SUSTAINABLE
DEVELOPMENT
GOAL

11

SUSTAINABLE CITIES AND COMMUNITIES

CONTRIBUTIONS OF EMBRAPA

Joanne Régis Costa
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Technical Editors

Embrapa

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

Sustainable Development Goal 11

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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 transversal themes for the 17 goals. This collection of books, one for each SDG, helps society realize the importance of agriculture and food in five priority dimensions – people, planet, prosperity, peace and partnerships –, the so-called 5 Ps of 2030 Agenda.

This collection is part of the effort to disseminate 2030 Agenda at Embrapa while presenting to the global society some contributions 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
Presidente da Embrapa

Preface

The Sustainable Development Goals (SDG) are an agenda designed at the UN Sustainable Development Summit 2015 comprised of 17 goals and 169 targets to be achieved by 2030. It is a universal agreement to foster sustainable changes, such as: to end poverty, to conserve the planet and to live a peaceful and prosperous life. The SDGs are based on Millennium Development Goals (MDGs), aiming to complete them, combine and expand activities so as to meet new challenges.

SDG 11 addresses sustainable cities and communities because of the urgent need to transform the way in which human settlements take place by means of using, constructing and managing urban and peri-urban spaces and their relationships with rural areas. This SDG focuses on making cities and human settlements inclusive, safe, resilient and sustainable.

This book addresses the contributions of Embrapa related to the targets that address SDG 11, assuming that cities, within a sustainability agenda, cannot be seen as spots on the map, but should be analyzed based on their interaction with other areas or regions with which they interact.

Technologies and other actions dealing with territorial planning and management, basic services, protection of world cultural and natural heritage, and disaster risk reduction that can contribute to SDG 11 are presented.

The five chapters of this book address the set of efforts of Embrapa to contribute to food security and to resilience of urban and rural areas, taking preventive and corrective action, facing the challenges of sustainable urbanization.

Technical Editors

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Chapter 1

Urbanization: perspectives and trends

Joanne Régis Costa
Patricia da Costa

Introduction

The United Nations predicts that the world's population will continue to rise in the coming decades, reaching 8.3 billion by 2030 and 8.9 billion by 2050. Subsequently, global population will stabilize at about 9 billion. Compared with an estimated 7.4 billion by 2015, 1.5 billion people would thus be added to the world population by 2050, even if fertility instantaneously reaches replacement levels and mortality remains constant at the levels observed in 2010-2015. The UN World Population Outlook for 2017 is the 25th round of United Nations population official estimates and projections prepared by the Population Division of the UN Department of Economic and Social Affairs (The impact..., 2017).

In this context, the impossibility of remaining with the current development model is visible. It is necessary to go for a type of development that integrates the social, environmental and economic dimensions, that is inclusive, offers security and sustainability.

The 2030 Agenda is multidisciplinary, urgent and requires numerous strategies to promote the transformation of the planet. Specifically about Sustainable Development Goal 11 (SDG 11), addressed in this book, the Agenda refers to building more just, democratic, safe, resilient and sustainable cities.

The targets, established within the scope of this objective, related to the mission of the Brazilian Agricultural Research Corporation (Embrapa), are presented in Table 1.

Urbanization

Urbanization was associated with a movement that reached substantial complexity levels, to the point of being considered as the most important contemporary phenomenon, since more than half of the world population resides in urban environments. According to 2050 projections by the United Nations Human Settlements Program (State..., 2008), cities will to hold 70% of humanity.

Table 1. SDG 11 targets related to Embrapa mission and respective indicators.

Target	Indicator
11.1 – By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	11.1.1 – Proportion of urban population living in slums, informal settlements or inadequate housing
11.3 – By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	11.3.1 – Ratio of land consumption rate to population growth rate 11.3.2 – Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically
11.4 – Strengthen efforts to protect and safeguard the world's cultural and natural heritage	11.4.1 – Total expenditure (public and private) per capita spent on the preservation, protection and conservation of all cultural and natural heritage, by type of heritage (cultural, natural, mixed and WHC designation), governmental level (national, regional and local/municipal), type of expenditure (operational or investment) and type of private financing (donations, private non-profit organizations and sponsorship)
11.6 – By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	11.6.1 – Proportion of urban solid waste regularly collected and with adequate final discharge out of total urban solid waste generated by cities 11.6.2 – Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted)
11.A – Support positive economic, social and environmental links between urban, peri-urban, and rural areas, by strengthening national and regional development planning	11.A.1 – Proportion of population living in cities that implement urban and regional development plans integrating population projections and resource needs by size of city
11.B – By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disaster; and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030[(1)], holistic disaster risk management at all levels	11.B.1 – Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015-2030

[(1)] Framework agreed upon at the Third UN World Conference in 2015 in Japan.
Source: Nações Unidas (2016).

At the *Third United Nations Conference on Housing and Sustainable Urban Development* (Habitat III) held in 2016, 167 countries adopted the New Urban Agenda (NUA), which aims to guide urbanization policy for the next 20 years. The NUA points out that by 2050, the world's urban population will almost double, making urbanization one of the most transformative trends of the 21st century (Nações Unidas, 2016).

The 2014 revision of the World Urbanization Prospects (World..., 2014) states that the world's urban population has grown rapidly from 746 million in 1950 to 3.9 billion in 2014, and that Asia, despite its lower level of urbanization, is home to 53% of the world's urban population, followed by Europe with 14% and Latin America and the Caribbean with 13%. Meanwhile, the global rural population has grown slowly since 1950. Currently, the rural population is 3.4 billion, and is expected to decline to 3.1 billion by 2050.

The close relationship between rural and urban areas reveals the need for broad territorial planning and management that seek sustainability in both spaces. The flows of goods, people, money and information between the rural and urban areas reveal this close and promising relationship between these spaces. Such relationship, according to Rosa and Ferreira (2010), allows us to observe the continuities and discontinuities between rural and urban and to rethink the concept of the continuum, seeking to understand rural and urban as parts of the same structure. They also underscore urban and rural permanently transforming comparative advantages and differences, which can only be assessed considering their articulation and contiguity. An isolated approach to any of the spaces is only a partial approach to reality (Classificação..., 2017).

To achieve SDG 11, this interdependence between urban and rural areas must be addressed. Urban areas are highly dependent on fossil fuels, energy, water and food. These natural resources are largely present in the countryside and are vital to supply the population and enable industry, commerce and services to function properly. The richest cities are the ones with higher energy demand and higher rates of solid waste and effluent disposal into the environment.

Population densification in Brazilian urban areas

The UN 2030 Agenda for sustainable development is global, but its targets directly relate to national, regional and local initiatives and can act as a guiding tool for the planning of permanent public policies.

The temporal and regional context that dynamically affects Brazilian society and territory, including the accelerated urbanization process, must necessarily be part of the background upon which one can reflect on the complex issue of urban sustainability in Brazil (Classificação..., 2017). In Brazil, there is a historical increase in urban population due to natural growth and migration of the rural population to urban centers, and it is expected to continue during the 21st century. People prefer cities for the opportunities and services offered, mainly jobs and education. This migratory flow overcrowds cities and their surroundings, lead to so-called slums, irregular and precarious occupancies that do not serve the population well-being.

Advancing unplanned urbanization causes the destruction of natural ecosystems and can alter water resources, among other environmental problems. Poor basic sanitation services are common, negatively impact the environment and pose risks to human health.

The maps of *Atlas nacional digital do Brasil 2017* (*2017 National digital atlas of Brazil*) (IBGE, 2017), released by the Brazilian Institute of Geography and Statistics (IBGE), contain a thematic booklet on sustainable cities. This booklet presents the following theme axes: urbanization, housing and urban mobility; urban environment and safety; planning, democratization and social participation; and culture and heritage. For all that is presented in the maps, one realizes that Brazil is far from having sustainable cities.

In 2017, Embrapa carried out the study *Identificação, mapeamento e quantificação das áreas urbanas do Brasil* (*Identification, mapping and quantification of Brazilian urban areas*) (Farias et al., 2017), which quantified and mapped all areas currently occupied by cities in the national territory. The study pointed out that 54 thousand square kilometers of Brazilian territory are occupied by urban areas, which corresponds to only 0.64% of the total surface of Brazil. This reveals significant population densification in large urban centers, mainly in metropolitan areas of Brazil, largely based on the verticalization of cities, i.e., the construction of large buildings to house residential and commercial activities in urban spaces.

Results of the mentioned study show that only a small part of the Brazilian population lives in the immense Brazilian territory formed by non-urban areas, but which are vast and provide services throughout Brazil: water and energy resources, agriculture and livestock, mining, tourism zones, indigenous lands, forests, conservation units, among others.

The rural, the urban and Embrapa

Considering rural and urban areas as opposed and excluding domains is an arbitrary approach based on physical and geographical criteria that do not consider social and economic processes in these territories (Sarmento et al., 2015). There is a strong relationship between rural and urban spaces, and in addition, there is a need for innovative territorial planning and management solutions.

The great densification of urban areas and the historical absence of integrated urban-rural planning in Brazil reveal important challenges for governments, not only in terms of adjusting the infrastructure, but also of meeting the demand for services and food so as to make cities and human settlements as inclusive, safe, resilient and sustainable as possible, according to SDG 11.

While there is a continuous urbanization, it is known that development cannot be based much longer on the extraction of natural resources, such as coal, gas and oil. In addition to these demands, as the population increases, the world will need preserved water resources and more food, which are produced mainly in rural areas. Therefore, developing alternatives for energy production (particularly from biomass), as well as strategies for the rational use of water, sustainable systems of agricultural production and conservation of biodiversity, is urgently needed. When the need for biodiversity conservation is mentioned, it is most commonly thought of the most endangered species and the consequent loss of genetic information. However, these are not the only damages caused by the reduction of biodiversity, perhaps they are not even the main ones. Much worse is the weakening of ecosystems that make them vulnerable to disasters (Veiga, 2005).

This dynamism and interdependence between rural and urban domains demand information that supports planning and management, thus allowing territorial cohesion, reducing territorial inequalities, promoting rural development, etc. Rural and urban areas must be understood as diverse domains. The use of only one approach, either alone or in combination, should be seen as a partial approximation of reality (Classificação..., 2017).

Thus, Embrapa has been seeking to understand the urban and rural dynamics, aiming at a more sustainable agricultural, livestock and forestry production for the whole national territory. In addition to knowing the profile of the space-time dynamics of agricultural products, Embrapa seeks to understand the trend of territorial evolution, strengthen the response to demands of Brazilian agriculture and anticipate future challenges based on territorial intelligence.

Embrapa has also been supporting the ecological-economic zoning of Brazilian territories, which is an instrument used to plan and organize the territory, following methodological guidelines published by the federal government (Figure 1).

