SUSTAINABLE DEVELOPMENT GOAL 12

# RESPONSIBLE CONSUMPTION AND PRODUCTION

## CONTRIBUTIONS OF EMBRAPA

Julio Cesar Pascale Palhares
Vânia Beatriz Vasconcelos de Oliveira
Murillo Freire Junior
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Technical Editors


Embrapa

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

**Sustainable Development Goal 12**

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Translated by
*Paulo de Holanda Morais*

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**Embrapa**
Parque Estação Biológica (PqEB)
Av. W3 Norte (Final)
70770-901 Brasília, DF, Brazil
Phone: +55 (61) 3448-4433
www.embrapa.br
www.embrapa.br/fale-conosco/sac

**Unit responsible for the content**
Embrapa, Intelligence and Strategic Relations Division

Technical Coordination of SDG Collection
*Valéria Sucena Hammes*
*André Carlos Cau dos Santos*



**Unit responsible for publication**
Embrapa, General Division

Editorial Coordination
*Alexandre de Oliveira Barcellos*
*Heloíza Dias da Silva*
*Nilda Maria da Cunha Sette*

Editorial Supervision
*Josmária Madalena Lopes*

Translation Revision
*Letícia Ludwig Loder*

Bibliographic Standardization
*Rejane Maria de Oliveira* (CRB-1/2913)

Translation
*Paulo de Holanda Morais*
(World Chain Idiomas e Traduções Ltda.)

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*Carlos Eduardo Felice Barbeiro*

Image Processing
*Paula Cristina Rodrigues Franco*

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*Rejane Maria de Oliveira* (CRB-1/2913) 

# Authors

**André Luiz Lemes Alarcão**
Agronomist, master's degree in Administration, analyst at the Institutional Management Executive Directorate, Brasília, DF, Brazil

**Antonio Eduardo Guimarães dos Reis**
Agronomist, doctoral degree in Water Resources, researcher at Embrapa, Brasília, DF, Brazil

**Antonio Flavio Dias Avila**
Agronomist, doctoral degree in Rural Economics, researcher at Embrapa, Brasília, DF, Brazil

**Antonio Gomes Soares**
Chemist, doctoral degree in Food Sciences, researcher at Embrapa Food Technology, Rio de Janeiro, RJ, Brazil

**Antônio Luiz Cerdeira**
Agronomist, Ph.D. in Biochemistry, researcher at Embrapa Environment, Jaguariúna, SP, Brazil

**Bianca Baccili Zanotto Vigna**
Biologist, doctoral degree in Genetics and Molecular Biology, researcher at Embrapa Southeastern Livestock, São Carlos, SP, Brazil

**Caroline Machado V. Turazi**
Agronomist, master's degree in Agricultural Studies, researcher at the Innovation and Business Division, Embrapa, Brasília, DF, Brazil

**Daiva Domenech Tupinambá**
Pharmacist, doctoral degree in Genome Sciences and Biotechnology, analyst at the Institutional Development Division, Embrapa, Brasília, DF, Brazil

**Elizabete Antunes**
Journalist, specialist in Scientific Dissemination, analyst at the Innovation and Business Division, Embrapa, Brasília, DF, Brazil

**Gustavo Porpino Araújo**
Journalist, doctoral degree in Business Administration, analyst at the Innovation and Business Division, Embrapa, Brasília, DF, Brazil

**Henrique Nery Cipriani**
Forest engineer, master's degree in Soils and Plant Nutrition, researcher at Embrapa Rondônia, Porto Velho, RO, Brazil

**Hércules Antonio do Prado**
Data processing technologist, doctoral degree in Computer Science, analyst at the Institutional Development Division, Embrapa, Brasília, DF, Brazil

**Joanne Régis Costa**
Biologist, master's degree in Ecology, researcher at Embrapa Western Amazon, Manaus, AM, Brazil

**Juliana Escobar**
Journalist, doctoral degree in Sociology, analyst at the Intelligence and Strategic Affairs Division, Embrapa, Brasília, DF, Brazil

**Julio Cesar Pascale Palhares**
Zootechnician, doctoral degree in Environmental Engineering Sciences, researcher at Embrapa Southeastern Livestock, São Carlos, SP, Brazil

**Marcelo Augusto B. Morandi**
Agronomist, doctoral degree in Phytopathology, researcher at Embrapa Environment, Jaguariúna, SP, Brazil

**Marília Ieda da Silveira Folegatti Matsuura**
Zootechnician, doctoral degree in Food Technology, researcher at Embrapa Environment, Jaguariúna, SP, Brazil

**Murillo Freire Junior**
Agronomist, doctoral degree in Food Sciences, researcher at Embrapa Food Technology, Rio de Janeiro, RJ, Brazil

**Neudes Carvalho da Silva**
Administrator, analyst at Embrapa Roraima, Boa Vista, RR, Brazil

**Rachel Bardy Prado**
Agronomist, doctoral degree in Environmental Engineering Sciences, researcher at Embrapa Soils, Rio de Janeiro, RJ, Brazil

**Ramon Augustus de Lima Menezes**
Accountant and lawyer, specialist in Public Accounting, analyst at the Institutional Management Executive Directorate, Embrapa, Brasília, DF, Brazil

**Robson Rolland Monticelli Barizon**
Agronomist, doctoral degree in Soils and Plant Nutrition, researcher at Embrapa Environment, Jaguariúna, SP, Brazil

**Rosana Guedes C. Ramos**
Mathematician, master's degree in Knowledge Management and Information Technology, analyst at the Innovation and Business Division, Embrapa, DF, Brazil

**Ronessa Bartolomeu de Souza**
Agronomist, doctoral degree in Soils and Plant Nutrition, researcher at the Innovation and Business Division, Embrapa, Brasília, DF, Brazil

**Sylvia Morais de Sousa Tinoco**
Biologist, doctoral degree in Genetics and Molecular Biology, researcher at Embrapa Maize & Sorghum, Sete Lagoas, MG, Brazil

**Vânia Beatriz Vasconcelos de Oliveira**
Communication scientist, master's degree in Rural Extension, researcher at Embrapa Rondônia, Porto Velho, RO, Brazil

# Foreword

Launched by the United Nations (UN) in 2015, 2030 Agenda for Sustainable Development is powerful and mobilizing. Its 17 goals and 169 targets 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 of 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 by 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 relationships

between public, private, and civil society. As such, this collection brings diverse views on the potential contributions to different objectives and their interfaces. This vision is not homogeneous; sometimes it can be conflicting, just as is society's vision about its problems and respective solutions, a wealth which is 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

This book addresses sustainable goods and services consumption, defined here as goods and services use that serves the basic needs, providing a better quality of life, and reduces the use of natural resources and toxic materials, waste production, and pollutant emission throughout the product or service life cycle, so as to not jeopardize the needs of future generations.

Thus, this publication addresses the 11 targets of Sustainable Development Goal 12 (SDG 12), presented in the following chapters: Environmental realities and sustainable consumption; Concepts and realities in agricultural research: sustainable consumption; Cost-effective natural resources management; Food loss and waste; Responsible chemicals handling; Solid waste management for rural and urban sustainability; Responsible consumption: ensuring production and sustainable consumption standards; Sustainable procurement; Civic action information and sustainable development promotion; Progress and future challenges.

The challenges of Brazilian research on agriculture and livestock on behalf of sustainable development are numerous, including organizing all knowledge created into a system, method standardization and integration, transformation of knowledge into solutions to be directly used by society, appropriate financial resources, bringing scientists and decision makers closer together, among others. Embedded in its mission, the Brazilian Agricultural Research Corporation (Embrapa) seeks to contribute to sustainable development of agriculture based on its research results.

*Technical Editors*

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Chapter 1

# Environmental realities and sustainable consumption

Julio Cesar Pascale Palhares
Rachel Bardy Prado
Gustavo Porpino Araújo

## Introduction

In the history of mankind, economic activities have never withstood so much environmental, social, and economic pressure as in present days. This pressure has demanded changes in the structures of natural and human resources management, technology standards, business approaches, and social values in light of economic and environmental aspects. According to scientists, we are living in the Anthropocene era, in which humans become the most important geological power to influence the planet. Through economic activities, humans have moved more sediments than all the rivers in the world, the planet has warmed, the sea level has risen, the ozone layer has been degraded, and the oceans have been acidified (Monastersky, 2015). Birkmann (2000) points out that one must acknowledge that the economy is a subsystem of society, as society is a subsystem of the ecosystem. The subsystems cannot outgrow the general system without damaging it.

## Environment and sustainable consumption

A reality to be considered is the one presented on the United Nations report *2017 Panorama of Food and Nutrition Security* (Panorama..., 2017). The publication shows that, after a constant decline for over a decade, hunger around the world is on the rise again, fueled by conflicts and climate changes. In 2016, hunger affected 815 million people, or 11% of the global population. Specifically in Latin American countries, there was a 2.8% reduction in the number of people facing hunger, and in Brazil there was a 2.0% reduction. The United Nations (UN) concludes that, in order to reach the Sustainable Development Goals (SDG), approaching the full complexity of food security is mandatory, which demands a holistic approach of all forms of malnutrition, one that takes into account the productivity and

revenues of the farmers, the resilience of production systems and the sustainable use of biodiversity (Panorama..., 2017).

According to the UN, by 2030, the world population will be of 8.6 billion, which represents a 1.3 billion people increase from 2017 to 2030. Given that population growth is mainly concentrated in developing countries such as India, Nigeria, Ethiopia, Indonesia and Pakistan, the challenge of ensuring global food security is even greater due to regions with higher birth rates not being self-sufficient in food production. Therefore, the demand for fibers, energy, food, and water should increase, mainly in countries that are still food importers.

These realities and prospects indicate likely scenarios of natural resources shortage in quantity and quality; human migrations due to environmental reasons and wars; shortage of skilled workforce to operate technological tools in use and those that will be developed, especially in developing countries; poverty reduction, but an increase in the social gap between the poor and the rich. The countries and/or their regions with greater rural poverty, malnutrition, and food insecurity are also often those with the highest levels of environmental degradation. This situation demands approaches and integrated management of production systems that simultaneously preserve ecosystem services and encourage greater investment in strategies to improve land use and water resources (Vries et al., 2002).

Impacts of these realities and scenarios on the agricultural sectors are stronger and possibly more intensive than on industrial and service sectors because they are more open and primary economy systems; therefore, they are more susceptible to climate change, quantitative and qualitative shortage of renewable and non-renewable natural resources, and social impacts of the growing urbanization of societies, which leads to lack and/or high cost of workforce. What makes agriculture unique as an economic activity is the fact that it can affect directly all of the assets on which it depends. These assets are: the nature, the social, the human, the physical and the financial capital. The lower the inventory of these assets is, the greater the environmental, social, and economic fragility of agricultural activities, and the lower the resilience of production systems will be.

Agrifood system sustainability is not limited to internalizing the concept in production systems; promoting and practicing sustainable consumption is also necessary.

Given this scenario, the most viable alternative to reconcile global demands and supply capacity for natural resources is sustainable consumption and production, which is summed up in Sustainable Development Goal 12 (SDG 12).

According to the United Nations Environment Programme (Programa das Nações Unidas para o Meio Ambiente, 2015, p. 21, our translation), sustainable consumption is defined as:

> [...] the use of goods and services that serve the basic needs, providing a better quality of life while minimizing the use of natural resources and toxic materials, waste production, and pollutant emission throughout the life cycle of the product or service, so as not to jeopardize the needs of future generations.

Sustainable production is defined as: "the incorporation, throughout the life cycle of goods and services, of the best alternatives possible to minimize environmental and social costs" (Programa das Nações Unidas para o Meio Ambiente, 2015, p. 21, our translation).

In 2012, during *Rio+20*, the program on sustainable consumption and production was approved. This is effective until 2022, and one of its aims is to promote fundamental changes in the way societies produce and consume so that global sustainable development can be achieved. To this end, all countries must foster sustainable consumption and production standards.

The United Nations Environment Programme (Programa das Nações Unidas para o Meio Ambiente, 2015) highlights that sustainable production and consumption are holistic approaches to minimize the negative environmental impacts of production and consumption systems and presents three main objectives:

- Disentangling environmental degradation and economic growth – doing more and better with less, thus increasing welfare gains from economic activities, reducing the use of natural resources and degradation and pollution throughout the life cycle of the product, i.e., a greater delivery of goods and services with less impact.
- Fostering the life-cycle approach – improving sustainable management and achieving resource use efficiency throughout the production and consumption phases of the product, including resource extraction, production of intermediate supplies, distribution, marketing, use, waste disposal and reuse of products and services.

- Creating opportunities adapted to the realities of developing countries – providing proper conditions for the creation of new markets and decent jobs and enabling technological leaps, bypassing inefficient, polluting and ultimately costly development phases followed by most developed countries in the past.

## Final considerations

In developed countries, many government and private policies and actions are in force for sustainable consumption and production, with well-defined goals for reducing waste production, recycling and reusing them, enhancing the production and consumption of organic and sustainable food, among others. However, in developing countries, the challenges are enormous because of the population's low levels of education and awareness, overexploitation and waste of natural resources at different levels of production chains, insufficient investments in policies, programs and research, corruption and disconnected public policies whose implementation and inspection are seriously difficult.

Brazil has the Action Plan for Sustainable Production and Consumption (Brasil, 2011). This plan proposes actions for the government, the productive sector, and the society that lead the country to more sustainable production and consumption standards. The objective of the plan is to promote policies, programs, and actions for sustainable production and consumption in the country, aimed at improving solutions to social and environmental problems, in accordance with national policies for poverty eradication and sustainable development, along with international commitments made by Brazil. Promoting sustainable agriculture and livestock is among its 15 priorities. For the 2016-2020 implementation cycle, the following stand out: sustainable consumption, sustainable agriculture, sustainable public procurement, solid waste management and sustainability reporting.

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Chapter 2

# Concepts and realities in agricultural research: sustainable consumption

Julio Cesar Pascale Palhares

## Introduction

It is increasingly evident that approaching agricultural growth not taking the limits of ecosystems into consideration has reached critical levels of environmental impact and that costs of environmental service losses are no longer bearable (Ecosystems..., 2005; Kitzes et al., 2008). Agriculture can negatively affect the environmental balance by inefficiently using natural resources and/or by using them (water, soil and air) as receptors for pollutants and contaminants. These facts are economically defined as negative externalities because they are not taken into consideration by the markets and, therefore, their costs are not part of product prices (Dobbs; Pretty, 2004; Moss, 2008).

Agricultural activities, like any other human activity, are potential environmental pollutants. Therefore, they must include environmental management as a routine in order to maintain and preserve natural resources. Nowadays, there is information, knowledge, and technologies to reduce potential negative impacts and mitigate their effects. Therefore, agricultural research is already contributing and will continue to contribute to sustainable agricultural activities in the future.

