adopting these systems, it is possible to avoid opening of new areas, which promotes environmental benefits (such as protection of native vegetation, and soil and water resources conservation), and regional socioeconomic development (Figures 10 and 11). Growing grains, pasture, and forests contributes to the sequestration of atmospheric carbon dioxide (CO_2) via photosynthesis and subsequent incorporation in the form of organic matter to the soil. It is also possible to reduce the age at which animals are slaughtered by improving production processes; feeding them with appropriated diet reduces methane emission per product unit, thus contributing to mitigate agricultural greenhouse gas emissions.

The systemic conception of this strategy also incorporates other desirable attributes to the agroecosystem concerning its environmental suitability, such as the maintenance of Permanent Preservation Areas (PPAs) and Legal Reserve Areas (LRA). Thus, the environmental services provided by PPAs and LRAs benefit production systems.

Agricultural zoning of climatic risk

The agricultural zoning of climatic risk (AZCR) is an instrument for agricultural policy and risk management in agriculture. It is a technology developed to minimize risks related to adverse climatic phenomena. It allows each municipality to identify the best time for planting crops for each soil type and cultivar cycle.

Farmers, financing agents, and other users can easily understand and adopt this technology. In designing AZCRs, parameters of climate, soil, and cultivar cycles are analyzed using a methodology validated by Embrapa and adopted by the Ministry of Agriculture, Livestock and Food Supply (Mapa). Thus, climatic risks involved in crop production that can cause severe losses in production can be quantified, thus strengthening the capacity of farmers to deal with the impacts of climate change.

Photo: Gabriel Rezende Faria

Figure 10. Cattle under integrated crop-livestock-forest system.

Photo: Síglia Regina Souza

Figure 11. Sheep under integrated crop-livestock-forest system.

Monitoring of the dynamics of land use and land cover

TerraClass is a project whose purpose is to deliver, every 2 years, in figures and explicit spatial schemes, systematic maps referring to land use and coverage in all deforested areas of the Brazilian Legal Amazon, identified by the Projeto de Monitoramento do Desmatamento na Amazônia Legal por Satélite (Project for Monitoring Deforestation in the Legal Amazon via Satellite – Prodes) (also see Chapter 4 on this topic).

Promotion of renewable energy sources

The Brazilian energy matrix is notable for its large share of renewable sources. In 2016, renewable sources represented 43.5% of the energy matrix in Brazil, while the world average was 14.2% (Resenha..., 2017). Solely considering renewable biomass sources, biomass derivatives of sugarcane (*Saccharum* sp.) are predominant (40.1% – ethanol and sugarcane bagasse), followed by firewood and charcoal (18.4%), and biodiesel (2.4%). Biomasses contribute as much for generating electric power, which is the case of sugarcane bagasse, as for supplying vehicle fuels. The use of biofuels for vehicles effectively started by means of public policies with the Programa Nacional do Álcool (National Alcohol Program – Proálcool) in 1975 (Resenha..., 2017) and the Programa Nacional de Produção e Uso do Biodiesel (National Program for the Production and Use of Biodiesel – PNPB) in 2005 (Programa..., 2005). Embrapa has played a fundamental role in supporting these programs by offering technologies for producing saccharine and oilseed plants, which are required for the generation of these biofuels.

Among these contributions, stood out actions led by Embrapa Agrobiology and Embrapa Soybean in the understanding of biological nitrogen fixation in sugarcane and soybeans (*Glycine* sp.), resulting in production systems with less use of nitrogenous fertilizers and reduced greenhouse gas emissions.

Another crucial point to promote the continuity and improvement of production systems are biological collections kept by Embrapa to support breeding programs. For crops arising from traditional oilseed plants, Embrapa Soybean Active Germplasm Bank, which maintains over 35 thousand different accesses, can be mentioned. In addition, there are collections of species that are under the process of domestication, such as Embrapa Cerrados Active Germplasm Bank of Macaúba Palm Tree (*Acrocomia* spp.) (Figure 12), with around 450 accesses.

Photo: Simone Favaro

Figure 12. *Macaúba* palm tree (*Acrocomia* spp.), perennial oilseed species under domestication by Embrapa Cerrados.

More recently, Embrapa has also been active in industrial processing. Embrapa Agroenergy is leading projects to optimize fermentation processes of saccharine biomasses for first and second generation ethanol production; processing technologies for oilseed species with higher energy density than soybeans; technological routes for biodiesel production; and use of coproducts (Geração..., 2013). In addition, Embrapa has contributed to the sustainable production of dynamic forests, such as the development of ICLF systems to supply woody biomass.

Another relevant segment is the use of residues of animal production for generating biogas and microgenerating electric power. Embrapa Swine & Poultry leads this work in partnership with Usina Binacional de Itaipu.

Ramsar Convention and wetland protection

The Ramsar Convention was negociated in the 1960s and signed in 1971 to pursue "the conservation and wise use of wetlands through national actions and international cooperation as a contribution towards achieving sustainable development throughout the world." It was originally created to preserve transboundary wetlands, which shelter waterbird species, and its current concept is based on three principles. Contracting parties shall commit to:

- Work towards the wise use of all wetlands.
- Place suitable wetlands onto the List of Wetlands of International Importance (the list of Ramsar Sites).
- Cooperate internationally on transboundary wetlands.

In Brazil, the convention was ratified in 1993 and formalized by Federal Decree in 1996. The Comitê Nacional de Áreas Úmidas (Wetlands National Committee – CNZU), representing the Ramsar Convention in Brazil, defines these areas as "ecosystems at the interface between terrestrial and aquatic, continental or coastal, natural or artificial environments, permanently or periodically flooded or with soaked soils" (Brasil, 2015b), and defines the extent of a wetland area by the limit of a shallow flooding or permanent or regular waterlogging, or in the case of areas susceptible to flood pulses, by the limit of reach of maximum average floods, including, if any, permanently dried areas within them, habitats which are vital for the maintenance of their functional integrity and biodiversity." Their outer limits are indicated by hydromorphic soil and/or permanent or regular presence of hydrophytes and/or woody species adapted to permanently soaked soils" (Junk et al., 2014). Brazil lists 22 Ramsar sites, with a total area of 8,783,614 ha.

Embrapa works on several themes contribute to the SDGs. Among them are research studies directly involving one of Brazil's biomes: *Pantanal* (Figure 13). Embrapa Pantanal has being conducting research on the characterization, mapping, use, and sustainable production of natural resources in *Pantanal*, management of native fauna and flora, traditional management of livestock, recommendations and direct actions to control invasive species and others threats to the biome, its wetlands and the Ramsar sites located there (Jongman, 2005; Crispim et al., 2017; Oliveira et al., 2017; Santos; Cardoso, 2017). In Brazilian wetlands, Embrapa researches, develops and proposes innovations on products, technologies, and methods of use, production, and sustainable management. Themes such as adapted and improved cultivars [açaí (*Euterpe* sp.), and rice (*Oryza* sp., etc.)], sustainable production, greenhouse gas emissions from ecosystems and/or agroecosystems, and provision of ecosystem services are other topics addressed (Queiroz; Mochiutti, 2012; Silva et al., 2017; Winckler et al., 2017).

Photo: Sérgio Galdino

Figure 13. *Pantanal*: one of the largest wetlands on the planet.

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