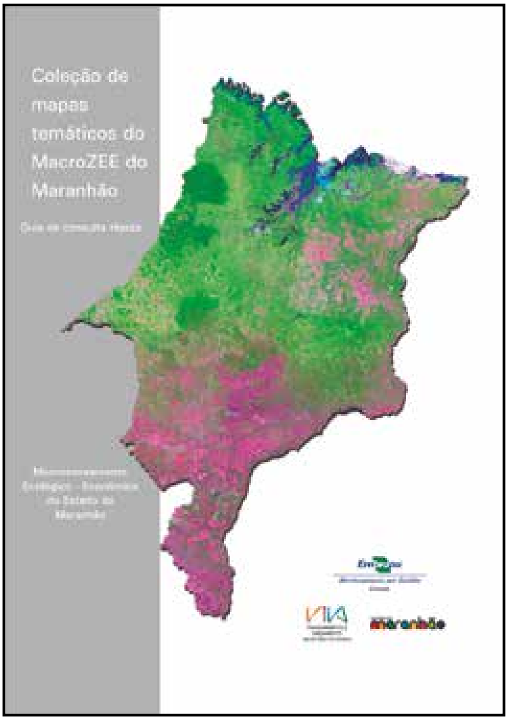

Figure 1. Collection of thematic maps of the macrozoning of the state of Maranhão, produced by Embrapa.

Source: Batistella et al. (2014).

Increasingly, it is necessary to apply technologies that serve different, either urban or rural, contexts and spaces, and integrate different areas such as: food security, small-scale agriculture, biotechnology, agroenergy, agricultural and livestock instrumentation, precision farming and agricultural risk management.

This knowledge generated by Embrapa has been made available to society in general and to meet the demands of the ministries and departments of the Brazilian President's Office, in order offer them strategic views and enable them to make strategic decisions.

Final considerations

Countryside and city are not opposites. They differ by the development logic of production forces and territory uses, by hegemonic and non-hegemonic agents, so that these subspaces share urban as well as rural contents, since there is no way to explain them dissociating one from the other. There is now a new concept for territory, composed of new urban and rural concepts, and it is necessary to understand it from a new perspective, that is, considering all the elements present in space, which is understood as totality (Locatel, 2013).

In this context, agribusiness is an expression of the urban industrial complex, whose mindset is greatly influenced by the need to export more and more. Agribusiness expresses the marked integration of cities and rural areas, thus making the urban-rural division obsolete (except in cases of calculating national figures). Agribusiness is an immense assembly line that brings together knowledge from Brazilian and foreign science and from the experiences of farmers. For the last 40 years, Embrapa has been promoting a unique technological development in the history of agrarian sciences, the result of which are a vibrant agribusiness, a new economy and an understanding of the technological development capacities to produce and aggravate inequalities, to be a partner in Brazil's economic development, and to help to understand and solve problems of those who have not had access to modern agriculture (Marra et al., 2013).

In the case of family agriculture, which supplies part of the market with a high diversity of food, there is a greater dependence on public policies and basic services, that is, it relies more on governmental investments and entrepreneurship that guarantee an inclusive development and the sovereignty in the food and nutritional security of Brazilians. It is up to institutions such as Embrapa to contribute with inputs for public policies, technological solutions and other actions to empower small and medium-sized farmers. The challenge is to transform the countryside and the city to achieve a truly sustainable development, as stated in the UN Agenda goals.

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Chapter 2

Challenges for sustainable urbanization

André Rodrigo Farias
Junia Rodrigues de Alencar
Joanne Régis Costa
Patricia da Costa

Introduction

The Sustainable Development Goal 11 (SDG 11) of the UN 2030 Agenda aims to make cities and human settlements inclusive, safe, resilient and sustainable. The *Third United Nations Conference on Housing and Sustainable Urban Development* (Nações Unidas, 2016) proposes a new agenda to guide "sustainable urbanization for the next 20 years." It is a big challenge, and partnerships between public and private sectors and civil society are crucial for effective progress towards sustainable urbanization.

When the city is observed from the perspective of a sustainability agenda, it becomes mandatory to consider the urban phenomenon not as a point on the map, but as a broader area that also includes the region over which it exerts its influence (IBGE, 2017).

Understanding urbanization not only as a particular and specific fact in societies but also as a phenomenon that relates to diverse social domains and geographic scales, allows in-depth analyses consistent with concrete reality. These analyses can support solid initiatives capable of producing the desired changes within the scope of SDG 11.

Within this context, behavioral changes and encouraging innovation in different areas (oriented to face challenges imposed by growing urbanization), are needed, among other changes.

Characteristics and trends in urbanization

According to Santos (1993), Brazilian urbanization can be seen as a process, as a form and as a content, that is, urbanization level, urban design, population's needs are to be analyzed in light of economic, political and socio-cultural sub-processes, technical achievements and territory uses in varied historical moments.

The history of cities, therefore, relates to the history of other relevant social events that directly influenced its emergence, its consolidation and its expansion. From this perspective, cities and societies are faces of the same coin, an inseparable set that is meaningless when viewed in isolation. There are no cities without social participation, just as there is no large gathering of people, housing, diverse services, jobs, cultural and political agitation without the required construction of buildings, streets, avenues and all other material characteristics that mark cities, especially in the present moment. For Rolnik (1997, p. 13, our translation),

> The history of cities is marked by special or ordinary events that act on immense inertia of buildings and traditions. We can capture this movement in multiple ways: through social history, following the subjects that constitute it; through the intellectual history, capturing ideas and concepts that weave its culture through the history of its architecture and urbanism, building a map of its geography built by man.

In this sense, it can be stated that urbanization has always been strongly related to economy, from the time it was a commercial center between agricultural areas distant from each other and a place of agglomeration of traders from various regions, until today, when cities are the main locus of housing for the majority of the world population, besides being the priority area for the installation of industrial parks, administrative and financial departments of companies of varied branches of economic activity, research, education and knowledge institutions, headquarters of public administration institutions, among other diverse sectors.

Due to this characteristic of bringing together different activities and social groups in an enclosed space, cities have historically become centers of great sociocultural and political diversity, of coexistence and of conflict between different social agents. So, it can be said that cities themselves are shaped and molded by this whole social arrangement in the same way that the actual and concrete structuring of cities mold social actions. For Lefebvre (2001), the city is a work because it is a social construction as well as the site where society projects itself, given the inseparability between society and geographical space, which is the material basis of its existence.

From this perspective, the city can be described as form and content, for a form concretely represents the material production of objects performed at different historical moments, but it is also content because it is constructed and continuously transformed according to the dictates and the social complexity in force. Therefore, analyzing the phenomenon of urbanization in the sense of making cities inclusive, safe, resilient and sustainable necessarily implies transformations of the social, political and cultural contexts in order to plan and promote initiatives that address directly these aspects. Furthermore, it is important to point out that such adjectives related to SDG 11 represent highly complex concepts, are open to numerous interpretations and involve a significant range of variables. Being aware of such complexity and endeavoring to seek precise definitions of their meanings is of paramount importance, especially in order to guide further research and establish guidelines for the development of initiatives aimed at meeting such assumptions.

The concept of inclusion, for example, is widely debated in different domains of society. This term can refer to unique proposals for organizing the educational system, in which the system itself is structured based on the diversity and needs of all students, regardless of subdivisions or subgroups of students (Mantoan, 2015), or to the urgent and necessary demands of people with disabilities, especially with regard to guaranteeing their rights and the exercise of their citizenship (Sassaki, 2003).

Despite several other examples of the use of the concept, what is relevant to point out is that dealing with inclusion, for obvious reasons, necessarily implies acknowledging the existence of exclusion and the fact that it is a social problem to be confronted. Searching the definition for the meaning of social exclusion, Sposati (1999) states that this concept relates directly to the concept of universal citizenship, and exclusion could be defined as the very negation of the latter. The author also makes an important distinction between poverty and social exclusion: while the former concerns the inability to acquire and retain property, the latter refers to a wide range of social situations in which material conditions only represent one of the variables. Social exclusion, from this point of view,

> [...] reaches cultural values, discrimination. This does not mean that the poor cannot be discriminated against because they are poor, but that exclusion includes even abandonment, loss of ties, and the denigration of social relations, which are not necessarily related to poverty. (Sposati, 1999, p. 4, our translation).

From this perspective, making inclusive spaces means understanding that part of society is permanently in a state of exclusion and that this phenomenon presents itself particularly in cities as these, by their own intrinsic characteristics, bring together an enhance this condition. In other words, educational, cultural, behavioral, financial exclusion, among many other possibilities, is given substance in the space of cities, which, in turn, reflect conflicts and social contradictions. It is precisely for these characteristics that the challenge of making cities inclusive involves transformations of various orders and in different social domains, in order to address all these issues based on the widest and most holistic perspectives possible.

It is important to emphasize that the sense of inclusion does not necessarily imply social and/or spatial homogenization, such as keeping all persons and spaces under a certain order imposed by someone or by some institution. Inclusion, from another point of view, is intended to offer equal conditions to all so that each individual is able to exercise their full citizenship, based on guaranteed rights and duties. In the cities, for example, inclusion may be expressed by the offer of equal and fully accessible conditions in terms of urban infrastructure, separated into its different kinds, such as urban mobility, basic sanitation conditions and electric power supply, leisure culture, education and health equipment. In these cases, it is a question of guaranteeing high quality material conditions for living in society.

This holistic conception of inclusive cities directly relates to the proposal of establishing safe cities, as posed by SDG 11, since inclusion and safety are mutually influenced. Inclusive cities tend to be safer cities in the same way that the latter tend to have lower levels of exclusion. The meaning of the noun safety (Segurança, 2018), which, according to Michaelis dictionary, represents a condition or state of what is free of damage or risk, when used to describe cities, may refer both to the possibilities of damage from natural disasters or phenomena caused by human action, or to the safety of individuals in city spaces with regard to social acts of violence of various motivations.

However, in both situations of unsafety, caused by either human action or natural processes, their respective solutions are extremely complex, involve many variables and social determinants and necessarily require a set of long-term systematic actions to produce representative and effective responses.

Based on these considerations, it is feasible to assume that permanently and integrally safe cities are related to utopian views. It is perfectly consistent, however, to accept that it is possible and, more than that, it is mandatory to make substantial progress in addressing issues of violence in cities and in proposing efficient natural phenomena risk management. In this way, their potentially negative impacts would be reduced to the smallest possible extent or they would be of short duration and intensity, so that the previous balance would be quickly restored, in accordance with the concept of resilience, the third specific target of SDG 11. This balance must be critically assessed, since not every balanced situation is desirable or does not require significant changes.