## Knowledge-inducing sustainable consumption

As well as advances in knowledge, there are other advances that must be agreed upon by all agents involved in food production in order to achieve a sustainable future faster. These challenges involve the understanding of concepts and realities often not understood by all. According to Pretty (2008), the lack of knowledge and management are the main obstacles for the establishment of sustainable agriculture. During the transition period from conventional to more sustainable systems, farmers should experiment more and therefore will be subject to the costs of making mistakes.

There is no research that reveals the information quality and the society's perceptions on the concept of sustainable development, but considering the way

the concept is addressed by consumers, it can be said that the lack of information reaches a significant part of these people, resulting in distortions of the concept and its application in the productive processes.

The concept of sustainable development appears for the first time in the Report of the World Commission on Environment and Development (1987). In *Our Common Future*, published in 1987, resulting from the work done by this committee, it can be read that:

> Our report [...] is not a prediction of ever increasing environmental decay, poverty and hardship in an ever more polluted world among ever decreasing resources. We see instead the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base. And we believe such growth to be absolutely essential to relieve the great poverty that is deepening in much of the developing world.

Analyzing the paragraph and our reality, we can state that the world is more polluted and with less environmental resources available; economic growth took place with no attention to natural resources preservation and conservation and poverty mitigation. There has been an economic rise of thousands of people in developing countries, not because of a social issue, but rather to increase the base of potential consumers without caring for the basic conditions for their quality of life (education, healthcare, housing, etc.).

In *Our Common Future* (World Commission on Environment and Development, 1987, p. 57), the bases for sustainable development are:

- A political system that secures effective citizen participation in decision making.
- An economic system that is able to generate surpluses and technical knowledge on a self-reliant and sustained basis.
- A social system that provide for solutions for the tensions arising from disharmonious development.
- A production system that respects the obligation to preserve the ecological base for development.
- A technological system that can search continuously for new solutions.

- An international system that encourages sustainable patterns of trade and finance.
- An administrative system that is flexible and has the capacity for self-correction.

In Brazil, poverty and social inequality are still significant and made worse due to class prejudice; literacy for all and quality education are long-term goals yet to be achieved; corruption, violence and slavery-like working conditions are day-to-day themes; land tenure and land reform are issues of little interest to governments and to a large part of society. Countless national characteristics attest that we are still far from having a sustainable consumption or production, and therefore we must act in the present to secure the future.

Taking into consideration the concept of sustainable development and its premises and the Brazilian and world situations, it can be stated that we are still far off from the long-awaited sustainability. The first step towards it is to know its real meaning.

## Water and agriculture: water resources as foundation for food production

Even though Brazil has large reserves of fresh water, including the majority of the world's largest aquifer – the Guarani Aquifer, the country is subject to non-homogeneous water distribution in space and throughout the year. Additionally, population concentration and water demand vary. Income distribution, water management, the amount of investments in infrastructure and human resources and other socioeconomic aspects may also impact water resources availability. These natural and social differences have been responsible for water scarcity events in the country.

It is a challenge for agriculture to demonstrate to Brazilian society that the production of the food it consumes can occur under water conservation practices in terms of quantity and quality. Having information, from the simplest ones, such as the water volume used to produce a kilogram of soy or beef, to the most complex ones, such as the water limits of a certain farm, region and country, will determine the safety and the water independence for productions, society and the country. It is worth highlighting that it is not enough to have only the information, for these must be worked to generate knowledge, which will lead to

water resources management. Therefore, extreme events, such as droughts, will have a smaller impact on our production, markets and society.

Agriculture agents know the importance of water for their activities, but this knowledge has not been translated into management, actions, programs, etc., that seek use efficiency and resource management. It is still very difficult to answer how efficient and productive (in terms of water) a certain food is. Measuring water consumption to produce a kilogram of fertilizer, seed, corn or milk should be an increasingly routine practice, since it will be an increasingly common question of Brazilian society. Food production is composed of several consumptions along its production chain. Managing these various consumptions, detecting points of water inefficiency, relating consumption to quantitative and qualitative availability, and finally proposing actions that aim at sustainable water use is a complex act, depending on the use of different methods.

## Final considerations

The myth that technology can solve all environmental problems resulting from human activities persists. This blind faith in technology is defined here as techno-idolatry,

> [...] the belief that the use of technology is the best option that can mitigate all negative environmental impacts that an activity can cause. It should be emphasized that, in this concept, technology is understood exclusively as an artifact that can be acquired only at the expense of financial resources, such as machines, products, etc. This is a limited use of the word. (Palhares, 2015, our translation).

The World Bank's recent report, Digital Dividends (Digital..., 2016), reveals that, despite advances in technology, the world has not been able to solve many of its structural problems. Digital technologies have the potential to promote development through three mechanisms: inclusion, efficiency and innovation. However, by crossing living conditions data with information on access to new media, it is clear that their ability to promote structural change does not necessarily correspond to this potential. The study data show that changes in productivity growth, fight against inequality, and democratic governance are still global challenges. Technology is and will always be an efficient and effective tool that must never be ignored, but overcoming environmental, social and

economic challenges will come from new scientific and social approaches based on theoretical and action frameworks of changing human behavior patterns and actions (Digital..., 2016).

Many are the likely paths to agricultural sustainability. This implies that there is no single configuration of technologies, practices and environmental management that is more widely applicable than the other. Agricultural sustainability insists on the need to adapt production specificities to the circumstances of different production systems (Pretty, 2008).

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Chapter 3

# Cost-effective natural resources management

Julio Cesar Pascale Palhares
Rachel Bardy Prado
Bianca Baccili Zanotto Vigna
Sylvia Morais de Sousa Tinoco

## Introduction

This chapter presents contexts and problems on several aspects related to target 2 of Sustainable Development Goal 12 (SDG 12), which refers to "Achieving sustainable management and efficient use of natural resources by 2030". It also describes and discusses the main products, processes and services that the Brazilian Agricultural Research Corporation (Embrapa) has made available to agroindustrial chains and to Brazilian society, in order to contribute to the target achievement and to input provision for indicators assessment. They were divided into the following themes: water use efficiency in agriculture, soil conservation, efficient plant genetic resources use, fertilizer use, and systemic product and process assessments.

## Contexts and problems

The Millennium Ecosystem Assessment (Ecosystems..., 2005) has warned the world about its dependence on natural capital and has identified that ecosystem services have degraded more rapidly and profoundly over the last 50 years than in any other analogous period in the history of mankind. The assessment anticipates further declines for the coming decades, especially in the light of population growth, economic expansion, and global climate changes.

Sustainable consumption and production mean doing more and better with less. It is about decoupling economic growth from environmental degradation, thus increasing the efficiency of natural resources use and promoting sustainable lifestyles.

However, sustainable consumption and production cannot happen without information. How can we say that we have a sustainable agriculture if we do not

have information about each of its productive activities, if the little information available is not used to produce knowledge and make decisions, and if, according to some agents, providing information can be understood as an impediment to the planning and implementation of its productive activities? There is nothing to be handled and managed without information. The complexity of agriculture, combined with a lack of information flow among researchers, professionals, policy makers, and consumers, exacerbates the difficulties of having sustainable consumption and production.

Agricultural activities demand different types of renewable and nonrenewable natural resources and are directly related to several ecosystem services (water supply, formation and cycling of soil nutrients, pollination, erosion and pest control, etc.). Brazil has many of these resources in quantity and quality. Therefore, because of these assets, Brazil stands out from other countries. Using these assets based on sustainable management and focusing on use efficiency, will result in their conservation and continuity, and in Brazil holding its position as a major food producer for its population and the world with a unique focus on nature and human capital valuation. However, unplanned and inefficient use will lead to environmental degradation and production migration, with environmental, social and economic conflicts as liabilities.

## Water as an asset

Global water scarcity has been reason for concern and discussion at different levels of society. By 2030, global demand for food will grow by 50% and for fresh water by 30%. Even without taking the effects of climate change into consideration, water availability is expected to decline by 50% by 2050, due solely to population growth (Ringler et al., 2010). According to the National Water Agency of Brazil – ANA (Agência Nacional de Águas, 2016), water use in rural areas represents 83% of total Brazilian demand, with 72% dedicated to irrigation. The irrigable area in Brazil is approximately 29.6 million hectares.

In terms of water quality, although urban pollution is the main source of degradation, diffuse pollution from rural areas can have a strong impact on regions with extensive agricultural areas. Therefore, the contamination risk of surface and underground waters is very high. As a consequence, damages to the aquatic biodiversity, to human health, and to the country's economy occur (Prado et al., 2017). Climate changes entail uncertainty and complexity to production in rural areas, thus demanding a greater variability in water availability and potential

changes in agricultural aptitude due to changes in temperature and rainfall. Water management is the transforming element in this adaptation process (Prado et al., 2017).

## Soil as an asset

Today, 33% of the world's soils are moderately to severely degraded due to erosion, salinization, acidification, and chemical pollution. Successive losses of productive soils should harm food production, food security, increase price volatility, and potentially lead millions of people to hunger and poverty (Marques Filho, 2016).

Although it has not been considered a priority in governmental agendas in the past (Guerra et al., 2014), soil conservation has received more attention recently, which resulted in the development of several agricultural production systems currently in use in Brazil. Among these, stand out the no-tillage system (NTS), integrated crop-livestock system (ICL), and crop-livestock-forest system (ICLF) (Machado; Silva, 2001).

Adequate soil and water use in agriculture also involves the efficient use of fertilizers and reduction of pesticides, as well as conservation actions aimed at reducing erosion processes and silting up of bodies of water. However, there are many challenges in order for policies and laws to be effective, and for conservation programs and projects to be expanded, encompassing the vast territory of Brazil and making sustainable consumption and production a reality.

## Contributions of Embrapa to achieving the goal

On the items below, the products, processes and services that Embrapa has made available to agroindustrial chains and to Brazilian society, in order to contribute to the achievement of SDG 12 and to provide input for its indicators assessment, are presented.

### *Water use efficiency in agriculture*

Among agricultural practices, irrigation is the largest consumer of water, in order to produce a large amount of food per liter of water. Irrigation requires technical knowledge and equipment acquisition, without which excessive use of water and energy and potential negative environmental impacts will occur. Embrapa

encourages the adoption of good irrigation practices, validates technical indexes for its improved efficiency, and designs equipment and support systems for irrigation to reach maximum efficiency. Some related products and services are: strategies for reducing water use in irrigated rice, software for efficient water use and saving on crop irrigation in the Cerrado, training in irrigation use and management (IrrigaWeb) and the Sistema Brasileiro de Classificação de Terras para Irrigação (Brazilian Land Classification System for Irrigation).

As livestock activities are also great water consumers, research on rainwater harvesting for watering animals and cleaning facilities has been carried out, as well as research on reusing effluents from animal production.

### *Soil conservation*

Soil conservation has not been treated with due diligence and seriousness in Brazil, except for a few Brazilian states as Paraná. As a consequence, annual soil losses in Brazil reach 500 million tons by erosion, thus causing an average loss of reservoir storage capacity of 0.5% per year, which is quite high. Also many rivers reach the sea with a very reduced flow due to silting, as one can see in Paraíba do Sul and São Francisco rivers.

Over the last decades, however, more sustainable and integrated production systems have advanced. In production areas of important commodities such as soybeans, corn, and cattle, NTS, ICL, and ICLF should be highlighted. As for ICLF, a research and development network was built in order to monitor and disseminate it, in which Embrapa plays the main role.

The Ecosystem Services in Agricultural Landscape Network (Prado et al., 2015) is also closely related to sustainability in the rural environment, since it aims to develop knowledge and tools to support actions and policies for restoration, maintenance and expansion of environmental services, and to strengthen sustainable production systems.

Another initiative is the Brazilian Soil Survey Program (Pronasolos), which started with an Embrapa Special Project. The work involves the Ministry of Agriculture, Livestock and Food Supply (Mapa), Embrapa, universities, research institutes and companies and specialized agencies. Its aims at investigating, listing, documenting, interpreting, and providing soil information for understanding, managing, conserving, and maintaining this resource to the nation.

## *Efficient plant genetic resources use*

Native plants use contributes to the sustainability of production systems, as they are adapted to local environmental conditions, bring greater genetic diversity, and provide more environmental services. There are numerous examples of genetic breeding programs and native Brazilian species cultivars released by Embrapa, ranging from Amazonian and Cerrado fruits to native forages for the Center-South area of Brazil. Besides that, native species cultivars have been released for ornamentation purposes. Greater efficiency in the use of renewable and non-renewable natural resources and conservation of ecosystem quality will be achieved through the development of cultivars that are more effective in nutrient use and aluminum-tolerant; through the management including soil correction and fertilizer use in appropriate amounts; through the development of processes for efficiency-enhanced fertilizer production.

## *Fertilizer use*

Fertilizer application is a key factor for maintaining crop productivity and transforming lands with low natural chemical fertility into productive lands, but this also means greater consumption of natural resources, energy and greenhouse gas emissions. Therefore, replacing traditional fertilizers with environmentally friendlier technologies are one of the objectives of Embrapa. Biological nitrogen fixation (BNF) in soybean and other crops made Brazil a worldwide reference for microorganisms use in agriculture for nutrient supply. In addition to that, microorganisms and microbial processes (such as phosphorus – P – solubilization, potassium – K –, growth regulators, nutrient-absorption facilitators such as mycorrhizal fungi) are being increasingly explored. Embrapa also operates in systems with fertility-built soils, no-tillage, creating modern cultivars with high productive potential.

## *Systemic product and process assessments*

The Life Cycle Assessment (LCA) is a management tool that allows evaluating the environmental performance of products throughout their entire life cycle. In the national agricultural sector, LCA can contribute to promoting a cleaner agriculture and to defending Brazilian agricultural products in the international market. Embrapa carries out projects to promote the application of a tool to assess the technologies created by the Company, and the creation of a national LCA research

network whose main objective is, among others, assess production systems of some of the most important products of Brazilian agribusiness: sugarcane, soy, corn, mango, eucalyptus, and beef cattle. Currently, Embrapa is conducting research on LCA for products such as beef and fruit farming.

Another tool used by Embrapa is the water footprint approach, which assesses the water efficiency of a product or process. Water footprint is defined as the volume of water directly and indirectly consumed to manufacture a product. The footprint assessment is an analytical tool, helping understand how the product is related to water demand and scarcity. Since 2009, Embrapa has developed projects that assess the water efficiency of agricultural products, and is the first in Brazil to use this type of approach to agricultural products. Embrapa develops water footprint research for the following products: beef cattle (Palhares et al., 2017), broiler chickens (Drastig et al., 2016), pork (Palhares, 2014), and cattle milk (Palhares; Pezzopane, 2015). The uniqueness of studies by Embrapa, compared to international studies, is that the former are made taking the productive and environmental realities of the various Brazilian production systems and hydrographic units into consideration, which makes it possible to make firmer decisions regarding natural resource management.

## Final considerations

For an efficient natural resources management in agriculture, it is necessary to combine different sectors of society, public and private governmental and non-governmental institutions , and to have farmers as allies, by valuing their key role in efficiently managing the natural resources in their farms and in the countryside as a whole.

Products, processes, and services created by Embrapa research must be increasingly validated by society and disseminated, so that they can be efficiently used by farmers and decision makers.

Furthermore, knowledge related to this target 2 of SDG 12 must improve in terms of developing low cost and easy to handle or apply products, processes, and services for farmers or decision makers.

Another important issue is to promote a greater integration of water, soil, and biodiversity as themes for both research and public policies and the natural resources management in agriculture by integrating concepts, approaches, and methods.

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Chapter 4

# Food loss and waste

Murillo Freire Junior
Antonio Gomes Soares

## Introduction

World food loss and waste can cause about USD 750 billion a year in damage. Post-harvest losses estimates in developing countries vary greatly, reaching up to 50% or more. According to data from the Food and Agriculture Organization of the United Nations (FAO), 54% of losses and waste occur at the initial stage of production – during post-harvest handling and storage, and 46% during processing, distribution, and consumption. Consumers often dispose of food after buying it because they verify that it does not meet their quality requirements, especially regarding appearance and taste. This is why there must be more research on reducing food loss and waste in the world so as to increase food supply, improve production costs, and reduce environmental impacts.

## Context

Nowadays, ensuring food security of the world's population is one of the major global challenges. FAO data (FAO, 2016) indicate that enough food production will be needed to feed the world's population, which is expected to reach 9 billion people by 2050. Thus, an integrated and innovative approach is needed to ensure sustainable food production for human consumption (Nellemann et al., 2009; Gustavsson et al., 2011).

Food insecurity is unacceptably high for the world population (FAO, 2016); there are high food losses every year due to various problems. These losses take place throughout production and between production and consumption (Stuart, 2009; Gustavsson et al., 2011). In some tropical countries in Africa, the Caribbean, and the Pacific, which have low technology indexes and little infrastructure, losses and waste can reach up to 40% to 50%. Thus, improving food security involves reducing food losses in the world (Stuart, 2009), increasing food supply without necessarily increasing the agricultural production area. Implementing actions to reduce losses at different stages of production begins with pre and post-harvest

practices, including processing, distribution and marketing until consumption (Freire Junior; Soares, 2014).

According to FAO, one-third of all food produced is lost or wasted, while 870 million people go hungry every day, and it is estimated that food waste in the world can cause about USD 750 billion in losses per year (Gustavsson et al., 2011).

In developing countries, food losses take place mainly during agricultural production. Retail and consumer food waste tends to be higher in middle and high-income regions – accounting for 31% to 39% of total waste – than in low-income regions (4% to 16%) (Gustavsson et al., 2011).

Post-harvest losses are also subject to technical and scientific discussion due to the growing awareness of the enormous environmental costs of these losses, which include wasting all energy and inputs used in production (water, fuel, fertilizers, agrochemicals), distribution (packaging, transportation), and storage. Moreover, food deposited in landfills, or simply disposed of in the environment, produces methane, a gas with a greenhouse effect 23 times stronger than carbon dioxide (Lipinski et al., 2013), thus increasing the environmental cost. Therefore, reducing post-harvest losses is also extremely important for environmental sustainability, greater efficiency of water and agricultural inputs use, and for a sustainable use of the energy spent in food production in the field. Feeding the world's growing population in a sustainable way is perhaps one of the greatest challenges in the modern world.

## Losses and waste in Brazil

Post-harvest food losses can be quantitatively (reduction in total produced) and qualitatively (reduction in product quality) observed from harvest to final consumption.

In Brazil, post-harvest losses can vary greatly depending on the seasons and the higher or lower level of technology of production areas. Among the main causes are inadequate handling in the field, improper packaging, overloaded vehicles, poor roads, bulk product marketing, products being excessively touched by consumers, and product accumulation in retail shelves.

In addition to injuries caused by harvesting, transportation is possibly the main cause of mechanical damage, whose intensity varies based on the distance to be covered and the type of product transported, among other factors. Packages

are often filled above capacity because of the common practice of charging the load according to total weight or total number of packages transported. The poor conditions of highways, along with the high speed of trucks, are among the main factors that affect the conditions of perishable products transported via highways, especially when the production area is somewhat distant from the main highway or marketing center.

According to research carried out by the Brazilian Agricultural Research Corporation – Embrapa Food Technology, average losses reach 30% in the entire fruit production chain, and 35% for vegetables. Costabile (2017) carried out studies on grain losses and concluded that these can reach 50% during the storage stage, often due to technical inefficiency in storage silos.

To reduce losses, there should be greater incentive to cooperativism for small-scale and family farmers in marketing fruits and vegetables , since the wholesale and retail market is quite cartelized. The advantages of cooperativism or associativism in marketing are: providing central locations for packaging, sorting and standardizing harvested products; buying supplies and packaging materials in larger quantities and more competitive prices; allocating storage space for harvested products while maintaining their quality and facilitating distribution logistics for wholesale and retail markets. In relation to grains and cereals, investments in smaller storage silos with relative humidity and temperature control are of vital importance for quality maintenance until the time of bagging and sale. In addition, smaller silos may be important to sort products by quality, thus allowing to reach better prices in the market.

The majority of wholesale markets have inadequate facilities for food packaging. Investing in supply centers modernization regarding equipment and box cleaning is a must. The vast majority of boxes in supply centers are under unhealthy conditions, with vector infestation, inadequate loading and unloading platforms; workers are not properly trained to handle loads; there is often product overloading; only a few boxes have storage cold chambers, and products at different temperatures are often put together, which may result in quality loss and increased percentage of post-harvest losses.

Post-harvest losses in Brazil are always assessed in terms of food types, and the chain as a whole, that is, from production to retailing, is not taken into consideration. In addition, data are often empirical assessments. According to Chitarra and Chitarra (2005), estimates of post-harvest losses of grains and cereals are between 5% and 30%, while for fruit and vegetable crops it varies widely and

can reach almost 100% of the total produced depending on the technology used since harvesting, handling, transportation, and post-harvest packaging (Figure 1).

Photo: Murillo Freire Junior

**Figure 1.** Losses on papaya harvest in the field.

Costa et al. (2012) verified that the greatest losses of agricultural products occur in the post-harvest stage, that potential gains can be significant and can be used as parameters for cost/benefit analysis in designing public policies for investment in storage infrastructure, transportation, and worker training.

Grain losses are enormous and can reach up to 20% of the total produced in Brazil (Martins; Farias, 2002). Their reduction could have a direct impact on investment for farmers and the production chain. There are weaknesses in logistics infrastructure and a lack of coordination between farmers, logistics companies, and processors. When it comes to grains, we can also highlight the waste of water resources, of the work done by farmers in the field, and of land use, when the grains do not reach the consumer market.

## Embrapa research on losses and waste

Research on post-harvest food losses at Embrapa began in 1992 at Embrapa Food Technology in Rio de Janeiro, with the arrival of Professor Steven Alonzo Sargent of the University of Florida, USA, who developed a project titled Post-harvest Losses – Strategies to Reduce Them, aiming at assessing and identifying losses and outlining strategies for their reduction. This project was joined by several Embrapa Units, as well as several federal universities that had expertise in post-harvest of grains, cereals, fruits, and vegetables. In 1994, Professor Adimilson Bosco Chitarra, of the Federal University of Lavras, was hired as a consultant to consolidate the fruits and vegetables post-harvest area at Embrapa Food Technology and to carry out the project titled Assessment and Quantification of Post-Harvest Losses in the Fruit and Vegetables Productive Chain.

Regarding packaging for fruits and vegetables, according to Embrapa internal system called Agropensa, Embrapa has projects currently running at Embrapa Tropical Agroindustry, Embrapa Temperate Agriculture, and Embrapa Semi-Arid Region. These projects focus on edible coatings that fit into modified atmosphere rather than the packaging itself. In Embrapa Food Technology, a project on the development of valuable packaging for fruits and vegetables has already finished. It managed to design, alongside with the National Institute of Technology and the Instituto de Macromoléculas (IMA) at the Federal University of Rio de Janeiro (UFRJ), packaging for papaya, mango, khaki, strawberry, and heart of peach palm (Figure 2).

At Embrapa, other projects are running as well whose main subject is plant health in cereals, grains, fruits, and vegetables. All these projects are focused on assessment, diagnosis, control, and quantitative analysis of diseases or risks of diseases. There are only a few studies on developing technologies to replace the current pest control mechanisms, namely fungicides, herbicides, and insecticides. Research to replace existing products should be a priority, as many diseases that affect farmers and sometimes consumers can come from the indiscriminate use of pesticides. Research on biological control may not be enough to prevent diseases and the design of new products becomes important.

Harvesting time is a key theme to ensure quality and consumer acceptance, since products harvested at inappropriate harvesting times can lead to high losses. However, the lack of transferring technologies designed for farmers is noticeable, making it difficult to improve the quality and homogeneity of harvested products.

Photos: Murillo Freire Junior

**Figure 2.** Packaging designed for papaya and mango that reduces losses.

It is important to encourage projects that can add value to products that lack appearance and quality for in natura sale and can be processed, thus increasing the sustainability of these products production chain. However, consumers are increasingly eager for ready-to-eat products, as more consumers have less time for household activities and food preparation.

Regarding refrigeration for horticultural products, it is verified that Embrapa has only a few projects according to the Agropensa system. Refrigeration use has been well studied, but its results are scarcely adopted by the private sector. Fruits and vegetables are still transported without refrigeration. It is important to align research with the needs and realities of farmers, wholesalers, and domestic marketing logistics, in order to reduce waste and increase input use efficiency in food production and distribution.

Regarding edible coatings and their uses in fruits and vegetables, it is noticed that Embrapa has projects both finished and in progress. Large-scale farmers who sell fruits use commercial coatings that are produced by private companies. The

effectiveness of technologies already developed by Embrapa should be assessed in terms of their adoption and their impact on marketing and consumption, in order to identify bottlenecks that might be halting the use of the technologies created.

## Losses and waste – opportunities and challenges to scientific, technological, and market progress

Minimizing post-harvest losses of already produced food is more sustainable than increasing production to compensate for these losses. After all, money already invested in production ends up being lost with the product itself (water, energy, agricultural inputs, and workforce, among others).

Research studies should encompass biotic and abiotic factors involved in post-harvest losses and the development of post-harvest technologies that suit the reality of production chains and consumption and commercialization markets. We must discuss the problems with the various players in the production chain, i.e. farmers, distributors, supermarkets, and consumers, in technical meetings, qualifications, and training courses.

Based on current information, there is awareness about the importance of this subject, but there is not an institutional policy to address food losses. Moreover, developing a standardized methodology to quantify food losses is needed, as well as devising a national strategic plan for managing food losses and waste. It is of paramount importance to address the main stages of the supply chain, based on its importance in the food basket for each Brazilian region.

Designing standardized manuals on good production, harvest, and post-harvest practices for basic products, focusing on loss reduction, is essential.

Likewise, it is essential to develop programs for technology transfer, training courses, and specialized technical assistance in order to reduce food losses in the numerous segments of the food supply chain. Also, proper information dissemination is important to promote public awareness of the social, economic, and environmental impacts of food losses and waste.

Greater financial resources to carry out research projects are needed. The allocation of governmental budget resources for the implementation of measures against food losses and waste, as well as the granting of tax incentives to organizations that collaborate with such action, is fundamental. Less than 5% of agricultural

research funding is allocated to post-harvest research areas (Kader, 2005; FAO, 2016).

It is observed that there is no State policy leading to food waste management; there are only a few isolated regulations to support food waste reuse. Facing this situation is among the main challenges. It is necessary to develop regulatory frameworks to promote legislation that regulates food waste management.

Finally, research should cover:

- Qualitative and quantitative loss mapping.
- Pre-harvest factors that impact on post-harvest quality.
- Harvest, screening, sorting, and packaging processes.
- Proper means of transportation, storage, and distribution.
- Strategies for post-harvest prevention and control of insects and pathogens.
- Technological strategies for taking advantage of out-of-standard in natura products and for by-products and waste commercialization.

For this purpose, technological development must contemplate:

- Assessing post-harvest losses during food production, distribution, and consumption, covering the countryside, supply centers, and retail trade.
- Training of all agents involved in the production and marketing chain.
- Designing new specific packaging to preserve product quality.
- Using alternative and non-conventional technologies to preserve product quality.
- Designing packaging to indicate product changes and deterioration.
- Using and processing co-products or waste, or both, for food purposes.

## Final considerations

We can conclude that, among the main causes of losses and wastes, are inadequate handling in the field, marketing of bulk products, improper packaging, overloaded vehicles, poor roads, consumers excessively touching the products, and product accumulation in retail shelves. Rates of lost and wasted food are high in Brazil.

Therefore, several research, training, and technology transfer actions must be adopted for its reduction.

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Chapter 5

# Responsible chemicals management

Antonio Luiz Cerdeira
Marcelo Augusto B. Morandi
Robson Rolland Monticelli Barizon

## Introduction

Target 15.1 of Sustainable Development Goal 15 (SDG 15) is "By 2020, ensure the conservation, restoration, and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains, and drylands, in line with obligations under international agreements". Concerning this theme, Brazil has reached a prominent position in the international agricultural context in recent years, becoming one of the largest producers of agricultural commodities such as soy, corn, coffee, sugar, among others. As a result of the agricultural model adopted by most farmers and the increase in cultivated area, Brazil has also become one of the largest consumers of agrochemicals in the world, since today this input is essential to the extensive agricultural model, in which agroecosystem there is low biodiversity.

From the 1970s, Brazil started using agrochemicals on a large scale, and by the end of the 1980s, there were practically no major concerns about soil and water resources contamination or impacts on biodiversity. The first legislation on agrochemicals in Brazil was determined by Decree nº 24.114/1934 (Brasil, 1934), which established the Regulation of Plant Health Protection. From that time until the enactment of Law nº 7.802/1989 (Brasil, 1989), this matter was regulated in Brazil only by ministerial orders, mainly from the Ministry of Agriculture, Livestock and Food Supply (Mapa) and the Ministry of Health (MS). This fact may have contributed to the lack of awareness regarding the problem, whose origin is also the lack of studies and scientific work on the subject at the time. Only after Law nº 7.802/1989 (Brasil, 1989) was enacted, a broader scope of issues related to agrochemicals, including registration, trade, inspection, final packaging disposal, among others, started to be addressed.

In addition to the scarcity of information on rural contamination by agrochemicals, the consumption of these products in Brazil has been increasing steadily in recent years, and, in 2012, more than 400 thousand tons of active ingredient (Figure 1) were consumed. Agrochemicals consumption increased by 190% between 2000

and 2012, and this upward trend in agrochemicals consumption is consistent when taking a more recent period into consideration. The increase from 2009 to 2012 was of approximately 60%, indicating that the increase in consumption will continue in the coming years.