As for the concept of resilience, its origin is associated with the scientific fields of physics and engineering, but it has now been used in several academic areas. According to Barlach et al. (2008, p. 102, emphasis added by the author, our translation), "from Latin, the world *resilio* means to return to an earlier state, being used, in Engineering and Physics, to define the capacity of a physical body to return to its normal state [...]". When associated with environmental studies, resilience refers to the ability of a given space (in this case, cities) to overcome a given adversity and to restore its previous condition or to adapt positively to that change. In the case of natural phenomena such as earthquakes and extreme climatic events, resilience would be related to the way a particular space would absorb the negative impact of such an event and to how the return of the previous condition would be realized. With regard to the social domain, however, it is necessary to consider the significant complexity between different social groups and the contradictions and conflicts in using the concept in scientific approaches and in public policy design.

All of these concepts, i.e., inclusion, safety and resilience, must necessarily be included in a sustainable urbanization approach, as they directly influence whether or not this primary target is met. Sustainability, which was initially widely used in environmental research and analysis, has now been used in different approaches and complemented by several adjectives in several area of study, such as economic, business and urban sustainability, among others. In addition, the notion of sustainability has been strongly related to the concept of development as part of different sustainable development proposals that are currently being presented and discussed.

Considering the objectives of this publication and the various definitions of sustainability, it is important to restrict the analysis to what we consider to be the central point of discussion of this theme: being sustainable or practicing sustainability means providing the necessary material or immaterial conditions for maintaining and developing life in society in accordance with the demands of current and future generations. In this perspective, sustainable cities are not only those with ecologically appropriate procedures and methods, but they involve a series of actions and political positions that reach various domains, whether related to natural or social processes. In this perspective, Boff (2012, p. 25, our translation) highlights:

> The concept of sustainability cannot be reductionist and applied only to growth/development, as it is prevalent in our times. It must cover all territories of reality, ranging from people, taken individually, to communities, culture, politics, industry, cities and especially the Planet Earth with its ecosystems. Sustainability is a way of being and living that requires aligning human practices with the limited potential of each biome and the needs of present and future generations.

Addressing these issues, of course, is not an exclusive attribute of public management institutions, research and development initiatives or organized civil society, but it involves establishing a collective view on society around priority issues to be addressed. With regard to the activities of Embrapa, the search for viable research, development and innovation solutions for sustainable agriculture (Embrapa, 2015) directly and indirectly impacts the life of cities, but it is not able, per se, to transform them in full, according, for example, to specific SDG 11 goals. These are, in short, scientific and technological innovations engendered by numerous research and development initiatives that produce beneficial effects in several areas of knowledge and productive fields, but which must be accompanied by other political actions within a certain strategy so as to reach paradigmatic changes in urban spaces.

According to this approach, transforming cities must be based on a collective understanding, that is, it must never be restricted to individual initiatives of an institution or solely and exclusively related to the government, although it plays the main role in several areas in cities and is exclusively in charge of some services. In this context, Harvey (2018) points out that:

> The question of what kind of city we want cannot be divorced from [...] what kinds of social relations we seek, what relations to nature we cherish, what style of daily life we desire, what kinds of technologies we deem appropriate, what aesthetic values we hold. The right to the city is, therefore, far more than a right of individual access to the resources that the city embodies: it is a right to change ourselves by changing the city more after our heart’s desire. It is, moreover, a collective rather than individual right since changing the city inevitably depends upon the exercise of a collective power over the processes of urbanization.

The collective understanding of urbanization is not restricted to social agents and institutions, but it is also closely related to the establishment of a territorial view of the process. This means that cities must be interpreted from a territorial perspective in which they are seen as one part in a whole that is always moving. In this context, it is important to recognize that analyzing a given city or the effectiveness of a public policy for cities will be necessarily influenced by other geographic and social domains, especially after globalization has emerged and been established.

Currently, cities not only relate to regions under their influence, but also establish multiple relations and diverse kinds of interactions with other cities, with other regions, with the country itself and foreign players and conditions, which is an unequivocal fact of the present historical moment. Not only are these relations diverse, but their pace is fast, leading to quick and often ephemeral large-scale changes.

All these variables, typical of the present moment, make the transformation of cities a great challenge for public/private planning and action and require reorganizing urban interpretation and instruments used for public policy design. On the one hand, there is a growing need to know the reality of each city based on collecting primary data on its spaces and society, seeking to build a broad picture of the current situation in these areas; it can all be performed by countless information technology and geotechnology advanced tools. On the other hand, a series of multidisciplinary and multi-institutional efforts are necessary to interpret this reality revealed by the data, producing information for public policy design, always considering that every policy for cities is social policy by definition, based on a given economic, political and cultural context and molded by other domains that, to a great extent, transcend the scope of the cities targeted by such policies.

For that matter, in what concerns the knowledge of Brazilian cities reality, the study *Caracterização e Tendências da Rede Urbana do Brasil* (*Characterization and Trends of Brazilian Urban Network*), coordinated by the Institute for Applied Economic Research (Ipea), considered Brazilian urbanization as a synthesis of economic processes, and its territorial transformations mainly induced by economic, especially industrial and agricultural, activities (Desenvolvimento..., 2002).

Santos (1993, p. 27, our translation) considers that:

> The term industrialization cannot be taken here in its strict sense, that is, as the creation of industrial activities in places, but in its broadest significance, as a complex social process,

> which includes both the formation of a national market with efforts to equip an integrated territory, and the expansion of consumption in various forms, which drives the life of relations (namely tertiarization) and causes the process of urbanization itself. This new economic basis surpasses the regional level, and extends throughout the nation; for that reason, an urbanization that is ever more involved and more present in the territory is due to sustained demographic growth of medium and larger cities, including, of course, state capitals.

According to UN's 2015 report on Millennium Development Goals (MDGs) (United Nations, 2015), since 1990, the proportion of the world's rural population without access to sanitation has declined by almost a quarter, and rates of open defecation in rural areas have declined from 38% to 25% by 2015. In the same year, one in three people (2.4 million) still used rustic sanitation facilities, including 946 million people still relying on open defecation. In 2015, it was estimated that over 880 million people lived in slum-like conditions. Contrary to this, only 18% of people living in urban areas lacked access to sanitation in the world. Between 2000 and 2014, more than 320 million people gained access to adequate water, sanitation and housing. The proportion of the urban population living in poor neighborhoods in developing regions decreased from 39% in 2000 to 30% in 2014. Although the target had been achieved, absolute numbers of urban residents living in slums continued to grow, partly because of the rapid pace of urbanization, population growth and the lack of land and housing policies. In 2015, it was estimated that more than 880 million urban residents lived in slums, compared to 792 million in 2000 and 689 million in 1990.

Sustainable cities and communities

The City Statute (Brasil, 2008), Law No. 10,257 of 2001, which regulates articles of the Federal Constitution that deal with Brazilian urban policy, is one of the greatest legal advances in terms of urban planning and management in Brazil. In section I, it presents, as one of the tools for urban territorial planning, the Master Plan; in legal terms, it is a tool for managing urban areas, although its range of action, in some municipalities, encompass urban and non-urban (rural) areas (Pereira, 2011). There are, however, countless weaknesses that make it difficult to implement a sustainability agenda for cities and human settlements on the planet and in Brazil. Issues are multifaceted and require multidimensional solutions.

Eliminating inequalities in access and service levels is therefore crucial to the UN's post-2015 development agenda. Perin (2004) states that reducing inequalities is a recurring theme and one of the major challenges of the 21st century, considering that less than 25% of the world's population consumes 80% of goods and 75% of energy produced on the planet, thus creating ghettos of individuals excluded from development.

In this sense, urban and rural planning and territorial management are necessary, based on permanent public policies that take into account all dimensions of sustainability and regional and local contexts. A commitment to territorial management and policies that guide urbanization by producing material and immaterial goods that reconcile economic growth with sustainable forms of appropriation and use of urban space are necessary, according to Vecchiatti (2004). In this way, it will be possible to promote quality of life and build sustainable cities and human settlements.

Internet of things and its implications for digital agriculture

Considering SDG 11 and the role of Embrapa in addressing challenges (mentioned in its guidelines and targets), it is worth noting some observations made in the World Bank's Development Report (Banco Mundial, 2016): although we are in the midst of the greatest information and communication revolution in the history of mankind, when more than 40% of the world's population has access to the internet, the poorest households are more likely to have access to mobile phones than to a toilet or clean water. Traditional development challenges persist and prevent the population to have a better quality of life.

To address these challenges, the UN Food and Agriculture Organization (FAO) recommends that all agricultural sectors be smart, and that agricultural work be equipped with innovative tools and techniques, particularly digital technologies, thus promoting increased production at a feasible and sustainable cost, within the context of digital agriculture (Minerva et al., 2015). Topics such as precision agriculture, automation and agricultural robotics, big data techniques and the Internet of Things (IoT) are part of this digital agriculture.

In the case of precision agriculture, some of its technologies are already being used, and an increasing participation in the management of production chains is expected, so as to improve yield per agricultural unit using the most continuously sustainable and modern means to achieve the best in terms of quality, quantity and financial return. A range of technologies that includes services such as Global Positioning System (GPS), sensors and big data to optimize crop yields are also used. Instead of replacing the experience of farmers and their instincts, decision support systems based on information and communication technologies (ICT) with real-time input can also provide information on all aspects of agriculture at a previously impossible level of detail, thus allowing results with less loss and maximum efficiency.

With regard to IoT, this technological revolution that connects daily-used electronic devices to the internet has been considered as one of the foundations for the so-called fourth industrial revolution that will impact on agriculture 4.0. It will be increasingly connected and remote, allowing performance command and control, location of machines, equipment and sensors and real-time field data generation and analysis. All these concepts converge in the sense of having a digital agriculture or smart farming. Opportunities and challenges arise in all areas, from investment, development and use of IoT technologies in the field to training, regulation, standard setting and information security issues. As a disruptive and enabling technology capable of promoting knowledge-intensive agriculture, it aims to sustainably increase agricultural productivity, thus leading to cost reduction and improved field conditions (Minerva et al., 2015).

There has been such a considerable concern about this theme in Brazil that the Brazilian Development Bank (BNDES) has signed an agreement with the Ministry of Science, Technology, Innovations and Communications (MCTIC) to begin drafting a National Plan for IoT to leverage the development of new technology in Brazil. The first initiative of the partnership is a technical study carried out by a consortium formed by McKinsey, Centro de Pesquisa e Desenvolvimento em Telecomunicações (Center for Research and Development in Telecommunications) and Pereira Neto/Macedo law firm, with financial support from BNDES, to diagnose and propose public policies on the internet of things (Amorim; Capelas, 2016); this is an opportunity to leverage Brazilian agribusiness, one of the most interested sectors in using IoT, and to become a worldwide reference in developing solutions for this area, thus disseminating the Smart Rural concept.