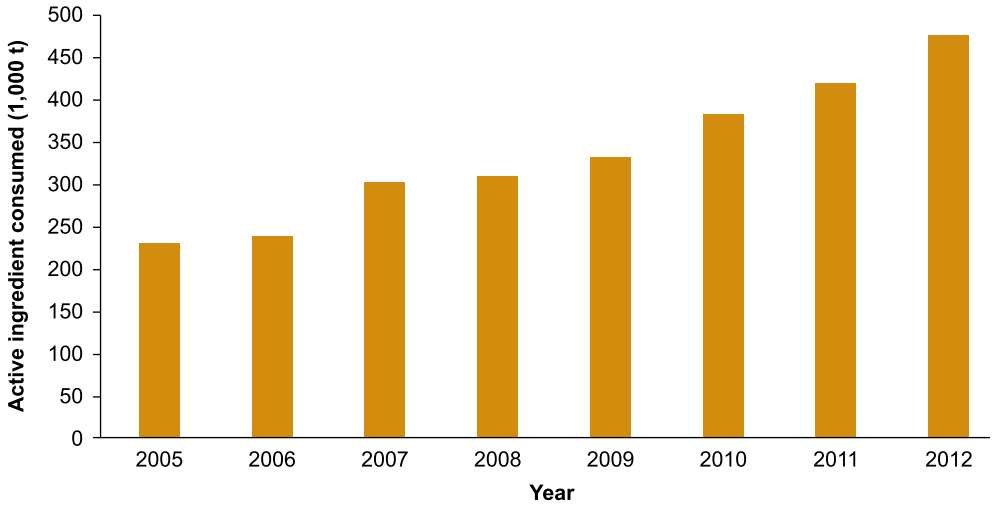


**Figure 1.** Agrochemicals consumption in Brazil, from 2005 to 2012.

Source: Adapted from Hofmann et al. (2010), Ibama (2012) and Theisen (2012).

The continuous and exclusive use of agrochemicals has resulted in selecting pests resistant to certain products, such resistance is not always promptly diagnosed (Ghini; Kimati, 2000). Due to the lack of perception, agrochemicals continue to be used, even with reduced efficiency due to resistance in the target organism, which can cause agroecosystem imbalances.

Herbicide use in most crops in extensive areas, due to weed infestation or plant cover desiccation for no-till farming, has been doubled or even tripled, sometimes without need. In addition to herbicide use in some crops, residue accumulation in the soil (Avila et al., 2010) is observed, which hinders the growth of vegetal species in crop succession and rotation systems, as well as in integrated crop-livestock system. To be also noted is the intensive and inadequate herbicide use, which has led to 33 resistant weed biotypes in Brazil (International Survey of Herbicide Resistant Weeds).

Despite positive results achieved by Brazilian agriculture (in 2017, Brazil hit a new record in agricultural production), the steady increase in agrochemicals

consumption has been raising great concern in several segments of society, due to the potential negative impacts of these substances to human health and the environment.

Recent food monitoring studies reveal high levels of agrochemical residues, with non-conformity indexes (i.e., residues above the allowed limit and/or unregistered products for the crop) often in more than 50% of the analyzed samples (Agência Nacional de Vigilância Sanitária, 2013). Of particular concern is the exposure of rural workers to agrochemicals, as pointed out by research institutions such as the Oswaldo Cruz Foundation, which coordinates the National System of Toxic-Pharmacological Information (Sinitox, 2018) and has recorded a significant number of farmers poisoned, especially due to improper handling.

Regarding environmental contamination, a few studies have assessed the impact of agrochemical use on different environmental compartments. However, based on the information available in Brazil (Sinitox, 2018) and especially in countries with more advanced studies on the subject, it is possible to establish the main causes that lead to environmental contamination by agrochemicals. Among these, the excessive use of these substances in crops is highlighted, thus causing ecological imbalance in agroecosystems, when the practices recommended in Integrated Management System (IMS) are not observed, such as biological control and rational agrochemical use, use of adequate application technology and adoption of cultural practices (e.g., fallow period, crop rotation), among others (Sinitox, 2018).

Another important aspect of environmental contamination by agrochemicals is the inadequate soil and water management, since one of the most relevant agrochemical transportation processes is surface runoff in agricultural soils. In this way, soil and water conservation systems that reduce surface runoff will also reduce agrochemical transportation.

In agrochemical leaching to groundwater, intrinsic factors of the physical environment, such as soil permeability and depth until the phreatic zone, ability of sorbing these substances and climatic conditions, are of great relevance and must be taken into consideration for the understanding of this contamination route.

The Brazilian Agricultural Research Corporation (Embrapa) has been carrying out activities that include actions listed below for the environmentally sound management of chemicals.

# Targets

## *Rational use of agrochemicals*

Conducting research to promote the rational use of agrochemicals is essential for improving the efficiency of phytosanitary control and mitigating the impact of these substances on natural resources and human health. Thus, technologies must be improved and/or developed aiming at reducing the use of these inputs in crops, especially taking the concepts of IMS into consideration. The IMS can be defined as the selection and use of control tactics that will produce beneficial consequences from economic, ecological, and sociological points of view (Kogan 1988; Metcalf; Luckmann, 1994). Therefore, the IMS should be seen as a rational pest control optimization, which can be obtained through the consistent use of several strategies, in order to maintain production above the economic damage threshold (EDT).

IMS entails 3 main aspects:

- Determining changes in the life cycle of a particular pest to keep it below the EDT.
- Combining biological knowledge with available technology in order to achieve the necessary change, i.e., the practice of applied ecology.
- Using surveillance and control methods adapted to technologies that are available and compatible with socioeconomic and ecological aspects.

Many concrete and promising results have been obtained, but IMS can not be said to be widely practiced by farmers. Even in success cases, for the same crop, alternative agrochemical use practices are adopted to control some pests, but not others. And, in most cases, there is no real integration of the different pest control methods, as advocated by IMS principles, but rather the control using only different agrochemicals (Campanhola; Bettiol, 2003).

As research challenges for implementing and expanding IMS use in productive systems, the following items suggested present potential for a market for innovation assets: 1) pest and natural enemy monitoring techniques; 2) decision-making tools on pest control (EDT, warning systems, etc.); 3) semiochemicals with pheromone properties; 4) bioproducts for pest control; 5) advanced plant strains genetically resistant to diseases and insect pests; 6) competitive weed cultivars; 7) agrochemicals relatively selective to natural

enemies; 8) application technologies that allow effectively achieving the biological target and reducing drift losses; 9) management techniques of resistant arthropods, pathogens, and weeds; 10) prospecting of less toxic to human health and the environment new molecules; 11) prospecting of new substances to improve agrochemicals efficiency (adjuvants, protectors, etc.). A holistic approach to ongoing projects and future research and development proposals at Embrapa is presented, covering four themes: 1) rational use of agrochemicals; 2) environmental dynamics of agrochemicals; 3) mitigation and remediation of agrochemicals impacts; and, 4) public policies and institutional development addressing agrochemicals.

The main themes to be approached holistically by R&D, along with their respective priority lines of action in RD&I and TT, are summarized in Figure 2.

Economic benefits may come from improving, adapting, and developing technologies, products, and processes to be transferred to farmers. Appraising the different strategies for the rational management of agrochemicals will ensure the selection of the most profitable ones.

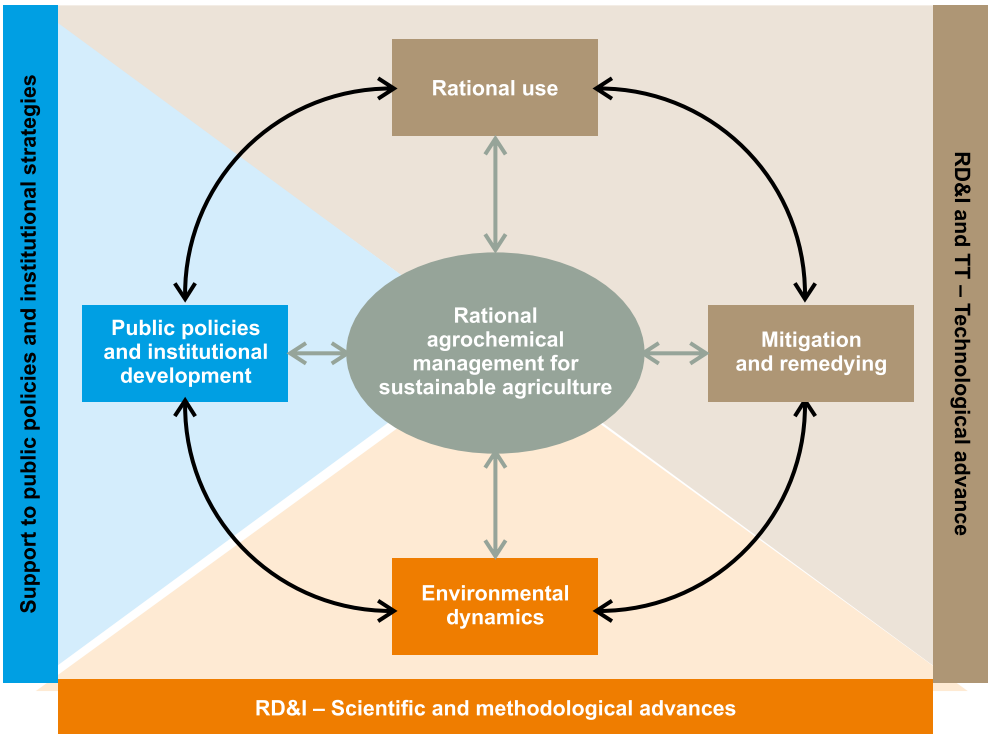


**Figure 2.** Outline of rational agrochemicals management projects.

### *Innovations developed by Embrapa and impacts on environmental contamination*

Other research challenges for assessing, mitigating, and remedying environmental impacts of agrochemicals can be highlighted: 1) prospecting of agrochemical degrading microorganisms (bioremediation); 2) prospecting of contaminated soil remediation plants; 3) technologies for removal (adsorption/degradation) of active soil and water ingredients; 4) study of climate change effects on pest behavior and agrochemicals efficiency; 5) agrochemicals effect on non-target organisms (pollinators, soil biota, natural enemies, etc.).

## Final considerations

Promoting rational agrochemicals management and research on the dynamics of these products in the environment, complemented by the Environmental Risk Assessment (ARA) and the adoption of impact mitigation and remediation measures, could directly benefit natural resources in accordance with sustainability goals required by society.

In terms of the social aspect, results may lead to improved human and animal welfare, especially in rural areas, concerning agrochemicals management. Water resources contamination may still affect rural and urban populations that use this natural resource. Workers and families living in agricultural areas, as well as rural schools, will be exposed to fewer drift-driven agrochemicals. Biodiversity will also be preserved or conserved, which will reflect in a more suitable environment for humans in the countryside, based on their customs.

Moreover, these research results can be used to create and organize economic information relating to the rational use of agrochemicals/reduced environmental impacts in different scales (crops, properties, agroecosystems, river basin), through different procedures: 1) assessment of the direct effects of rational use techniques on application costs and obtained production value; 2) economic valuation of environmental services that may serve for future payments of these services, taking into consideration environmental, economic and social impact indexes resulting from rational agrochemicals use (Constanza et al., 2011); 3) dissemination of evidence on product traceability and certification, which can leverage greater competitiveness in foreign markets. In this context, Brazil's commitments in international biodiversity treaties may contribute to achieving SDG goals by providing the means to meet the requirements of natural resources preservation and conservation.

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Chapter 6

# Solid waste management for rural and urban sustainability

Vânia Beatriz Vasconcelos de Oliveira
Joanne Régis Costa
Henrique Nery Cipriani

## Introduction

Solid waste management, discussed in this chapter, is related to target 12.5, which aims to substantially reduce waste generation by means of prevention, reduction, recycling, and reuse by 2030. Taking the peculiarities of the Brazilian Agricultural Research Corporation (Embrapa) into consideration regarding the development of technological solutions for the rural sector and the Company's social commitment to promoting environmental well-being for the whole society, the contributions addressed in this chapter are discussed under two aspects: a) Embrapa as a Brazilian governmental organ acting to encourage the adoption of sustainable practices in the agricultural production sector; and b) internal procedures in implementing the Company's Environmental Management Plan, which began in 2010, and has already become a benchmark in the public business sector.

## Context

Unsustainable production and consumption standards, besides intensifying the exploitation of natural resources for production of goods used by society, are compromising the future of mankind, because, in rural areas, this process results in forest impacts and soil and water resources depletion. Dumpsites or floodwaters, where more than 60% of daily waste is deposited in Brazil (Ribeiro; Ziglio, 2006), are part of Brazilian urban landscapes. The countryside, in turn, is a big organic and inorganic waste generator (Fessenden, 2015), which can be recycled or reused in the city. Likewise, organic urban waste, which represents more than 50% of the waste generated in the cities (Associação Brasileira de Empresas de Limpeza Pública e Resíduos Especiais, 2016), or even inorganic ones, has great potential for application in the field (Pires; Mattiazzo, 2008).

Waste generation reduction is part of the guidelines for changing consumption patterns, focused on Agenda 21 under various approaches, among them is

"minimizing the generation of wastes " (Agenda 21, 1995). One of the strategies recommended and disseminated by the Ministry of the Environment (MMA) is applying the 3Rs principle: reducing (raw materials and energy use and waste in generating sources), directly reusing products, and material recycling. Embrapa operates based on the 3 Rs, for it conducts research studies that include using agricultural products waste in crops and in agroindustrial processing (seeds, straws, husks) and even construction and timber waste (sawdust) that are used to correct soil acidity and create energy or directly applied on the soil to improve fertility and generate income for the farmer. In this way, Embrapa provides information, designs research and technology, supports events, and conducts training courses for different audiences aiming at waste prevention, elimination, recycling, reuse or reduction. The Company is also very concerned about creating technologies that contribute to reducing water and energy consumption, as well as reducing greenhouse gas emissions. Information provided in publications is generally presented as part of booklets and manuals on good practices, which present procedures and facilitate the understanding of technicians and farmers on diverse production segments, including cattle and swine production, aquaculture, poultry, fruit growing, and extractive forestry production, among others.

Based on the assumptions that Embrapa research collaborates with technological solutions and contributes to designing public policies on solid waste and to promoting sustainability in rural and urban environments, the objective of this chapter is to address problems and solutions related to waste production, particularly rural solid waste (RSW) (from livestock and crops) , which, along with urban solid waste (household, industrial or service waste), has been one of the major environmental problems of recent decades. In this chapter, contributions of Embrapa are presented in terms of technologies and technical advice in order to reduce solid waste production, as well as initiatives that contribute to achieving target 12.5, which seeks a substantial reduction of waste generation through waste prevention, reduction, recycling, and reuse, especially those from agricultural activities.

## Actions of Embrapa to support public policies regarding solid waste management

Environmental sustainability, which is a priority guideline for MMA, includes topics such as deforestation, forest code, climate change, biodiversity protection, genetic heritage, and sustainable agriculture. In 2010, MMA embraced the

urban sustainability challenge and sought to implement the Política Nacional de Resíduos Sólidos (National Solid Waste Policy – PNRS), taking on the challenges of the so-called brown agenda, in which garbage and sewage are the main problems (Brasil, 2012). Due to its mission and objectives, Embrapa had already been acting in line with public policies for environmental sustainability, and has also started to support initiatives for the PNRS implementation, for there is a logical connection between environmental issues and urban policies.

Internally, as of 2010, the Company laid down guidelines for implementing environmental management in all its decentralized units, thus defining the five main aspects of integrated environmental management, namely: 1) environmental education; 2) common waste management and water and energy use optimization; 3) laboratory waste management; 4) experimental field waste management; and 5) adjustment of Embrapa experimental farms to environmental legislation (Penha; Tomé Júnior, 2010). Implementing environmental management resulted in developing solid waste, laboratory and experimental field waste plans in Embrapa Units throughout Brazil.

Externally, Embrapa has representatives in committees and working groups to design public policies for solid waste management. In this context, there are some initiatives, such as the partnership between Embrapa Acre and the Municipal Environment Department of Rio Branco (Semeia), through which Embrapa research, technology transfer, and environmental education activities support the implementation of the Municipal Integrated Solid Waste Management Plan of Rio Branco. Among other actions, it involves assessing the efficiency of composting processes in the solid waste treatment unit, as well as the use of organic compounds and substrates for agriculture and landscape projects in the city of Rio Branco, in the state of Acre. In Rondônia, since 2016, the local Embrapa Unit takes part in a technical group coordinated by the Chamber of Commerce of Rondônia (Fecomércio), whose purpose is promoting debates and contributing to develop the Municipal Plan for Solid Waste Management of Porto Velho.

## Agricultural waste management

### *Recycling and reusing*

Several agricultural practices and processes related to recycling and reusing organic waste have been improved and developed at Embrapa Units, in order

to convert them into co-products, thus contributing to the economic and environmental sustainability of production.

Embrapa Agrobiology has developed technology for producing organic fertilizers and substrates used in landscape projects and seedlings production. They are based on 100%-vegetable, renewable, and abundant raw materials, such as castor bean meal with sugarcane bagasse or napier grass straw. Their quality is higher than that of similar products available in the market. They are free of biological contamination and they are low cost. They can be produced on small farms and also on large scale, in an industrial plant, as they are based on a simple manufacturing process. The step-by-step process for making 100% vegetable composting is available in the video *Produção de Húmus com o Uso de Gongolo* (*Humus Production Using Millipede*, available only in Portuguese), made available by Embrapa on YouTube[1].

Earthworm culture or vermicomposting is the process of converting (household or agriculture) organic residues into organic compound (humus or vermicompost). Embrapa Agrobiology has developed a bamboo bed that demands low investment and makes the process cheaper and ecological because of the materials used. Besides that, it enables better aeration and milder temperatures for earthworms, adapting well to both small and urban farmers. Another technology developed by the abovementioned Unit is a device to produce organic compounds based on millipede activity. Millipedes are a promising alternative for composting organic waste such as grass, woody materials, and even cardboard. Compost from millipedes can be used in seedlings production and its quality is higher than that of commercial compounds, especially for vegetable production. On the Internet, video information and posts aimed at children and adolescents are available (Correia et al., 2014).

Witch's broom is the main disease of the cupuaçu tree (*Theobroma grandiflorum*), causing up to 70% reduction in plant productivity. To avoid dispersion of the *Moniliophthora perniciosa* fungus in the production area, witch's broom remains are usually burnt. Researchers at Embrapa Roraima assessed the composting of cupuaçu trees prunings and verified that the process eliminates the disease-causing pathogen and generates an organic compound that can be safely used as substrate for seedling production and plant fertilization (Lima-Primo et al., 2017).

[1] Available at: <https://youtu.be/9EffxSrKzHQ>.

Waste from green coconut husk (fibrous mesocarp) accounts for about 70% of all litter produced on Brazilian beaches. Embrapa Tropical Agroindustry, in partnership with Fortalmag Metalworking, developed a set of equipment for husk processing. Coconut powder is a biodegradable, renewable, and very light material. Due to its physical structure, it has high porosity and high potential for moisture retention. The fiber can be used as raw material for manufacturing pots and plates for planting (replacing tree ferns), vehicle upholstering and biodegradable blankets. As an innovation, Embrapa has promoted the use of the product in applications that comply with product ecodesign principles, such as interior panels and decorative pieces (Mattos et al., 2011).

## *Waste for acidity correction and soil conditioning*

Conditioners are substances that, once added to the soil, help to improve their chemical, physical, and biological characteristics, thus increasing its ability to support plants. This is the case of biochar obtained from controlled burning, or pyrolysis, of different animal or vegetable compounds, which contributes to the increase of organic matter in the soil. Transforming an environmental liability into a beneficial input to wood and food production is the goal of a research developed by Embrapa Agrosilvopastoral (located in the state of Mato Grosso), which consists of testing the use of biochar (made from sawdust, vegetable remains, chicken bedding, and urban litter) as soil conditioner (Faria, 2017).

Construction and demolition waste (CDW) generation and storage is an environmental problem, accounting for more than 50% of the total solid waste generated in medium and large urban centers. In partnership with Prohab São Carlos/state of São Paulo, Embrapa Instrumentation developed a methodology for the use of recycled construction and demolition waste (R-CDW) as acidity correctors and soil conditioners (Lasso et al., 2013).

Embrapa Soils (located in the state of Rio de Janeiro), in partnership with Calderon Consulting, has developed a fertilizer that can be produced using organic waste from agroindustries, animal farming, agricultural remains, etc. Because it is sustainable, this technology has been classified as a green patent. The fertilizer is a modern, efficient product with a good cost-benefit ratio. The partner industry intends to supply grain, vegetable and cattle raising farmers that need pasture recovery.

### *Reusing agroindustrial waste in animal feeding*

Agroindustrial waste can be used in ruminant feeding. Besides helping to reduce the environmental impact, residues use in domestic animals feeding may be an option to reduce animal products costs. Embrapa Rondônia carried out a study to evaluate the presence of agroforestry processing industry residues in dairy cattle feeding. In addition to technical information, results included scientific information on food technology, nutritional characteristics of agroindustrial by-products, and dairy cattle performance.

Embrapa Dairy Cattle studied barley residues use in cattle feeding. The greatest limitation of moist barley is its energy content, especially for high milk producing cattle (over 25 kg/day). For cows producing less than 20 kg of milk per day, moist barley may be a good alternative, depending on price and availability. Usually, barley residue content should not exceed 20% of the dry matter (DM) intake. That is, for cows ingesting 20 kg of DM a day, only 4 kg should come from barley, and the other 16 kg from the diet.

## Final considerations

The principle of solid waste generation reduction (target 12.5 – SDG 12) is based on taking attitudes and making decisions on accessing consumer goods at individual and collective levels. The abovementioned technological solutions for the agricultural production sector indicate possibilities. Therefore, reaching this target involves not only developing and adopting research-based technological solutions, but also raising environmental awareness and taking consumer ethical attitudes. In this case, raising awareness, through environmental education, about the controlled use of natural resources in industrial production and consumption reduction is an urgent matter. In this sense, taking proactive attitudes is not exclusive to a particular segment, so joining efforts of all (government, industry, commerce, and citizens in general), especially in reducing waste generation (because reusing and recycling are alternatives to waste treatment that do not halt the need to reduce consumption and, consequently, waste generation) is a must.

Encouraging civic participation, in order to proactively contribute to this target, should take place in all areas of (formal and non-formal) education, and research studies that can help to reduce this impact should also be in harmony with sustainable consumption. In this regard, disseminating more good practices

contributes to appreciating socio-biodiversity, improving renewable natural resources use, reducing harvest and post-harvest losses, adopting good management practices to reduce soil losses, and reducing food losses.

In both urban and rural domains, the potential of Embrapa to contribute, within the limits of its attributions, in a context in which several institutions are teaming up to provide solutions to society, is noticeable. It takes place not only by the dissemination of information in technical-scientific events, but also by contributing to public policy design, by participating in committees that manage natural resources, by organizing events and training courses and marketing products to make science reach ordinary citizens.

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Chapter 7

# Responsible consumption: ensuring production and sustainable consumption standards

Antonio Flavio Dias Avila
Daiva Domenech Tupinambá
Antonio Eduardo Guimarães dos Reis
Hércules Antonio do Prado

## Introduction

Our contribution to achieving target 12.6 of Sustainable Development Goal 12 (SDG 12) is addressed in this chapter under two aspects: a) the Brazilian Agricultural Research Corporation (Embrapa) as a Brazilian governmental agency acting to encourage the adoption of sustainable farming practices; b) sustainability at Embrapa as it accomplishes its mission, both in research, development, and innovation processes (RD & I) and in management activities necessary for these processes to take place.

## Supporting agricultural sustainability

Embrapa and Brazil's agricultural research and innovation system are embedded in the competitive and successful Brazilian agricultural industry business environment. In a context of severe Brazilian economic downturn, such as in 2014 to 2017 period, agriculture has been standing out as an important source of income and jobs, food security for Brazilians, and spare production for exports that has been drawing a surplus in Brazilian balance of trade. It currently accounts for approximately 25% of gross domestic product (GDP), 40% of jobs, and 50% of exports. In 2016, due to major climatic constraints in important producing regions of Brazil, there was, for example, a reduced grain production, but, in the 2016-2017 cycle, Brazil reached a record grain harvest of over 240 million tons.

Innovation was the determining factor for Brazil to reach this level, and Embrapa played a major role in and is recognized for that result. Right now, there is a strong private agricultural sector, with countless Brazilian and multinational companies of great prominence providing a variety of competitive options to Brazilian

farmers. Embrapa maintains strategic agendas, many of which in partnership with the private sector, to create new cycles of results and innovations in order to keep agriculture competitive and within the scope of sustainable development, as recommended in the Sixth Embrapa Master Plan (Embrapa, 2015).

Brazilian agribusiness, as a competitive and risky activity, is full of problems and opportunities. Despite the fact that 90% of the Brazilian population is in urban environments, agribusiness accounts for 25% of the Brazilian GDP, which demands more responsibility to face challenges in productivity and production quality. Among the practices created by Embrapa and its partners to promote sustainable agribusiness, the following can be highlighted: biological nitrogen fixation, integrated crop-livestock system, agricultural zoning of climatic hazards, no-tillage system, biological control practices, and integrated pest management for several crops (wheat, soybean and cotton, among others).

Contributions of Embrapa on several public policies already in force and with positive impacts on sustainability, such as the Forest Code, the Pantanal fishing control, the Low Carbon Agriculture Program of the Ministry of Agriculture, Livestock and Food Supply – Mapa (ABC Plan), ecological and economic zoning programs and fruit fly control, soil conservation policies, family agriculture innovation program, biodiversity and biosafety laws, among others, should be highlighted.

The data presented in Embrapa Social Report (Embrapa, 2017), published annually from 1997 to 2016, reveal economic, social and environmental impact assessment indicators on the main technologies created by Embrapa Units and adopted by farmers and agroindustries. There are numerous evidences, obtained from sample surveys with farmers and/or from public and private extension consultants, that contributions to improving the quality of life and the environment in rural areas have been positive. This positive impact is enhanced in cities as better quality products are increasingly made available, with lower contamination rates and, above all, at more affordable prices.

Some of the contributions that Embrapa has made to rural business sustainability (competitiveness) and environmental sustainability in the agribusiness context, are highlighted below.

## *Environmental strategy*

The voluntary commitment made by Brazil during the *15*th *Conference of Parties* (COP-15) to reduce greenhouse gas emissions from 38.9% to 36.1% as of 2020

led to several challenges in research, development and technology transfer for agriculture. In order to achieve these goals, the Política Nacional sobre Mudanças no Clima (National Policy on Climate Change) – Law No. 12.187/2009 (Brasil, 2009) was enforced, along with the formulation of sectoral plans for mitigating and adapting to climate change, among them the ABC Plan.

Among the technologies used to reduce greenhouse gas (GHG) emissions, there was a 4 to 5 million hectare increase in the adoption of integrated crop-livestock-forest system (ICLF), which was developed by Embrapa and is already adopted in more than 11.5 million hectares.

Areas where ICLF systems are adopted in Brazil are located mainly in five states, namely: Mato Grosso do Sul (2 million hectares); Mato Grosso (1.5 million hectares); Rio Grande do Sul (1.4 million hectares); Minas Gerais (1 million hectares) and Santa Catarina (680 million hectares). Among farmers predominantly focused on livestock farming and who adopt this strategy, 82% use ICL system; 9%, ICLF; and 7%, IPF. Among grain farmers who adopt this strategy, 99% adopt ICL system; 0.4%, ICLF; and 0.2% ,ILF on their farm.

According to research estimates, adopting ICLF systems in Brazil has been significantly increasing in recent years. Among cattle ranchers, over the last 5 years, there has been a 10% increase. Among grain farmers, there has been a 1% increase every 5 years (Embrapa, 2017).

The ICLF potential for mitigating climate change impacts ranges from 18 to 22 million Mg $CO_2$ eq (Embrapa, 2017). This commitment was reaffirmed in the Paris Agreement on Climate Change by the Brazilian government in 2016, which undertook to strengthen the actions of the aforementioned plan, whose goal was to add 5 million hectares to the area adopting integrated crop-livestock systems by 2030.

## *Basic rural sanitation services*

Brazil has approximately 31 million inhabitants living in rural areas and isolated communities, according to data from the Brazilian Institute of Geography and Statistics (IBGE, 2013). Only 22% of this population has access to adequate basic sanitation services; and reality indicates that there are still almost 5 million Brazilians who do not have a toilet, that is, they defecate in open air. Therefore, about 24 million Brazilians still suffer from the chronic and serious problem of lack of basic sanitation. Reasons range from the lack of priority in public policies to the

very culture of rural dwellers, who do not see basic sanitation as a necessity. The Sistema de Saneamento Básico na Área Rural (Basic Sanitation System in the Rural Area) developed by Embrapa Instrumentation (São Carlos/state of São Paulo), made up by technologies called biodigester septic tank, filtering garden and the Embrapa chlorinator, aims to solve this problem with simple, efficient and easily replicable solutions. These contributions by Embrapa to rural sanitation public policies are already being disseminated throughout Brazil. Embrapa chlorinator, as the name suggests, is a simple technology to enable the chlorination of water for rural residential use. Biodigester septic tank and filtering garden are technologies to treat sewage generated by a rural residence.

## Institutional sustainability initiatives

Institutional sustainability can be defined as a business model concerned not only with profit but also with environmental and social impacts of such activities, through the conscious use of natural resources, in order to guarantee a habitable planet for future generations. Therefore, sustainability is based on the economic-environmental-social tripod, pillars of which must evolve harmoniously.