In 2016, Embrapa Agricultural Informatics and the Intelligence and Macro-Strategy Division of Embrapa organized the panel named Internet of Things and Its Implications for Digital Agriculture in order to detect trends and signals for the ICT observatory in agriculture – linked to Sistema de Inteligência Estratégica da Embrapa (Agropensa) (Embrapa Strategic Intelligence System) – and support the formulation of new research, development and innovation strategies. Representatives from IBM Brasil, John Deere, Bayer CropScience, Centro de Pesquisa e Desenvolvimento em Telecomunicações (CPqD) (Center for Research and Development in Telecommunications), Universidade Nova de Lisboa and the consulting firm McKinsey participated in the event.

IoT is considered a new 21st century computing paradigm, which will allow the physical world to be coupled with the information world and will provide an abundant services and applications, thus allowing physical users, machines, data and objects to interact with each other in autonomous and transparent way. To build up this reality, multidisciplinary research efforts are required, involving several areas of knowledge, such as: distributed systems, mobile systems, computer and sensor networks, software engineering, artificial intelligence, nanotechnology, as well as specific knowledge areas in agriculture. Technologies that will support IoT are: big data, high performance computing, cloud computing, radio frequency identification (RFID) and communication and positioning systems.

The panel discussed agriculture and potential areas for applying IoT, such as: precision agriculture, automation, logistics, herd management, and environmental and productivity monitoring. At the end of the panel, an initiative was announced, called SitIoT, which makes an experimental area of Embrapa Environment available for partners to test their IoT technologies and innovations for agriculture, so as to develop integrated and interoperable solutions.

Brazilian agribusiness is one of the main sectors favorable to the use of IoT, due to its high degree of solidity (Roselino; Diegues, 2016). This is one of the central axes of economic development in Brazil, characterized by a profitable business structure, links with global production chains and high investment power. The historical presence of technology in solution development for agribusiness (often led by public institutions such as Embrapa and several other institutes) and the prominent position of Brazilian agribusiness worldwide lead to a high potential demand for digital solutions.

IoT involves the use of sensing technologies, analytical solutions for data analysis, telematics and geospatial positioning technologies, tools and softwares for making real-time decision systems, communication systems, traceability and food certification and logistics. Combining these technologies favors rational use of natural resources and inputs and reduced transport losses. IoT will help reduce rural exodus by incorporating a technological appeal and better working conditions, thus reducing physical labor. Digital agriculture will help the population (Figure 1) and public policies design, because the amount of data generated will be much larger and varied than that available today. With more information, public policies can certainly be designed taking regional differences into account, both in macro and micro regions.

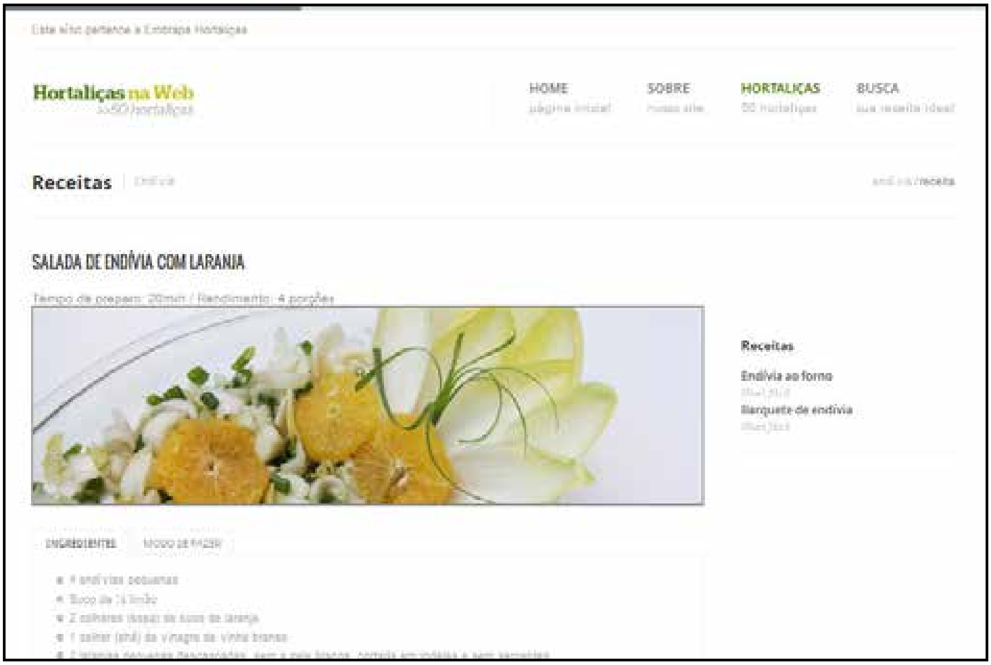

Figure 1. Hortaliças na Web (Vegetables on the Web) is a web page developed by Embrapa Vegetables to encourage vegetable consumption and to promote a healthy diet for the whole family.

Agriculture, however, faces challenges such as limited arable land, global climate change, water scarcity, cost of available energy, and impact of urbanization on its workforce. Such challenges can be mitigated with the adoption of digital agriculture, as it favors reduced crop loss due to diseases and climatic events; builds up savings by applying pesticides and fertilizers only when necessary; optimizes water consumption; offers better working conditions, reducing physical labor and attracting younger generations; and allows precise scheduling of harvest (Enabling..., 2016). There are also post-harvest benefits, such as reduced transport and processing losses that occur on the way to the consumer.

Final considerations

In this chapter, characteristics and trends in urbanization, need for urban and rural planning and territorial management, and the role of Embrapa in terms of this SDG have been highlighted. The IoT was also approached by the panel of experts named Internet of Things and Its Implications for Digital Agriculture, organized by

Embrapa Agricultural Informatics and its Intelligence and Macro-Strategy Division of Embrapa.

The use of digital technologies in agriculture is expected to contribute to raising productivity rates, increasing input use efficiency, reducing labor costs, improving workers' quality of work and safety, and reducing environmental impacts. Digital agriculture will increasingly be related to the domains Embrapa aims to achieve: advancing agricultural sustainability, creating employment opportunities and reducing rural and urban poverty, supporting public policies design, keeping Embrapa at the knowledge frontier and strategically positioning Brazil in bioeconomy.

Although digital technologies are spreading rapidly across much of the world, there are still large digital dividends that must be taken into account by all those working to end poverty and promote shared prosperity. The biggest boom in information and communication technologies throughout history will not be truly revolutionary until its benefits reach all people around the world (Banco Mundial, 2016).

Given this context, implementing action strategies paves a broad and solid way so that Embrapa and its partners can promote development for all.

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Chapter 3

Territorial intelligence: planning, management and systems to support strategic decisions

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Introduction

Territorial planning and management are fundamental for constructing a sustainable development project. Urban and rural communities supported by ongoing participatory planning and management processes gain resilience to meet threats and seize opportunities.

Territory is understood as “the spatial limit within which the State exclusively and effectively exercises the power of empire over persons and goods” (Silva, 2001, p. 120, our translation). One can also define territory as “a portion of the geographic space where one projects power relations, which generate appropriation and control over this space, regardless of whether or not it is territorialized by one or more agents” (Magdaleno, 2005, p. 119, our translation).

Territory management is the strategic practice based on scientific and technological tools, space and time controlling power, coherent decisions and actions to reach an objective and that equitably expresses the new rationale and attempt to order chaos. Territory management must necessarily involve the understanding and interpretation of social, political, economic factors and, at the present time, environmental factors, so as to reach a balanced perspective, not ignoring fundamental local aspects. Nature can no longer be separated from social and economic processes; this dichotomy must be abolished (Tommaselli, 2012).

In this sense, Embrapa has been working not only on generating technological solutions, but also on providing subsidies for territorial planning and management, in order to improve the quality of life in rural environment or in the rural-urban link.

Next are the main contributions of Embrapa to achieving targets 11.1, 11.3, 11.6, 11.A and 11.B (Table 1 of Chapter 1).

Strategic territorial intelligence

Territorial intelligence comprises a territory in its totality and allows planning and managing integrated actions for its development.

In this context, Embrapa collaborates with knowledge, such as decision support systems, software, applications, agricultural and hydrological models, technological solutions for food production, monitoring instruments and platforms. This is of strategic importance for all sectors of society, whether in urban or rural areas.

Embrapa Territorial (located in Campinas, SP) is an Embrapa Unit that provides data and information on the national territory to strengthen governance actions and public and private management of agricultural production chains and to anticipate future challenges with territorial intelligence. In addition, all Embrapa Units offer knowledge to promote sustainable development.

Information available in the databases of Grupo de Inteligência Territorial Estratégica (Strategic Territorial Intelligence Group – Gite) offers summaries and diagnoses for any Brazilian state or region on five themes: natural, agrarian, agricultural, infrastructural and socioeconomic frameworks. Gite services have been supporting the planning, implementation, monitoring of actions, the evaluation of policies and public and private investments, in several production chains and geoeconomic regions. Such information is used by governments to carry out concrete actions at the municipal, state and federal levels. Following are some highlights of Gite's performance.

In 2015, Gite provided the Ministry of Agriculture, Livestock and Food Supply (Mapa) with a map of the national distribution of rural settlements. It had been requested by the ministry's Department of Integration and Social Mobility and indicated the coverage area and total number of families in settlements according to regions, states and time since establishment. The database, provided by the Instituto Nacional de Colonização e Reforma Agrária [National Institute of Colonization and Agrarian Reform (Incra)], comprises 9,255 settlements distributed in 88 million hectares, benefitting almost 1 million families. The Embrapa survey indicates that settlements are present in all Brazilian states, including the Federal District. Maps with settlements by states and regions were prepared. The map showed the largest absolute number of settlements (46%) is in the Northeastern region, but the Northern region stands out in terms of occupied area (76%) and number of settled families (44%).

Recently, Gite has completed the updating of tabular and vector databases of lands legally attributed in Brazil, which include terrestrial conservation units, indigenous lands, agrarian reform settlements, *quilombola* communities and military areas with public forests. These updated results reveal a total of 315,924,844 hectares of land allocated in Brazil (37.1% of the national territory), overlaps discounted (50,518,987 hectares).

The system also showed that the Matopiba region (states of Maranhão, Tocantins, Piauí and Bahia taken together) has 73.2 million hectares and 20% of these areas are allocated as Legal Reserve.