At Embrapa, in order to fully comply with current environmental legislation, the Embrapa Environmental Management System is being designed; it aims to manage solid waste generated by its Units, from its inception in laboratories, experimental fields, and other areas of the Company, to its final disposal in an environmentally sound manner. To this end, Embrapa already has an established institutional process to develop its Plano de Gerenciamento de Resíduos Sólidos (Solid Waste Management Plan – PGRS), a legal obligation of large solid waste generators created by Law No. 12.305/2010 (Brasil, 2010), which established the Política Nacional de Resíduos Sólidos (National Solid Waste Policy – PNRS). This document is prepared annually by more than 40 Decentralized Units (DUs) based on an institutional model and fully complying with federal and local legislation, when available.

Another important aspect regarding institutional sustainability, in addition to the aforementioned Company's initiatives on environmental issues, are sustainable initiatives of Embrapa as a state-owned enterprise. In this sense, efforts have been made to improve the effectiveness and efficiency of Embrapa research centers and Central Units (UCs) in order to comply with the corporate agenda. This agenda is based on strategic planning, in which priorities are focused on the

search for technological solutions that, in the end, meet the real needs of Brazilian agriculture, thus generating the expected socioeconomic and environmental impacts, as explained in the Sixth Embrapa Master Plan (Embrapa, 2015).

In searching for greater efficiency in using public resources allocated to Embrapa, one of the priorities has been the continuous search for improvements in management quality, especially on cost rationalization, in order to avoid waste and duplication. Also in this same context, efforts have been made to increase the volume of resources from external sources, in order to minimize dependence on National Treasury resources. In addition to these efforts by Embrapa Headquarters and its Decentralized Units, these themes are also part of Embrapa's performance management as indicators of institutional performance.

On the other hand, within its research and development actions, Embrapa has sought to improve its agenda, focusing on priority actions that, above all, generate agricultural relevant impacts. This orientation, intensified every year, implies improving the management of research projects and related actions, in order to focus on strategic lines for the sector and, therefore, on greater impact research. Because of challenges and rapid progress in scientific frontiers, research costs tend to grow along with sophistication of methods, processes, and instrumentation. From that perspective, Embrapa also hopes to contribute to the strengthening and creation of a great alliance for agricultural innovation, based on the premise that there are common purposes among the R & D organizations that need boldness to stimulate and leverage the innovation process focusing on problem solution and capturing opportunities for Brazilian agriculture and agribusiness (Arranjos..., 2016).

## Final considerations

As stated above, Embrapa has made relevant contributions in the context of this SDG, particularly by encouraging the adoption of sustainable practices in agriculture and practicing sustainability in its own way of acting, which encompasses both research, development and innovation (RD & I) processes and organizational management. Contributions for designing public policies stand out, with relevant impacts on the agricultural productive environment and the treatment of solid waste generated by the Company. Additionally, it is highlighted that the future presents important challenges in increasing the emphasis on research and management projects, in order to produce increasingly significant results for Brazil, particularly focused on sustainability.

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Chapter 8

# Sustainable procurement

André Luiz Lemes Alarcão
Daiva Domenech Tupinambá
Marília Ieda da Silveira Folegatti Matsuura
Neudes Carvalho da Silva
Ramon Augustus de Lima Menezes

## Introduction

This chapter is related to target 12.7 of Sustainable Development Goal 12 (SDG 12), which aims to promote sustainable public procurement practices in accordance with national policies and priorities. This target is interrelated with the issue of sustainable consumption, discussed in the previous chapter. Here, however, the focus is on the use of governmental institutions purchasing power to promote sustainable development, through bids that no longer take into account only the lowest price, but products and services that have lower environmental impact. This chapter presents the Brazilian Agricultural Research Corporation (Embrapa) contribution to reaching this target by both adhering to sustainable purchasing mechanisms, and carrying out research to collaborate for the development of sustainable products.

## Sustainable procurement: what is it?

The term sustainable purchasing applies to that business relationship in which a supplier of goods, products or services seeks to offer to its customer, along with the main object of the transaction, one or more qualifying elements that have been added to it during production or distribution, and that imply producing economic, social, and environmental advantages for society, so as to directly or indirectly promote global sustainability.

The customer, in turn, attributes a certain value to these elements and adopts them as objective criteria to guide his/her preference in choosing one or other similar product or service.

In this context, sustainable purchasing can be defined as the commercial operation that, besides fulfilling the purpose of the supplier's profit and satisfying the buyer's need, additionally serves interests of a third party: society. The

concept of sustainable purchasing applies to any business relationship, whether it is between individuals, individuals and companies, between two corporations, companies and governments, and so on.

According to Article 3 of Law No. 8.666/1993 (Brasil, 1993), sustainable bidding is the one designed to ensure compliance with the constitutional principle of isonomy, the selection of the most advantageous bid for the administration, and the promotion of sustainable national development (wording given by Law No. 12.349, of 2010) (Brasil, 2010b).

In this sense, it can be said that sustainable public procurement is the formal administrative procedure to use the public sector purchasing power to generate economic and socio-environmental benefits and to contribute to promoting sustainable development by including social, environmental, and economic criteria in acquiring goods, hiring services and performing works.

The implementation of sustainable public procurement (SPP) throughout the world is an initiative of the United Nations Environment Program (UNEP) supported by a global support platform, called the 10-Year Framework of Programmes on Sustainable Consumption and Production (10YFP), which brings together numerous interested parties, creates synergies and leverages resources to reach common goals.

The 10YFP is a global framework to strengthen international efforts to promote durable consumption and production (DCP) in developed and developing countries by supporting regional and national policies and initiatives, by conducting technical and financial assistance programs, and by exchanging knowledge and good practices. The United Nations aims, therefore, to promote the efficient use of resources and the preservation of ecosystems, to fight against poverty, to improve durable goods, and to make tourism a sustainable development force on a world scale over the next 10 years.

## State's purchasing power promoting sustainability

The large purchasing power of governments around the world make it mandatory to promote the adoption of sustainability criteria in public procurement. According to the United Nations Environment Program (Procuring..., 2011), government procurement accounts for significant percentages of a state's gross domestic product (GDP), ranging from 10% to 25% in most countries.

By including value drivers and sustainable criteria in their hiring policies and practices, state entities can influence suppliers to develop services and products that, for example, switch to renewable raw materials and smaller amounts of natural resources, observe the life cycle of products, optimize production methods and adopt low environmental impact logistics, offer systems for product use, operation, maintenance, reuse, and recycling, and, finally, commit to dealing with such consequences throughout the entire cycle of production and consumption (Procuring..., 2006).

It is estimated that the annual expenditures of the Brazilian government on acquiring goods, merchandise and services necessary for its operation reach 15% of the national GDP (Valente, 2011), thus making the State the largest buyer in the country. Using this enormous amount of resources can encourage positive transformations in productive sectors, thus making this relation as a potential instrument for environmental protection and economic and social development.

Promoting sustainable development and including social and environmental responsibility as part of the trade relations between public and private sectors can also contribute to establishing a higher standard ethical behavior, thus benefiting common citizens and forecasting a better future for individuals and their community.

## National policies and priorities regarding sustainable procurement

The 1988 Federal Constitution, according to its Article 225 (Brasil, 1988), has imposed on public authorities and civil society the duty to defend and preserve the right of present and future generations to ecologically balanced environment. Although it does not explicitly mention the term sustainability, the Constitution lists actions related to this concept when, for example, places on the government the duty to "control the production, marketing, and use of techniques, methods, and substances that pose a risk to life, quality of life, and the environment." (our translation).

In 2010, Law No. 8.666/1993 named Public Bids and Contracts Law (Brasil, 1993) included the promotion of sustainable national development as one of the principles that must be guaranteed in public contracts. From that moment on, government purchases were able to include sustainability variables in their planning and execution stages.

It is observed, in the spirit of laws, the desire to highlight the relevance of production and consumption relations, which involve both public authorities and civil society, for the defense of the environment and national development.

Decree No. 7.746/2012 (Brasil, 2012), amended by Decree No. 9.178/2017 (Brasil, 2017), establishes criteria that the federal public authority may adopt in its procurements to promote sustainable national development: I - low impact on natural resources; II - preference for materials and technologies of local origin; III - greater efficiency in natural resources use; IV - greater job creation, preferably on a local scale; V - longer service life and lower maintenance cost; VI - innovations that reduce the pressure on natural resources; VII - sustainable origin of natural resources used; and VIII - use of forest products originating from sustainable forest management or reforestation. State-dependent bodies and companies may also require that goods be made up of renewable, recycled, non-toxic or biodegradable material, among other sustainability criteria.

These criteria reveal national priorities for sustainable public procurement as they address environmental and natural resource management, technological development, and local job creation, as well as reduced deforestation.

It should be noted that the same Decree also established the Interministerial Committee for Sustainability in the Public Administration (Cisap) in order to propose the implementation of sustainable logistics criteria, practices, and actions within public agencies and state-owned companies.

It is expected that this action will strengthen governance and articulation that must exist between different state entities, for the improvement of policies, laws, and norms that govern sustainable purchases.

## Embrapa research on product life cycle assessment

Life Cycle Assessment (LCA) is an environmental impact assessment methodology that is based on material and energy accounting for all production processes in the life cycle of a product – including natural resources extraction, stages of transformation and its use and final disposal. It is scientifically based and standardized by the International Organization for Standardization (ISO), specifically by ISO 14040: 2006 and ISO 14044: 2006 (International Organization for Standardization, 2006a, 2006b), which gives it international recognition.

LCA results can be used to develop and improve processes and products, to devise commercial and communication strategies and to design public policies. Incorporating LCA can expand the traditional focus on input and output analysis by purchasers and be a criterion for procurement decision making that provides a relevant contribution to improving sustainable procurement.

Embrapa plays an important role in national and international communities related to this theme. It is a management committee member and coordinates the Comissão Técnica de Inventários de Ciclo de Vida (Technical Commission on Life Cycle Inventories) of the Programa Brasileiro de Avaliação de Ciclo de Vida (Brazilian Life Cycle Assessment Program – PBACV) of the Ministry of Science, Technology, Innovation and Communications (MCTIC). It is currently the main Brazilian institution contributing to SICV Brasil and Ecoinvent, respectively Brazilian and Swiss life cycle inventory databases.

Embrapa coordinated, for instance, an LCA study that resulted in the BNDES Financing Policy for Integrated Production Plants for Sugarcane and Corn Ethanol (Milanez et al., 2014). At present, Embrapa is leading the construction of a methodological and instrumental framework for the new National Biofuel Policy, named RenovaBio (Brasil, 2017). Invited by the Ministry of Foreign Affairs (MRE), Embrapa takes part in the Alternative Fuels Task Force of the International Civil Aviation Organization (Icao); its main objective is to assess the potential reduction of greenhouse gas emissions by using alternative fuels in aviation.

Embrapa is also involved in designing protocols for environmental statements based on LCA. It actively took part in developing Ordinance No. 100, dated March 7, 2016, of the Instituto Nacional de Metrologia, Qualidade e Tecnologia (National Institute of Metrology, Quality and Technology – Inmetro), which approved the General Requirements for Type III Environmental Labels Program – Environmental Product Declaration (Inmetro, 2016, our translation). In this context, it leads several other initiatives, such as the concept of Carbon Neutral Brazilian Beef (Alves et al., 2015) and the Environmental Labeling of Poultry Meat.

## Public procurement process

Public procurement is the purchasing or service relationship that results from an administrative process carried out within state entities in order to meet immediate needs for goods, products or services of the public administration, by treating competitors equally. It should be pointed out that, under the terms of Article 37,

item XXI, of the 1988 Federal Constitution (Brasil, 1988), and of Article 2 of Law No. 8.666/1993 (Brasil, 1993), public procurement provided by third parties must be selected by bidding process, except for the cases provided by law (exemption or non-enforceability).

According to Mendes (2012), the cycle of public procurement is divided into three considerably distinct phases: the internal phase, during which contracting is planned; the external one, in which procedures for supplier selection are developed; and the contractual agreement, which seeks to ensure compliance by both parties with the agreed commercial conditions.

The internal phase obviously stands out as the most favorable stage for including sustainability criteria in public procurement processes. At this stage, the administration identifies its needs, declares the willingness to procure, and defines criteria to meet its demand based on law. This implies that such criteria be legally permitted and properly internalized in the organization's culture and policy.

## Sustainable procurement and its evolution at Embrapa

Tied to the overriding need for strictly observing the law while conducting administrative processes, procurement protocols at Embrapa developed simultaneously with the slow modernization of the legal framework that regulates public procurement in Brazil. Historically, Embrapa procurements were based on more traditional economic rules, in which price was preponderant and determined any product or service procurement.

Since 2010, Embrapa has been seeking to improve governance and public procurement models and corporate practices. It has strengthened its tactical managerial perspective, started adopting objective sustainability criteria when acquiring common goods and merchandise, and made corporate purchases that favored the standardized adoption of these criteria.

As of 2014, Embrapa sought to improve contract management processes and supply chain efficiency, carried out projects and implemented effective actions related to governmental programs of the Projeto Esplanada Sustentável (Sustainable Esplanade Project – PES), the Programa de Gestão de Logística Sustentável (Sustainable Logistics Management Plan – PLS), the Plano de Gerenciamento de

Resíduos Sólidos (Solid Waste Management Plan – PGRS) and spending efficiency programs.

At Embrapa, we observe a gradual development of an organizational environmental culture that emphasizes the value of socio-environmental responsibility and strongly induces knowledge and technology production for an agricultural sector that increasingly preserves natural resources, thus generating less environmental impact.

Embrapa's internal production process is also based on this developing culture, and is driven to seek more environmentally efficient means of producing results, either by reducing waste production, recycling, reusing, or promoting sustainable public procurement.

Therefore, addressing sustainability depends on what Embrapa produces, and also on how it produces it, within the ideals contained in its first impact axis, which includes a quest for sustainability in all its technical, economic, social, and environmental dimensions (Embrapa, 2015).

Particularly for sustainable procurement, Embrapa has prepared a *Guia Prático de Licitações Sustentáveis* (Practical Guide for Sustainable Biddings, available only in Portuguese) that will be published in 2018 as a joint initiative of the following Embrapa departments: Sustainability, Quality and Environment Management Coordination (CSA) and Procurement and Contract Coordination (CCS), both belonging to the Department of Assets and Supplies.

As of 2018, in accordance with the State Responsibility Law, Law No. 13.303/2017 (Brasil, 2016), Embrapa will now have its own regulation to public biddings and contracts, in which its fundamental guidelines for conducting sustainable purchases will be stated. In another aspect, after restructuring the Company and following a world trend, norms for social responsibility, such as ISO 26000 and ISO 20400 (Associação Brasileira de Normas Técnicas, 2010, 2017), which deal with sustainable procurement and provide guidelines for including sustainability in procurement process, will be important tools for improving sustainable procurement at Embrapa.

## Waste management and corporate sustainability

Corporate sustainability can be defined as sustainable development applied to companies, which must map the environmental impacts generated by their activities, seeking ways to mitigate them (Veloso; Agostinho, 2017). The Sustainable Development Goals (SDG) gather social demands and pose

future challenges for the business sector in the quest for sustainability of its activities.

At the core these changes, issues such as reverse logistics and solid waste management are part of the current reality of sustainable enterprises.

Reverse logistics as defined by Law No. 12.305/2010 (Brasil, 2010a) – which established the Política Nacional de Resíduos Sólidos (National Solid Waste Policy – PNRS) – is an instrument of economic and social development based on a set of actions, procedures and means to collect and deliver of solid waste back to companies, either for reusing or environmentally adequate final disposal. This sustainable practice, in addition to complying with current environmental legislation, generated positive financial gains for companies and gave a competitive edge in relation to other unsustainable companies (Shibao, 2010).

Solid waste management was defined in the same law as the

> [...] set of actions directly or indirectly carried out in the collection, transportation, transshipment, treatment, and environmentally correct final disposal of solid waste and tailings, in accordance with municipal plan for integrated solid waste management or with solid waste management plan [...] (Brasil, 2010a).

Its main objectives are solid waste non-generation, reduction, reusing, recycling, and treatment and its environmentally adequate final disposal. One of the main tools to assist in the implementation of a solid waste management system is PGRS. This legally binding document must be adopted at all levels of public administration: PNRS, states and municipalities, and all companies classified as large waste generators, whether it is basic sanitation, industrial , healthcare, civil construction, agrossilvopastoral, transportation and mining waste. In addition, solid waste management is mandatory to obtain operation license from the environmental agency.

In compliance with the current environmental legislation, Embrapa has developed an institutional model of PGRS for all its Units. After having mapped the process, local sustainability committees were created to draft and implement the documents. At the end of 2017, all Embrapa Units had a single, standardized document with the diagnosis of their waste management processes, as a first step for implementing and developing the Embrapa Environmental Management System, based on ISO 14001 (Associação Brasileira de Normas Técnicas, 1996),

which presents the requirements and guidelines for the implementation of an Environmental Management System in companies and also presents itself as a powerful tool in the quest for corporate sustainability.

## Final considerations

Through its research, development, and innovation activities on applied methodologies to LCA of products, Embrapa contributes with the improvement of global sustainable procurement practices.

Internally, a normative basis for adopting sustainability criteria in public purchases of goods, merchandise, and services that Embrapa acquires in order to make its operations feasible has been formed in recent years. These actions will result, in 2018, in the publication of a specific regulation of biddings and contracts, as well as in a practical guide on sustainable biddings, which will be followed by other actions.

Sustainable procurement and biddings play a strategic role as public agencies promote sustainability, which generates social, economic, and environmental benefits, and foster the sustainable market for public goods and services, innovation and competitiveness of the local and national industry.

Entrepreneurial and innovative approaches in public administration are increasingly needed. Embrapa, committed to the Sustainable Development Goals (SDG) in general, and to target 12.7 in particular, has sought to promote sustainable public procurement practices in accordance with national policies and priorities.

The development of this theme in Embrapa includes new challenges that basically deal with the development of permanent actions incorporated into the daily life and culture of the Company, with dynamic processes to improve expenses reduction and purchases and contracting prioritization. This demands that all employees are engaged in the process, aiming at the consolidated establishment of a sustainable standard.

Based on its most important values, Embrapa launches a new perspective on worldwide issues from a responsible sustainability standpoint, focusing on innovation, on collective actions, and on planetary welfare.

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Chapter 9

# Information for citizenship action and sustainable development promotion

Elizabete Antunes
Vânia Beatriz Vasconcelos de Oliveira
Rosana Guedes C. Ramos
Juliana Escobar
Joanne Régis Costa
Ronessa Bartolomeu de Souza
Caroline Machado V. Turazi

## Introduction

This chapter is related to target 12.8, which aims to ensure that, by 2040, people everywhere have relevant information and awareness for sustainable development and lifestyles in harmony with nature. Based on the mission and guidelines of the Brazilian Agricultural Research Corporation (Embrapa) and the technological solutions it provides, the focus is mainly on delivering information from scientific research results, the source of which is the scientific researcher, who is the spokesperson for relevant information that should reach people everywhere. Other important social actors in this process are professionals working in communication and education who, based on this information, will express it under different forms, in order to encourage consumer taking citizenship action. This important link in the productive chain also represents the ordinary citizen who is required to act in favor of sustainable development.

## Context

Providing access to information for all people everywhere seems to be an easily attained goal within the contemporary communicative context in which digital culture takes over, transporting information at instant speed. However, according to Dowbor (2017), producing and disseminating information, in compendiums of statistics and in fragmented media, by countless public institutions and civil society organizations, led to a gap in this process: technologies and basic information are available, but tools for organized knowledge for citizenship action were not created.

For Dowbor, an information network for citizenship action involves discussing a series of tools to create a broad and diversified process. Corporate support to information for citizenship initiatives is among the 11 tools mentioned by the author. Another aspect to be taken into consideration is the communicative character of our time, which inexorably implies multiple interaction between user-audience and screens (Gómez, 2014). The author refers to the daily interactions between citizens, which the author identifies as communicative citizenship, a concept that goes beyond the rights and obligations of citizens, and is based on from two issues: what citizens should learn from what comes from the screens and how to facilitate this learning (Gómez, 2014).

It is within this context that the initiatives of organizing and disseminating Embrapa's information on socio-environmental responsibility and commitment to promoting sustainable development are developed.

## Problem

The chaotic context described above, caused by the large amount of information generated by various sources, is aggravated by content self-production. This, in turn, is facilitated by access to information and communication technologies (ICTs) and social networks. That is, the ordinary citizen is much more likely to produce and disseminate his own information, but, at the same time, as a reader, listener, interacting viewer, this large amount of information leaves him confused, in doubt as to how to act or, on the opposite end, convinced that his decisions were the right ones, because of the greater or lesser degree of credibility he attributes to sources to which he had access.

Embrapa, as a public company and source of scientific knowledge, must offer it to different audiences (technicians, farmers, students in areas related to its field of activity and ordinary citizens as consumers). To this end, Embrapa operates on two internally and externally interrelated fronts: communication management and technology transfer, and educational training processes to qualify peer educators. Topics related to sustainable development are varied: responsible consumption, environmental restoration, agroecology, organic production, soil and water conservation, environmental education, recycling, adequate waste disposal, among others. Teaching/learning modalities used are very diverse: on-site, distance/semi-distance learning, as well as conferences, symposiums, seminars, courses, lectures, video-lessons, hotsites, field days, workshops, among others.

In order to follow trends and face challenges posed by scientific information management and dissemination, Embrapa is aware of the technological revolution over the last decades, marked by accelerated computerization and digitization of procedures, previously performed in manual or analog modes, and by the development of new information and communication technologies (ICTs).

This chapter seeks to make explicit Embrapa's actions to disseminate technical-scientific knowledge it generates, and thus contributes to ensuring that people everywhere have access to relevant information and be aware of sustainable development and lifestyles in harmony with nature.

## How does Embrapa promote its work?

Embrapa coordinates several initiatives on knowledge management and technical and scientific information organization and availability aimed at both peers (researchers and scientists) and the lay audience (various segments of Brazilian society, among which we highlight agriculturalists, rural technicians, rural extension technicians and other agents involved in agricultural production chains, young and small-scale family farmers, teachers and students of different schooling levels, as well as children and adolescents, entrepreneurs and opinion takers) (Embrapa, 2015).

### *Scientific dissemination and science popularization*

Embrapa publishes electronic books (e-books) in specific format for reading on small screens of mobile devices such as tablets and cell phones. Audio and video content has been digitized and is freely available on the Internet. Embrapa's technical-scientific production, once accessible only in printed form in libraries, has become available to Internet users around the world through online repositories with open access to information.

In order to reveal Embrapa efforts to provide society with relevant information and to promote citizen awareness for sustainable development, we present here a summary of our main actions to popularize science and disseminate scientific knowledge.

**Internet** – Embrapa seeks to follow the best digital practices, and one of its main advances in communicating with the general public was the improvement of its digital environments centralized on Embrapa Portal. Embrapa has also joined

the universe of online social networks; it has institutional profiles and channels: twitter.com/embrapa, youtube.com/embrapa and flickr.com/embrapa.

All the online information products aimed at the external audience, as well as citizen support services, are accessible at Embrapa Portal, which also includes a corporate intranet for Embrapa employees and associates. Moreover, its portal holds special pages and websites to make specific information easily accessible and to generate value for users.

In 2016, the Embrapa Portal ranked first in Latin America in the world web ranking of research centers (Webmoetrics), ranking 36th in the overall ranking of that year. In Embrapa Portal, farmers and technicians can quickly access methods and experiences developed by the Company and its partners to promote sustainable development in the different Brazilian biomes, as well as good agricultural practices for sustainable land use. Therefore, research results to promote agricultural sustainability development and innovation are within reach of a click.

Through Embrapa Portal, the user can access all digital information products and services offered by the Company, presented below.

**Scientific dissemination to peers (scientists and researchers)** – Releasing journals to disseminate original technical-scientific works for professors, researchers, and students in related fields as priority audiences is a constant activity of Embrapa. Among these journals are the *Brazilian Journal of Agricultural Research* (*PAB*) and *Cadernos de Ciência & Tecnologia* (*Science and Technology Journal – CC&T*).

On a monthly basis, *PAB* welcomes unpublished works in fields such as Plant Physiology, Plant Pathology, Crop Science, Genetics, Soil Science, Food Technology, and Animal Science, among others. All of its editions are available on www.embrapa.br/pab. *CC&T* proposes to reflect and debate on agricultural development in its social, economic, environmental, cultural, and political aspects. All volumes, published quarterly, are also available for free online access.

Another editorial line is made up of serial releases that are available to society in general at Embrapa Portal. They are: *Circular Técnica* (*Technical Newsletter*), *Comunicado Técnico* (*Technical Bulletin*), *Boletim de Pesquisa e Desenvolvimento* (*Research and Development Bulletin*), *Série Textos para Discussão* (*Texts for Discussion Series*) and *Série Documentos* (*Documents Series*).

**Democratic access to scientific knowledge** – Embrapa has conceived, created, and is the coordinator of an open access to the technical-scientific information project, made up of *Embrapa's Open Access Repository to Scientific Information* (*Alice*) and *Repository for Technological Information of Embrapa* (*Infoteca-e*), which make editorial content of Embrapa available for reading and free downloads. Also joining the project is the *Open Integrated Information System in Agriculture* (*Sabiia*), an automated search engine that collects and centralizes information offered by national and international institutions that, like Embrapa, are committed to free access to scientific information.

**Printed and electronic publications** – The concern to offer qualified information to varied reader profiles translates into the multiple options of Embrapa catalog of publications that, in addition to hundreds of individual titles, includes collections focused on specific topics or designed for specific audiences. Among them are those focused on sustainable development and manufacturing methods in harmony with nature, created in the 2000s, in tune with the most pressing themes in the field of diversity and sustainability in the countryside: the Coleção Povos e Comunidades Tradicionais (Traditional Peoples and Communities Collection); the Coleção Transição Agroecológica (Agroecological Transition Collection) and the Coleção Direito Ambiental (Environmental Law Collection). They add to the already traditional series: Coleção Plantar (Planting Collection); Coleção Saber (Knowing Collection); Coleção ABC da Agricultura Familiar (ABC of Family Farming Collection); Coleção Agroindústria de Alimentos (Food Agroindustry Collection) and the Coleção 500 Perguntas 500 Respostas (500 Questions 500 Answers Collection) and the series Sistemas de Produção Embrapa (Embrapa Production Systems – SPE).

It is also worth mentioning the editorial projects aimed at children and adolescents, such as the Coleção Educação e Cidadania (Education and Citizenship Collection), in eight volumes, Cartilha dos Jogos Ambientais da Ema (Ema Environmental Games Booklet), in seven volumes, Almanaque Hortaliça (Greenery Almanac), in five volumes, and Hortaliças para Crianças (Greenery for Children), in three volumes.

On the Embrapa Bookstore Website, all Embrapa publications can be purchased in print, and some are also available as e-books.

The Agência de Informação Tecnológica (Technology Information Agency – Ageitec), in turn, is a serial online publication. Each volume is called Knowledge Tree and is focused on a specific theme, whose content follows the three stages of the productive chain: pre-production, production, and post-production.

**Audiovisual production** – Prosa Rural was created in 2003 aiming at bringing information about technological solutions developed by Embrapa and its partners to the illiterate population. Thus, in 2006, the four regionalized programming grids of the program (North, South, Center-West, and Northeast/Jequitinhonha Valley) were established. It is weekly and broadcasted by a network of partner stations distributed throughout Brazil. Its collection of over 2 thousand programs is also available online at Prosa Web Radio Station and, through Prosa Rural App, launched in 2017, is available to everyone who owns cell phones or other mobile devices.

The Dia de Campo na TV program (DCTV), created in 1998, is rebroadcasted throughout Brazil by Canal Rural and by other 55 stations that operate by parabolic signal. The news stories and segments that compose it are available at DCTV Channel on YouTube. Covering varied themes, DCTV seeks to cover all research areas aiming at disseminating technologies developed by Embrapa and partners for different audiences.

**Support for formal education** – The Minibibliotecas (Mini-libraries) are an extra-curricular initiative that seeks to popularize technical-scientific knowledge produced by Embrapa by means of printed and audiovisual publications in order to support both extension specialists and educators who work in the regular education system, focusing on agricultural and rural schools. Based on this strategy, Embrapa started training community leaders to use its Mini-libraries and encourage the rural population to read agricultural publications. On its website, there is an online bookshelf with the main titles that make up the Mini-libraries collection.

Another online-only initiative for science dissemination aimed at children and adolescents during school time is the website Contando Ciência na Web (CCWeb), which, by means of games, illustrations, texts, audios, videos, and publications, tries to adjust information related to agriculture and livestock for this audience. In addition to the website, there is the Embrapa & School program, a historical effort of Embrapa to approach and guide children's audience. The program reaches thousands of students each year through lectures, visits, and activities in events.

## Relationship with the media

One of the great communication challenges for a science and technology company is to provide knowledge and scientific research results to everyone who can benefit from them. At Embrapa, the communication is aligned with the

objectives, guidelines, and impact axes described in its Master Plan (PDE) and integrated with the decision-making process.

The cross-cutting communication actions help support research and development, technology transfer, and institutional development macro-processes, seeking to promote debate and interaction and to encourage harmony in the relationships between Embrapa and its audiences.

Embrapa keeps a relationship with the press that has been very efficient throughout its history. This is integrated with Embrapa News Agency, which weekly releases new stories and send them to more than 4,500 subscribers, most of them journalists.

In addition, Embrapa keeps its own media. One of them is the portal, which is updated daily and gathers news from all Embrapa Units. Each Unit has its own portal, and all are articulated in a network. Another media is the Conexão Ciência (Science Connection) TV program, produced with NBR TV, the federal government channel. There, new interviews with scientists on a subject of relevant public interest are presented weekly.