Preserved areas are the main focus of the latest surveys of Gite, based on data from the Rural Environmental Registry (CAR). Data analyzed come from declarations and maps registered by farmers in the Rural Environmental Registry System (SiCAR) – under the coordination of the Ministry of Environment (MMA). Integrating SiCAR database with Strategic Territorial Intelligence System (Site) of Embrapa allowed the crossing-over with other databases. Based on that, Gite performed comparative analyses between protected and preserved areas in the states of Rio Grande do Sul, Mato Grosso, São Paulo, Rondônia and Maranhão.

Gite uses Strategic Territorial Intelligence (ITE), a set of tools and methods applied for understanding of a territory as a whole by means of the integration of information from different sources. This integrated information serves to support decision-making for territorial development. It is a fundamental tool for Gite to plan agricultural research innovation.

Gite organized Strategic Territorial Intelligence Systems (Sites), which group numeric, iconographic and cartographic data, integrated with Geographic Information Systems (SIG) supported in spatial databases. Regarding cartography, they comply with regulations of the Brazilian Institute of Geography and Statistics (IBGE) and the National Spatial Data Infrastructure (Inde).

Data come from several public institutions and, in general, is organized in five themes: natural, agrarian, agricultural, socioeconomic and infrastructural frameworks (Figure 1). These five themes combine several information plans, either obtained or created. This integrated and multifactor view favors the contextualization and integrated analysis of territorial situations and the design of evoluted scenarios.

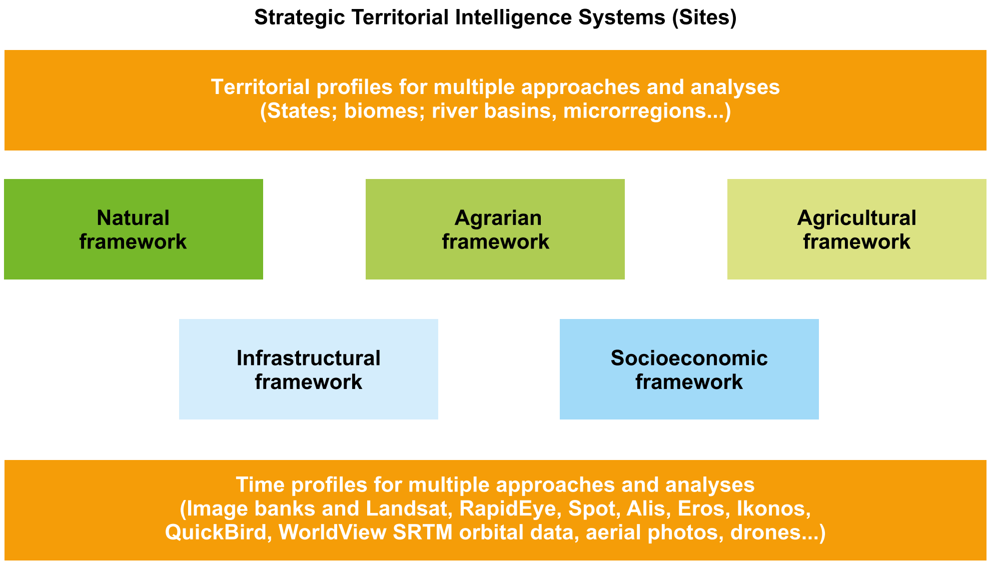

Figure 1. Main themes and territorial and time profiles structured in intelligence systems developed by Grupo de Inteligência Territorial Estratégica (Strategic Territorial Intelligence Group – Gite).

Source: Embrapa (2017).

The Sites can be used to understand regional transformations. An example is the work developed to help recovering goat and sheep herds in the Brazilian Northeastern semi-arid region after the drought cycle. As requested by Mapa, a study analyzed production figures and herd density in micro-regions and, based on that, pointed out priority regions where optimal resource use and greater economic impact and social return would be achieved.

Public and private institutions has been massively demanding the above-mentioned information from Embrapa.

Information provided by Gite contributes to improve planning capacity and participatory, integrated and sustainable management of human settlements.

Participatory community-level planning

Brazilian space occupancy and use generally occurred without planning. This lack of adequate planning negatively affects the rural area and adjacent cities and vice versa.

In this context, it is important to work with methods that may help communities develop a systemic vision and critical sense, thus reducing conflicts and environmental impacts and enabling common interest initiatives, which are fundamental for managing river microbasins, with a greater participation in management and governance organization of groups, associations, etc.

PGMacro method

Planning and management based on macro-education (PGMacro) systematically arranges participatory processes to organize social actors so that they achieve common interest results. Developed by Embrapa, it arranges a sequence of workshops and meetings as opportunities for all to speak up for themselves and join in knowledge construction on the interpretation of the local reality; PGMacro stresses that and pointing co-responsibility is shared by all to obtain good results, encouraging and strengthening the cooperation and innovation, as well as synergistic intra and interinstitutional work. The method requires a moderator to keep communities, public, private and civil society organizations in dialogue and to keep the understanding and focus on agreed future strategies, such as developing and adopting technological solutions, public or organizational policies, which are only possible and feasible if based on a broad community participation. Another feature is the relationship multilevel involvement of the target group, which often requires training of multiplying agents.

The PGMacro method was successfully used in numerous planning actions, among which the Master Plan of Atibaia, in the state of São Paulo, in 2006, which used the methodological tool to integrate rural and urban communities in planning the future of the agricultural sector of that city. Because of the crisis in the local agricultural sector and the increase in the real estate value of “bare land", the growing of slums due to rural exodus was a risk. The work presented local agriculture as a solution for land use and territorial occupancy, and rural development as one of the guidelines for social development and established an environmental policy to encourage actions to strengthen the agricultural sector, without environmental damages (Brasil, 2012).

Planning for farm management

Planning is critical to proper farm management. The method developed by Embrapa Western Amazon includes current farm management, history of the area, socioeconomic and environmental aspects of the farm and the community in which it is inserted, as well as its relationship with the market. Planning is done with the family during walks around the farm, formal and informal conversations. The families' goals and the problems identified are ranked in order of priority so that the most serious or urgent issues can be immediately addressed. The farm is seen as a whole made up of several systems (forest, *capoeiras*, annual crops, perennial crops, etc.), which can lead to recommending different alternatives depending on objectives, surface, composition, arrangement and management. This tool allows farm planning aiming at the recovery of degraded areas and conservation of natural resources, thus contributing to improved environmental quality and income generation.

In addition, courses, lectures, round tables, technical visits and field days are scheduled. In this way, developing capacities lead to autonomy and, thus, to guaranteed sustainable actions.

The method was recognized as a Good Environmental Education Practice for Family Agriculture by the Brazilian Ministry of Environment, and the project was regarded as a reference in the Amazon biome (Brasil, 2012). In 2011, the Associação Agrícola do Ramal do Pau Rosa (Assagrir) (Agricultural Association of the Pau Rosa Branch), partner of the project, was nominated for the Prêmio Fundação Banco do Brasil de Tecnologia Social (Banco do Brasil Foundation's Social Technology Award). The award is sponsored by Petrobras and was held in partnership with the Brazilian Ministry of Science and Technology (MCTIC), the United Nations Educational, Scientific and Cultural Organization (Unesco) and KPMG Auditores Independentes.

The method presented contributes to participatory, integrated and sustainable management of rural human settlements, to resource efficiency and to mitigation of direct negative environmental impacts in rural areas that indirectly affect adjacent cities.

Territorial management

Decision-making for sustainable management must be based on reliable, accurate and current data and information and must consider economic, social and environmental issues.

Agricultural and hydrological models, mapping of agricultural areas and integration of spatial data for management

Simulation models are good tools for obtaining information and can be used for the evaluation of different scenarios, thus supporting decision-making. Embrapa is experienced in using simulation models to evaluate the effects of different technologies or environmental conditions, whether in agricultural production or natural resources availability. Examples are: a) the use of agrometeorological models to identify the best planting dates, used to support the agricultural policy by means of the Agricultural Climate Risk Zoning; b) the use of crop growth models to evaluate the agricultural production potential, under different climatic aspects (Cuadra et al., 2015; Silva et al., 2015a), and the consequent impact on food supply; c) the use of hydrological models to assess how changes in use/cover impact on the availability of water resources essential for sustainable urban areas (Seminário da Rede Agrohidro, 2016).

Identifying agricultural areas and the consequent dynamics of land use and land cover also directly impact on the quality of life of urban and rural populations. Native vegetation destruction and agricultural water usage affect the hydrological cycle, which can cause conflicts over water usage in urban environments. The conversion of natural habitats and the disorderly growth of urban centers also have negative impacts on populations. Embrapa is experienced in mapping land use and land cover, especially in agricultural areas and related expansion dynamics (Victoria et al., 2012; Kastens et al., 2017).

It is also essential to use compatible data and information, thus allowing the manager to carry out an integrated assessment of the current situation and its possible consequences. Geographic Information Systems (GIS) allow the integrated analysis of spatial data on different subjects, if they can be located in space. Such systems are widespread and used by Embrapa in its research projects. However, a fundamental part of GIS is data collection. On this front, as part of GeoInfo project (Drucker et al., 2017), Embrapa has been working to make available spatial data collected by research projects, in compliance with norms and standards established by the National Spatial Data Infrastructure – Inde (Comissão Nacional de Cartografia, 2010). Thus, by means of widespread communication protocols established by Inde, the population in general and decision-makers can easily access a range of spatial data generated by Embrapa, including spatial analysis based on models that aim to evaluate the current status of natural resources and the impacts that may be caused by changing weather patterns or conditions of land use and cover.

Environmental management plan for small rural property

Embrapa Environment has created a tool for the quantitative evaluation of socio-environmental impacts of rural activities of farms, which contributes to the proper management, elimination or mitigation of environmental impacts, since farms are the most real scope of landscape transformations for economic gains. Social, economic and environmental indicators were integrated to measure the performance of productive activity against ustainability criteria (Rodrigues et al., 2003). The tool also allows the evaluation of agricultural technological innovations impacts within the territory, when applied in panels that bring together specialists, technicians and development agents, so as to support public policies design (Rodrigues; Rodrigues, 2007). However, the main focus is to help farmers prepare for quality certification of products and processes when a new activity or management is initiated.

This was the case of small farmers in the region of Atibaia, state of São Paulo, who decided to join Programa de Produção Integrada de Morango (Integrated Strawberry Production Program) (PIMo), which is part of Produção Integrada Agropecuária (Integrated Agricultural Production) (PI Brasil), coordinated by Mapa, which offers the Certified Brazil Seal, after proof of compliance with technical standards by third party audit. It is worth noting that strawberry is a traditional product from the region and that its cultivation had been declining, leading to production stagnation and farmer discouragement, so much so that the younger generation was migrating to cities in search of better economic conditions.

After having been trained by technical managers and auditors, six farmers were monitored and evaluated in the 2011 harvest by Sistema Ambitec-Agro Módulo PGA (Plano de Gestão Ambiental) [Ambitec-Agro System PGA Module (Environmental Management Plan)] of PIMo, and, at the end, they received a document with recommendations for production process improvement (Buschinelli et al., 2016). All farmers were certified by Certified Brazil Seal, supported by the National

Institute of Metrology, Quality and Technology (Inmetro), which, in addition to product traceability, allows better production price and reaching market niches for strawberry, which is a fruit for in natura consumption that has been placed among the top-ranking fruits in terms of pesticide residues, a fact that did not exist within PIMo.

The initiative motivated other farmers in the region to join the program, and currently there are ten partner farms about get the certification.

Integrated waste management

All economic activity, whether rural or urban, generates waste that can be defined as discarded (solid, liquid or gaseous) materials that are not useful to those who generated them, but can be recycled or used in another activity (Consumo sustentável, 2005). Waste is one of the main environmental problems in Brazil, and the Plano Nacional de Resíduos Sólidos (National Solid Waste Plan) (PNRS) includes reducing generation and regionally using and managing waste to reduce pollution, stimulate economy and make economic activities in Brazil more sustainable. One of the challenges in waste management is to connect producing to consuming regions, which are often far from each other, which makes management expensive and discourages reusing and recycling. The rural area is a major generator of both organic and inorganic waste (Fesseden, 2015), which may be recycled or reused in the city. Similarly, there is high potential for urban organic waste, which represents over 50% of waste generated in cities (Brasil, 2017), or even inorganic waste, to be used in rural areas (Pires; Mattiazzo, 2008).

In this context, Embrapa research and technology transfer actions are highly relevant, ranging from waste composting techniques (Teixeira et al., 2002), including using urban waste, such as sewage sludge, in crops (Silva et al., 2004), to biodigesters for power generation (Oliveira, 2005), which can be used in the countryside and in the city.

There are also technologies for producing organomineral fertilizers (Santos, 2016) and biocoals (Farias et al., 2017) that use waste in their manufacture. It should be noted that large part of agricultural residues may become energy by combustion or direct application in soil to improve fertility, which can also generate income (Nigussie et al., 2015). Transforming waste into marketable products can encourage adequate disposal and reduce impacts of logistical difficulties, thus contributing to the sustainability of cities.

Another example of waste use is civil construction waste to correct soil pH, because of its lime content (Lasso et al., 2013).

In addition, Embrapa is developing new materials from cellulose and agricultural production residues; and studying enzymes that decompose cellulose for second-generation ethanol production.

Urban and peri-urban farming

Cities are highly dependent on food produced in the countryside. However, this reality is undergoing some change, although on a small scale, as food is being produced by agriculture carried out in cities and in areas close to them.

Urban and Peri-urban Farming (UPF) is a multifunctional agriculture production activity (Melo, 2016), an important activity to be considered in territorial management. According to Pires (2016), urban farming has been taking place and providing changes in city landscapes, usually in small areas and mainly for own consumption or for small-scale sales in local markets. It is performed mainly in backyards, on terraces or patios, or in urban gardens, community spaces or public spaces.

Urban farming supplies supplies 15% to 20% of the world's food and can play an important role in achieving global food security (Corbould, 2013). Idle areas are used to plant vegetables, medicinal and aromatic herbs, ornamental plants, to raise small animals and to install micro-industries (Valent et al., 2017).

According to the Committee on Agriculture (Coag) of the United Nations Food and Agriculture Organization (FAO), farming in the urban environment can significantly contribute to increasing the quantity of food available, improving the supply of fresh food, providing employment and income generation opportunities, increasing food security, due to either the food it can produce or – by generating income – the acquisition of non-produced products (FAO, 1999).

As urban farming develops, the greater the need to establish goals based on this agriculture, as well as to establish rules to avoid problems potentially caused by inadequate management of agricultural or livestock production within the urban area (Pessôa, 2005).

Although in specific areas, Embrapa has been contributing to promote UPF by conducting training and some research studies in this area, as well as holding events and participating in forums to discuss the issue. Below, we present some actions undertaken by Embrapa, in specific contexts, to help promote UPF and fight against hunger in cities.

Sistema Filho

Sistema Filho is a system of integrated vegetable production of fruits, grains and vegetables in irrigated intercropping, which is versatile and agronomically efficient, suitable for intensive production in small areas. The system was developed by Embrapa Cerrados, in partnership with Embrapa Vegetables. The name of the system refers to the initials of the (Portuguese) words for Fruit Production Integrated with Crops and Vegetables. Fast cycle crops such as vegetables and grains are planted immediately after planting fruit trees. With irrigation, it is possible to produce up to five harvests of vegetables and grains in the first 2 years after the orchard installation, which leads to efficient use of soil, water, sunlight, fertilizers, raw materials and labor (Guimarães; Madeira, 2017).

Productive yard

It is an initiative carried out in the urban and peri-urban area of Belém by Embrapa Eastern Amazon to enrich backyards with fruit plants developed by Embrapa. Courses and lectures, planting follow-ups, distribution of textbooks (Figure 2) and folders, as well as socioeconomic and environmental surveys were conducted.

The introduction of improved cultivars and rational cultivation techniques in urban areas directly contributed to improving the families' quality of life (Silva, 2007) due to increasing food availability.

Vegetable garden in small spaces

Divided into four chapters, the book *Horta em pequenos espaços* (Clemente; Haber, 2012) (Figure 3) addresses basic knowledge to helps in planting, conducting and maintaining gardens in small urban spaces, by informing, in simple language, how different factors for vegetable production, such as water, plant, soil and light, interact. The book also addresses the nutrients of vegetables and how they can contribute to a healthier life (Clemente; Haber, 2012).

Maize intercropped with corn in urban agriculture area

In urban agriculture, areas are often small and intensively used, which may lead to soil exhaustion and withdrawal from the activity. Intercropping as green manuring is a promising practice for urban gardens, as it is cheap and improves soil productive capacity. This work aimed to introduce it in an urban community garden in the city of Santo Antônio Descoberto, state of Goiás, and to evaluate soil

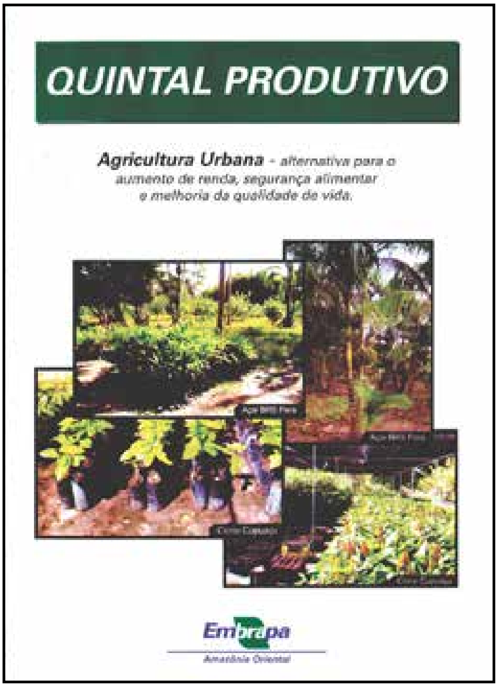

Figure 2. Embrapa textbook with information on management of fruit plants.

Source: Silva (2007).

Figure 3. Book released by Embrapa Vegetables with information on planting and managing vegetable gardens.

Source: Clemente and Haber (2012).

conditions before and after its use. In the garden, each of the 18 families cultivated a 300-m^2 lot. Of these, intercropping was adopted in seven. Mucuna-anã was sown 15 days corn, between rows. Corn was harvested at 90 days. Ten days later, maize phytomass was cut and maintained on the soil with corn stalk for another 10 days and incorporated one week later. Fertility, soil density and penetration resistance were evaluated in analyses performed prior and subsequent (one week) to incorporation. Green manuring reduced soil density and penetration resistance, increased exchangeable Ca and Mg contents, sum of bases and effective cation exchange capacity, as well as the available S content (Alcântara et al., 2005).

Recommendations for pest control in urban gardens

Embrapa Vegetables published a Technical Circular addressing recommendations on pests that attack urban gardens and methods of control of these pests, focusing on the use of cultural practices (Figure 4) and on alternative pesticides that are slightly aggressive towards the environment and of low toxicity to humans (Michereff Filho et al., 2009).

Strategic management decision support systems

Strategic management decisions support systems include systems, tools and techniques to collect and elaborate on information from a database to support decision makers. They add value to the decision, increase accuracy, shorten time, and improve decision quality.

INOVA-tec System for evaluating technological innovations impact

Externalities caused by productive activities to meet consumption needs can negatively impact the natural environment, thus requiring new approaches in the decision-making processes of organizations. Among them, are incorporating innovations that favor reduced environmental impacts and adopting models to evaluate the overall performance of these innovations from comprehensive, integrated and varied perspectives (Jesus et al., 2015).

The INOVA-tec System software, developed by Embrapa Environment, assists in evaluating the context in which a technology is employed and offers an impact evaluation of technology used in the field. At the end, suggestions are presented to optimize the technology use and to manage its impact on each of the dimensions under analysis (Jesus-Hitzschky, 2007).

Photos: Marcos Esteves

Figure 4. Activities of Embrapa Vegetables involving urban agriculture (A) and students learning about vegetables and the work of Embrapa (B) in Brasília, Federal District.

INOVA-tec System presents 57 impact indicators divided into topics for analysis and grouped into seven dimensions: environmental, social, economic, human resources training, institutional development, innovation introduction, unwanted events. In INOVA-tec System, the user should select the indicators more suitable to the technology and also insert more specific indicators, which will be parameterized during the evaluation, thus allowing for the evaluation on a case-by-case basis.

This methodology allows evaluating innovation by means of the following tools: innovation scenario analysis worksheet, which provides the index of significance; and the Magnitude Index, which organizes the impact indicators according to the dimensions, thus allowing the user to enter the values for level of importance or magnitude of these parameters. Impact indicators are grouped into the following dimensions: A: Environmental, B: Institutional Development, C: Training, D: Economic, E: Social, F: Innovation Introduction, G: Unexpected Events and H: Specific Indicators; the later must be entered by the user, in order to allow a case-by-case evaluation of the technology. Using the INOVA-tec System methodology and software, it is possible to assign the weights to the moderation factors for each of the indicators within the spreadsheets, and the results (the significance and magnitude indices) are automatically calculated and presented in the Matrix of Evaluation. The software also presents results in the form of tables, matrices, graphics and the conclusive report.