Another media action is the *XXI – Ciência para a Vida (Science for Life)* mag*azine*, available on the Internet. It addresses in depth major research topics carried out by Embrapa throughout Brazil. To monitor what is published in the press, Embrapa has a clipping service that checks about 1,500 print and online vehicles, of general and specialized interest.

## Promoting and attending events

Promoting conferences, seminars, fairs, and exhibitions, as well as field days, lectures and trainings, and taking part in events organized by third parties are among the actions that materialize Embrapa's efforts to offer society relevant information and to raise citizen awareness on sustainable development and lifestyles in harmony with nature.

Embrapa's participation in agricultural fairs and exhibitions is important to consolidate its image and strengthen its relationship with strategic audiences, such as rural extension technicians, farmers, cooperatives, congresspersons, and opinion leaders, so that all Brazilian regions are represented and diverse themes are addressed; thus, Embrapa technologies can be present in the main agricultural production chains.

We highlight the participation of Embrapa in the following agricultural fairs:

- *ShowRural Coopavel* (Cascavel/state of Paraná) – This is considered the agricultural fair with the best market return due to the volume of business generated, number of farmers and technicians present, and diversity of topics addressed.
- *Expodireto Cotrijal* (Não-me-Toque/state of Rio Grande do Sul) – This fair has been growing in commercial and political importance every year, attracting mainly audiences from Mercosul countries.
- *Tecnoshow Comigo* (Rio Verde/state of Goiás) – This is a major event of nationwide impact, focused on the agricultural reality of the central region of Brazil.
- *Agrishow* (Ribeirão Preto/state of São Paulo) – This is a prominent event in the agricultural machinery and equipment sector, where Embrapa maintains a Technological Reference Unit (TRU) for integrated crop-forest-livestock system (ICLF).
- *Expozebu Dinâmica* (Uberaba/state of Minas Gerais) – This is a recent event, which is held separately from *Expozebu*. Embrapa attends it since its first edition, focusing on livestock and strong methodological appeal for livestock dynamics, with guided technology presentations, training courses, and technological circuits.
- *Agrotins* (Palmas/state of Tocantins) – This is the main agricultural event in the Matopiba (an acronym of Maranhão, Tocantins, Piauí and Bahia states) region, where Embrapa maintains a TRU of ICLF and a technological showcase.
- *Agrobrasília* (Brasília/Federal District) – This is considered one of the great agricultural events of the Midwestern region.
- *Bahia Farm Show* (Luis Eduardo Magalhães/state of Bahia) – Second largest agricultural event in the Matopiba region, it gathers a large number of agricultural sector authorities and attracts a significant amount of farmers and technicians (mainly from the private sector).
- *Expointer* (Esteio, state of Rio Grande do Sul) – This is the main exhibition focused on livestock located in Brazil's Southern region.

In addition, Embrapa is invited annually to attend major events of governmental programs and technical-scientific events. We highlight Embrapa's participation

in governmental educational programs, such as the national conferences to the youth on the environment, *National Environment Week* and *National Science and Technology Week*, promoted by the Ministry of Science, Technology, Innovation and Communications (MCTIC) since 2004. The objectives are to raise people's, especially children and young people's, awareness on themes and activities pertaining Science and Technology (S&T); to value creativity, scientific attitude and innovation; and to help the population to know and discuss scientific research results, relevance and impacts.

## Peer educators training

Embrapa seeks to expand training and qualification of peer educators in technical assistance and rural extension programs in order to promote technology transfer and updated priority area knowledge exchange and construction. Embrapa does not directly provide technical assistance and/or rural extension, but it needs such processes to fulfill its mission of promoting development. Expanding and strengthening partnerships through peer educator training provide access to information and facilitates the incorporation of technological solutions in productive systems.

In the group of peer educators, there are technicians from public and private Technical Assistance and Rural Extension (Ater) agencies, cooperatives, associations, rural unions, non-governmental organizations (NGOs), and other agents that work directly with farmers throughout Brazil to present them technological solutions to be adopted.

The qualification of peer educators involves several methodological practices also connected with public policies or emergency needs to solve a problem in a given context or region. For instance, Embrapa carries out caravans to train extension agents and technical assistance professionals, during which Embrapa researchers travel through Brazil to assist farmer with implementing emergency actions to solve some problem, as happened in 2013–2014 to control *Helicoverpa* and other pests, in which occasion the adoption of integrated pest management (IPM) was also encouraged. Training courses are not restricted to national borders; they may also be provided in partnerships with other countries that seek Embrapa knowledge to enhance its development, such as:

- Training of Mexican technicians in the scope of the Projeto Formação de Técnicos Especializados em Agricultura, Pecuária e Silvicultura Tropical para o Desenvolvimento das Zonas Tropicais do México (Training Project

of Specialized Technicians in Tropical Agriculture, Livestock and Forestry for the Development of the Tropical Zones of Mexico). The partners in this action were the Mexican Agency for International Development Cooperation (AMEXCID); the National Institute for *Forestry, Agriculture, and Livestock Research* (INIFAP); the Ministry of Foreign Affairs/Brazilian Cooperation Agency (MRE / ABC) and Embrapa.

- Training of technicians from Mozambique taking part in the Projeto de Apoio aos Programas de Segurança Alimentar e Nutricional de Moçambique (Mozambique Food and Nutrition Security Programme Support Project – Psal), which is part of a trilateral technical cooperation between Mozambique, Brazil, and the United States.

Disseminating knowledge generated at Embrapa through peer educators enables small-scale farmers and their families to access to technical assistance and rural extension services and information that leads to sustainable local development.

## Collective information production for citizenship action

Although still incipient, we identify some Embrapa initiatives to promote multiple interaction (audience-users-screens) towards communicative citizenship. For Gómez (2014, p. 96, our translation), communicative citizenship is relevant and "[...] must be fundamentally addressed based on education as one of the most precious objects of human and democratic formation today." In this education and information production process, it is also essential to give voice to people who are major players of sustainable development, be they traditional populations or ordinary citizens.

In training events (meetings, courses, workshops, etc.), multiple face-to-face interactions enable the construction of new meanings of the addressed themes. As an example, the Traditional Peoples and Communities Collection, launched in 2017, resulted from a collective information production. It gathers experience reports on work performed with rural communities and their traditional knowledge throughout the country. Another very important editorial publication that provides citizens with relevant information to guide them to take action is the Coleção Educação Ambiental para o Desenvolvimento Sustentável (Environmental Education for Sustainable Development Collection), launched at the *Rio +12 Conference*. It addresses the construction of macro-education pedagogical and

methodological proposal, discussing how to see, judge, and act on the perception of environmental impact and culminating in the debate on socio-environmental responsibility of companies and schools.

Collective production, in this interaction process, refers not only to editorial procedures but, above all, to debating and creating a discourse that contemplates the perception and role of the social agents involved. An example of this is the methodological proposal for the production of environmental videos after participants have interacted and analyzed the literary-cultural discourse of Amazonian artists to address topics such as: deforestation, wildfires, climate change, and, above all, local socio-biodiversity appreciation. Similar experiences involve different types of audience, from extractive farmers to elementary urban school students (Oliveira, 2017). Results show the possibility of communicating and educating in non-formal educational context, as is the case of rural/forest extension activities, whose objective is to disseminate technological solutions on environmental conservation and to encourage citizenship action for sustainable development.

In both cases, interactants co-construct meaning in various ways and fulfill different functions, either as speakers, as interlocutors, or as mediators of speeches from different sources: family farmers, environmental educators, researchers, journalists, writers and interpreters creating their own discourse, to be expressed by varied forms of communication, including the interpersonal one.

## Final considerations

Faced with the challenge of reaching relevant information to all people everywhere by 2040, this chapter addressed conceptual aspects related to scientific communication in order to encourage citizenship action in favor of sustainable development and communicative citizenship, which calls into question what citizens should learn (from what reaches them by the media) and how to facilitate this learning. It is, therefore, an old question related to the means and the reception of what is transmitted by them, which in communication science is called mediatization.

While organizing information about the contribution of Embrapa for scientific dissemination and popularization of science, we have seen that Embrapa proposes and coordinates editorial products and services created according to the audience, in a process that includes adjusting the language to the target

audience; choosing data (text, image, audio, video) presentation format; and defining both the support (print, electronic, digital, online) and the means of communication to be used (book, journal, leaflet, radio or television broadcast, Internet).

Embrapa uses varied resources so that information can reach the most diverse citizen profiles, from researchers who hold doctoral degrees and are polyglots to technicians specialized in some area of the agricultural field, educators, students and others interested in these topics. As discussed above, there are also actions to reach the illiterate and unlearned portion of the population, such as institutional radio and television programs.

This is how Embrapa provides society with relevant information capable of raising awareness about sustainable development and lifestyles in harmony with nature. A future challenge is to expand interaction with the audience and articulate with other information subsystems, of both State entities and civil society organizations, thus allowing an integrated vision of the progress or difficulties in each community, city or region.

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Chapter 10

# Progress and future challenges

Julio Cesar Pascale Palhares
Rachel Bardy Prado

## Introduction

Brazilian agricultural research faces many challenges to promote sustainable development, among which are systematizing all knowledge created, standardizing and integrating methods, transforming knowledge into solutions to be directly used by society, gathering enough financial resources, bringing scientists and decision makers closer together, among others.

Based on its research results, the mission of Embrapa is to contribute to the development of agriculture while ensuring the sustainability of rural environments.

The program Embrapa Agropensa surveyed megatrends for Brazilian agriculture. Among these, those related to the targets of Sustainable Development Goal 12 (SDG 12) are shown in Table 1.

## Knowledge creation regarding sustainable consumption and production

Due to its widespread geographical reach, Embrapa has Units focused specifically on the problems of large Brazilian ecoregions or natural resources such as Embrapa Eastern and Western Amazon, Embrapa Coastal Tablelands, Embrapa Cerrados, Embrapa Pantanal, Embrapa Soils, Embrapa Forestry, Embrapa Environment, Embrapa Mid-North, Embrapa Temperate Agriculture, etc. Because Embrapa project portfolio is organized according to relevant theme networks, the Company has been operating and contributing to address several issues related to SDG12.

Some networks are worth mentioning, named Portfolio and Arrangements by Embrapa, such as:

**Portfolios** – Climate change, biological control, coexistence with drought, integrated crop-livestock-forest system, rational pesticide management, land use and coverage dynamics monitoring, native forest resources, ecologically based production systems.

**Table 1.** Megatrends for Brazilian agriculture and its connections to SDG 12 targets.

| Target | Megatrend |
|---|---|
| 12.2 | Expanding the use of integrated and sustainable agricultural production systems, aiming at reducing environmental and economic risks and increasing productivity and profitability.<br>Carrying out studies and performing agricultural practices that lead to increased efficiency of input use in agricultural systems.<br>Devising indicators and socio-environmental certification protocols for farms and rural products, seeking to increase process efficiency and reduce environmental impacts.<br>Developing alternative nutrient sources and expanding the use of biological nitrogen fixation (BNF) to a larger number of plant species.<br>Developing technologies and protocols to recover degraded agricultural areas for production or conservation purposes, and encouraging the creation of tools to support the implementation of incentive programs to encourage restoration of degraded areas. |
| 12.3 | Developing technologies for easy handling and convenience as features of food, as demanded by the growing urban population.<br>Ensuring a systemic perspective while developing new technologies, so that all links of productive chains are covered and final consumer and their demands and preferences are met.<br>Developing technologies to reduce agricultural product post-harvest losses.<br>Supporting public policies and programs to reduce food loss and waste (FLW). |
| 12.4 | Developing technologies and systematically arranging knowledge that contribute to generating data and information on soil and water resource use and conservation. |
| 12.5 | Developing value-adding technologies for co-products, wastes, and effluents from different chains.<br>Optimizing the use of agricultural waste and developing new processes for the management and use of animal production waste.<br>Encouraging the development of new initiatives and processes to help reduce product and input losses in agricultural production chains. |
| 12.8 | Developing more integrated processes for the use of open standards that allow data communication and information in all domains (rural/rural – rural/urban).<br>Expanding the adoption of strategies to develop Crowd Science or citizen science, to appreciate and incorporate external knowledge about processes and phenomena analyzed and/or to validate results and products from research projects.<br>Creating and systematically arranging knowledge and tools to support the implementation of programs to disseminate good agricultural practices.<br>Supporting the restructuring of Technical Assistance and Rural Extension organizations to promote regionalized technology transfer actions. |

**Arrangements** – Environmental services in the rural landscape; conservation and sustainable use of bee genetic resources in agroecosystems and impacts on Brazilian agribusiness; strengthening of rainfed family farming systems in the Brazilian semi-arid region; technological innovations for sustainable agricultural production in protected environment; agroecological innovation: knowledge creation and exchange with family agriculture in the Northeast region of Brazil; agroecological systems as an alternative for the development of family farming in the Midwest; monitoring of forest deforestation and degradation and ecosystem services; family agriculture without burning the Amazon; technology generation, improvement, and transfer for sustainable production of coconut and its by-products in Brazil; knowledge creation and exchange for sustainable development of traditional peoples and communities; sustainable diversification of grain production in the lowlands of Rio Grande do Sul; communication network to strengthen the image of Embrapa as a reference in sustainable technologies for the Amazon, among others.

Sustainable technologies and solutions for rural areas have been created, validated, disseminated, and adopted based not only on Embrapa research, but also on partnerships with different sectors and agents in society, such as rural extension, farmers, agro-industries, private companies, governmental organizations (at federal, state and municipal levels) and non-governmental organizations, universities, river basin committees, among others. These theme networks have been working in Brazil and abroad, in an interdisciplinary way, in favor of more sustainable consumption and production based on different methodological approaches and scales of work.

## Final considerations

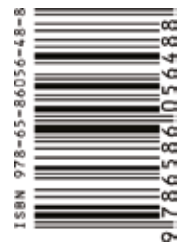
Based on new approaches and understandings of food production multidimensionality, new paths can lead to sustainable consumption and production, providing: increase in production and productivity rates, taking ecosystem support capacity into consideration; knowledge and technologies for greater productive, social, cultural, ecological, and economic system efficiency; agriculture-livestock integration, resulting in more environmentally balanced, nutrient and energy efficient and lower environmentally impacting systems; perception and understanding of dimensions, flows and interactions within production systems and with their surroundings; closer science, agriculture and society interactions in order to answer questions, propose actions and assess sustainably relevant interventions; other social segments better understanding

of agricultural activity, greater appreciation for its social capital and reduction of social and environmental conflicts; placement of humans in agriculture not only as a producer, but also as part of a system that, in addition to producing, plays the role of maintaining the ecological basis and social structure; sound public institutions that can meet the needs of agriculture and citizens; companies with greater social reach, resulting in economic, environmental and social benefits; stronger democracy, with less social conflict.

Embrapa

MINISTRY OF
AGRICULTURE, LIVESTOCK
AND FOOD SUPPLY

PÁTRIA AMADA
BRASIL
BRAZILIAN GOVERNMENT

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