The use of INOVA-tec System revealed new and important information that allowed a global and systemic analysis of several technologies used in the field. By correlating results for two variables used to evaluate the innovation general impact (namely, the index of significance and the magnitude index), the system also allows to identify underrated innovation technical potential when the context is favorable to its market dissemination, but with a low overall performance according to the indicators. This calls for corrective actions internal and external to the productive unit.

Thus, experience with using INOVA-tec has made evident the need for companies and agricultural production units to establish a specific function for environmental management with clearly defined responsibilities. As benefits of this action, the following stand out: a) the strategic value that sustainability provides to the business; b) the evolution towards a proactive environmental stance, which includes making available to society the results of its socio-environmental practices; c) the greater competitiveness of the company, both in the domestic market and abroad; d) the expansion of the innovation social reach, since supplier selection reduces the possibility of buying inputs and raw materials from suppliers who adopt unsustainable practices (for example, who use child labor, inadequate soil management, indiscriminate use of agricultural pesticides, etc.).

Agrometeorological Monitoring System

The Agrometeorological Monitoring System (Agritempo) is a climate and meteorology monitoring system developed by Embrapa Agricultural Informatics that produces and provides (through internet) agriculture-relevant information. It provides newsletters and maps on agricultural drought, accumulated rainfall, phytosanitary treatments, irrigation need, soil management and agricultural pesticide application conditions. The main innovation offered by Agritempo is task automation by using Information and Communication Technologies (ICTs), thus making the system totally automatic and independent from human action. The whole process of entering data, incorporating it into the database and constructing maps is automatically performed by Surfer software, being performed by the system without human intervention. This provides greater speed and accuracy and improves the database quality itself, since the system automatically performs some tests on the collected variables. Agrometeorological, regional and national bulletins are also automatically generated by the system. Information provided enables the farmer to access safe and correct procedures regarding input use so as to reduce negative environmental and social impacts (and risks involved in the inadequate use of fertilizers and pesticides, also causing waste) and to assist farmers and extension specialists in seeking for more economically rational solutions (cost reduction versus production increase, leading to positive impacts).

Another innovation was the launching, in 2017, of the Agritempo GIS mobile app (Figure 5): software that offers easy access to agrometeorological data on several Brazilian states and municipalities by providing georeferenced monitoring, prediction, drought index and frost prediction maps. In addition, users can customize their navigation by incorporating to "Favorites" the cities and states of their interest. Partners of Embrapa to develop this solution were the Ministry of Agriculture, Livestock and Food Supply (Mapa) and the State University of Campinas (Unicamp). Agritempo GIS is available for download in Google Play Store.

Software for georeferenced data and image collection

FieldAgro, also referred to as Geofielder, is a software developed for the georeferenced collection of data and images, which makes it possible to perform

Photo: Neide Makiko Furukawa

Figure 5. Agrometeorological Monitoring System (Agritempo): information of interest to the agricultural sector.

samplings and inspections in areas of interest. Every data collection inspection operation is accurately recorded, ensuring that information is collected in the required time and location.

This technological solution, developed by Embrapa Instrumentation, was transferred to Stonway Tecnologia da Informação Ltda., without exclusivity (Jorge; Monzane, 2010).

System for Observation and Monitoring of Agriculture in Brazil

The System for Observation and Monitoring of Agriculture in Brazil (Somabrasil) was developed to organize, integrate and publicize geospatial databases online through explicit spatial analysis and dynamic visualization tools, which will allow one to closely follow agricultural production. The technology, developed by Embrapa Satellite Monitoring in partnership with the Strategic Affairs Division (SAE) of the Presidency of the Republic (Batistella et al., 2012), gathers useful information for the monitoring of agricultural dynamics and for understanding the changes to land use and land cover in Brazil. Other systems have also been developed to support public policy and decision making at various levels and scales. However, these platforms often feature geospatial information focused on a specific theme. It is fundamental to organize and integrate census variables with data generated from remote sensing into a geographic database in Brazil, in order to enable studies and activities to characterize and monitor agricultural activities, conservation of natural resources, mappings and zonings.

Somabrasil has over 14,000 users, mainly from academia and public management. The technology can incorporate other functionalities and other databases, being able to be customized to meet the demands of specific customers. The WebGIS interface enables the user to interact with the databases through basic and advanced queries to generate useful information on zoning, monitoring the spatial dynamics of agriculture, research priorities and public policies. This contributes to the understanding of changes in land use and land cover. Such understanding allows the user to review the way agriculture works in the territories and anticipate possible economic or social problems due to this practice. An example of the application of the system was the technical cooperation between Embrapa Satellite Monitoring and the Agricultural Policy Division of the Ministry of Agriculture, Livestock and Supply (SPA/Mapa), established to use Somabrasil to generate queries and mappings of specific interest of the division. The products and services generated at Somabrasil to meet the technical cooperation agreement enable a quick view and access to data on climatic risk agricultural zoning (Zarc) (Brasil, 2017). The organization of Zarc data within the Somabrasil database allowed identifying inconsistencies in the database, which were promptly corrected by the Mapa staff. Finally, the generation of Zarc maps in Somabrasil provided agility for the SPA/Mapa technicians, who can quickly identify in which locations cultivating specific agricultural crops is recommended.

New tools that will make it possible to check and analyze information on rural credit and insurance are also being developed and can contribute to the

Programa de Garantia da Atividade Agropecuária (Agricultural and Livestock Assurance Program – Proagro) and to the planning and monitoring of Brazilian agriculture. The joint efforts of Embrapa Satellite Monitoring and SPA/Mapa to develop Somabrasil allowed elaborating spatial representations and producing data based on georeferenced bases so as to allow the gradual incorporation of geospatial components into agricultural and livestock plans, in order to generate spatial analyses and reports by crossing information. Other activities complement projects already under development by SPA/Mapa and aim to identify, qualify and quantify the risks involved in agriculture, define the target audience for agricultural risk minimization policies and facilitate decision-making within SPA.

Brazilian Land Classification System for Irrigation

The Sistema Brasileiro de Classificação de Terras para Irrigação (Brazilian Land Classification System for Irrigation – SIBCTI), developed by Embrapa Soils in partnership with other institutions (Amaral, 2011), is an online specialized system that returns a classification for data related to soil, water, irrigation methodology and culture. The objective is to avoid that lands not suitable for irrigation are included in the productive process, thus reducing environmental impact and loss of financial resources (Amaral, 2011).

Brazilian Soil Information System

The Sistema de Informação de Solos Brasileiros (Brazilian Soil Information System – Sisolos) was developed in partnership between Embrapa Agricultural Informatics and Embrapa Soils (Oliveira et al., 2008). The system is aimed at storing, managing, retrieving and making available information on Brazilian soils.

The system database contains attributes of soils collected and analyzed from all regions of Brazil and can be accessed via internet. The database is continuously updated by researchers from Embrapa and representatives of future partner institutions (Oliveira et al., 2008).

Information and communication technologies to support technological solutions

Embrapa has been present in the digital transformation of Brazilian agriculture since the 1990s, in the rise of internet, organizing and making available online technical-scientific information. Information and technologies are assessed, entered, stored and monitored in the Sistema de Soluções Tecnológicas da

Embrapa (Technology Solutions System of Embrapa – Gestec). Searching for solutions under the "Product" category of Gestec – selecting only Softwares – and the "Service" category – selecting only web services, which include Embrapa Information Technology (IT) area – returned 162 digital technological solutions to benefit agriculture (Figures 6 and 7) within the 2000 to 2017 period.

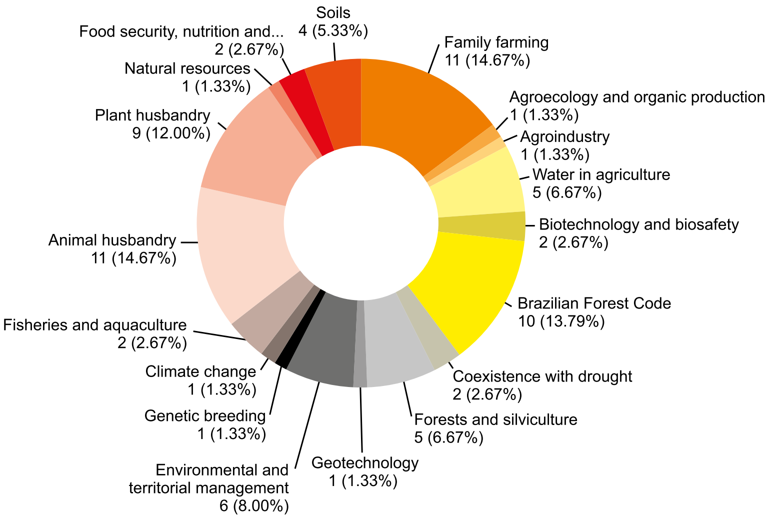

Figure 6. Softwares developed by Embrapa from 2000 to 2017, according to the categorization of themes in Gestec.

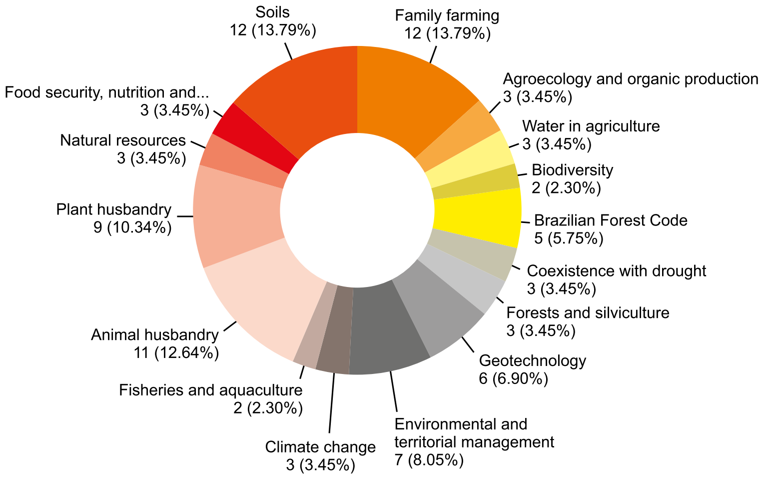

Figure 7. Web services developed by Embrapa from 2000 to 2017, according to the categorization of themes in Gestec.

Between 2000 and 2017, Embrapa developed 75 softwares to meet the demands of Brazilian agriculture (Figure 6). These include growth simulators for forest management, milk production systems management, animal feed simulators, methods for better use of agrochemicals, economic monitoring of forest operations, agrometeorological monitoring, land classification system for irrigation, soil classification, agricultural and environmental planning and mobile applications.

Between 2000 and 2017, 87 web services were entered in Sistema Gestec, also in line with Embrapa strategic objectives, thus supporting more efficient and effective decision-makers both in managing their enterprises and in developing criteria for public policies design and/or adoption. These services are platforms with information on climatic risk zoning, soil map, knowledge trees on crops, animals, plants and Brazilian biomes, databases of all the knowledge developed by Embrapa and partners of technical-scientific information, geospatial analysis of the Legal Amazon, genetic resources, among others.

Sistema Gestec is directly linked to the Embrapa portal. All the technologies entered in the system are available to society on the internet.

Systems to support studies on climate change

Agriculture is an economic activity that depends directly on climatic factors. Any change in climate can affect crop productivity and management. Embrapa has been carrying out studies on greenhouse gases (GHGs) from agricultural sources, effects of climate change on agriculture and technologies for its mitigation. In addition, Embrapa has been developing tools to support studies and technological solutions in this area.

Multi-Institutional Platform to Monitor Greenhouse Gas Emission Reductions

The Multi-Institutional Platform to Monitor Greenhouse Gas Emission Reduction (ABC Platform) is located at Embrapa Environment facilities in Jaguariúna, state of São Paulo, and aims at monitoring the reduction of GHG emissions in Brazilian agriculture, as well as Brazil's soil carbon stock dynamics, as a result of the implementation of certified technologies.

The platform, for its multi-institutional nature, involves a wide range of partners, such as the Brazilian Ministry of Agriculture, Livestock, and Food Supply; the

Ministry of the Environment; the Clima Network - Brazilian Research Network on Global Climate Change; the Ministry of Science, Technology and Innovation; universities, among others.

Multisensor Calibration and Atmospheric Correction System

The Multisensor Atmospheric Calibration and Correction System (SCCAM) is a web service developed by Embrapa Satellite Monitoring to enable the calibration and atmospheric correction of multi-sensor remote optical data.

The system comprises a chain of methods, programs and computational algorithms applied to images from several orbital optical sensors and made available in an interactive WebGIS, so that the user can access the collection of calibrated and corrected images.

Corrections of specific scenes can be requested and will be responded to according to the system support team availability; priorities are Embrapa and partners projects. One can also access technical notes and publications on calibration and correction works. The service keeps a continuous focus on each new sensor that is launched or considered of strategic importance for agricultural monitoring and mapping of land use and coverage, in order to obtain its full processing capacity.

The procedure allows the images/data to reveal target biophysical compounds, thus reducing or eliminating atmospheric effects, which is a basic element for example in improving plant biomass measurements for low carbon agriculture mapping; or in identifying/semi-quantifying mineralogical properties of the soil relevant for the management of agricultural crops, among others.

Virtual database of Coastal Ecosystems of the Campos Basin

The virtual database of Coastal Ecosystems of the Campos Basin (WebGIS) uses platforms based on free and open software and follows international and national standards for services and protocols, such as the Open Geospatial Consortium (OGC) and National Spatial Data Infrastructure (Inde). WebGIS is one of the results of the project titled Global Climate Change and the Operation of Coastal Ecosystems in the Campos Basin: A Spatial-temporal Perspective, developed under the Long-Term Ecological Research Program (Peld/CNPq). Its objective is to support research entities and management departments in the management and sustainable development of the area. The system covers Restinga da Jurubatiba National Park (Parna) and provides information on the management plan and other results of geoecological analysis developed in the project. Information plans contain data on the Parna administrative boundary, geology, geomorphology, slope, digital terrain model, shaded relief, pedology, hydrography, rainfall, satellite images and aerial photographs, land use and occupancy, and vegetation indexes. The work was done by Embrapa Satellite Monitoring and the Federal University of Rio de Janeiro (UFRJ).

Another example of applying WebGIS is the development of geotechnologies to identify and monitor pasture degradation levels (GeoDegrade project) carried out by Embrapa Satellite Monitoring. The project aims to develop methodologies for identifying and monitoring pasture degradation in the Amazon, Cerrado and Atlantic Forest biomes. With WebGIS, it is possible to guide the user in viewing information, which results in a better presentation of the results to society (Nogueira et al., 2013). One can access: the initial WebGIS interface (Figure 8); toolbars for control and manipulation of available information; base maps; theme maps; field data collected in the Amazon, Cerrado and Atlantic Forest biomes, field photographs; table of attributes and metadata. The tutorial for searching for DeoDegrade project data in WebGIS is presented by Silva et al. (2015b).

Figure 8. GeoDegrade project's virtual database system of Coastal Ecosystems of the Campos Basin.

Source: Embrapa (2015).

Soil organic carbon map

Embrapa Soils has released the digital organic carbon map of Brazilian soils (Figure 9) at 0 to 30 cm deep. The map gathers mathematical modeling and field data to assist in various natural resource conservation programs.

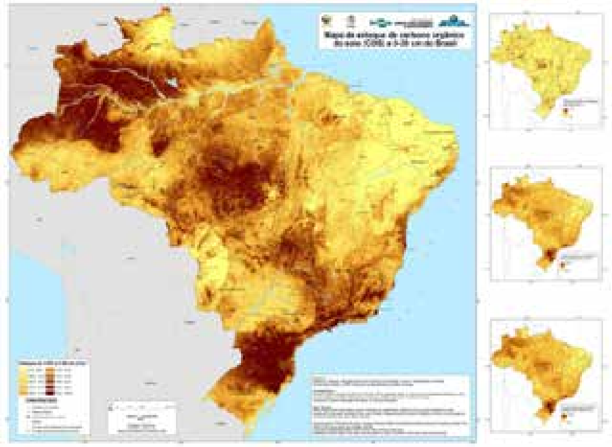

Figure 9. An example of a soil organic carbon map developed by Embrapa Soils.

Source: Dias (2017).

One of the immediate beneficiaries is the Low Carbon Emission Agriculture Program (ABC) of the Brazilian Ministry of Agriculture, Livestock and Food Supply, which can use it to direct GHG emission reduction practices.

The work used environmental information available, such as data on soil, relief, vegetation, and climate, associating them with statistical mathematical methods to infer information in unmeasured locations. One of its most important pieces of information is the total soil carbon stock at 0 to 30 cm in Brazil.

The map released by Embrapa is part of the global soil organic carbon map, an initiative of the Global Soil Partnership of the Food and Agriculture Organization of the United Nations (FAO).

Instrumentation solutions for sustainable development

Embrapa develops instrumentation solutions to promote sustainable agricultural development. Domestic facilities impact the rural and urban population health, which has led Embrapa to develop several solutions, such as the biodigester septic tank, considered a social technology that is now part of public policy of the Ministry of Cities and was defined as a standard within the Programa Nacional de

Habitação Rural (National Rural Housing Program – PNHR), which is part of the Minha Casa, Minha Vida (My House, My Life) Program.

Some technologies developed for rural or urban housing and for equipment use that improve property management, both in rural and urban areas, and that contribute to achieving targets 11.1 and 11.6, are presented below.

Environmental sanitation

Biodigester Septic Tank

The biodigester septic tank (FSB), developed by Embrapa Instrumentation, is an anaerobic biodigestion system to treat household sanitary sewage (Figure 10). The treated liquid effluent exiting the pit can be used in agriculture as a biofertilizer (Silva et al., 2017). This social technology is considered a benchmark by the federal government.

The assembly of a basic set, designed for a house with five dwellers, is made with three one thousand liter water tanks (fiber cement, fiberglass, masonry, or other

Photo: Pedro Hernandes

Figure 10. Display of biodigester septic tank for treatment of domestic sewage.

material that does not deform), pipes, fittings, valves and faucets. The toilet tubing is diverted to the biodigester septic tank.

This technological solution has been used in different places in Brazil and was even adapted to the reality of Amazonian floodplains. The Projeto Manejo Comunitário Integrado de Recursos Ambientais do Estuário Amazônico (Integrated Community Management of Environmental Resources of the Amazon Estuary Project), coordinated by the Associação dos Trabalhadores Agroextrativistas da Ilha das Cinzas (Association of Agro-Extractive Workers of Ilha das Cinzas – Ataic) in partnership with Embrapa Amapá and funding of the Financiadora de Estudos e Projetos (Finep), implemented suspended cesspits, and good results were observed. This was the beginning of the first experiment adapted to meet the needs in the flooded areas of the Amazon River estuary, where water level varies daily due to ocean tides. The system prevents contamination of the springs and generates fertilizer for family farmers.

The FSB prototype – developed as part of the project to treat domestic sewage of Ilha das Cinzas riverine community, located in Arquipélago do Marajó, Gurupá, state of Pará – has an average cost of BRL 2,300.00, including the wood structure and the tank.

Installing new biodigester tanks in Itatupã-Baquiá Sustainable Development Reserve, where Ilha das Cinzas is located, is under study by the Instituto Chico Mendes de Conservação da Biodiversidade (Chico Mendes Institute for Biodiversity Conservation – ICMBio).

Chlorine dispenser

Consuming contaminated water can cause a number of diseases, such as hepatitis, diarrhea, typhus, giardiasis, etc., which cause serious damage to health and can lead to death.

Chlorine, used in the correct ratio (0.1 to 3.0 parts per million), destroys all germs, is not harmful to health and combats contamination.

The chlorine dispenser (Clorador Embrapa, 2010) is a simple, inexpensive and easy to install device (Figure 11) to chlorinate water from the reservoir (water tanks) of rural or urban houses. The resident can assemble the device using materials found in building supply shops at low cost. Technological solution developed by Embrapa Instrumentation.

Photo: Monica Ferreira Laurito

Figure 11. Easy to assemble and low cost chlorine dispenser.

Filtering Garden

The filtering garden (Figure 12) is a technological solution developed by Embrapa Instrumentation for the treatment of domestic sewage water containing soaps, food and grease residues and the effluent treated by the biodigester septic tank. Sewage is treated in a small lake with rocks, sand and aquatic plants. Its maintenance is simple and brings landscape harmony. The filtering garden is inexpensive and simple to maintain. The treated liquid can be reused for cleaning sheds and machinery, as well as for irrigation.

Technologies and processes for sustainable production

Sensors

The Dihedral and Igstat sensors, developed by Embrapa Instrumentation, in partnership with other institutions, determine the soil moisture in the field and in urban gardens and, thus, avoid unnecessary irrigation, excess and lack of water in plants, so as to contribute to water and energy saving and to proper crop management.

Photo: Pedro Hernandes

Figure 12. Filtering garden for treatment of domestic sewage.

The sensitivity of the Dihedral sensor can measure a wide range of water tension. This indicates the correct moment to irrigate various types of soils and substrates. The sensor can be either stationary or portable and is unique for its simple operation and for not being affected by factors such as temperature, salinity, soil density and ferromagnetic substance contents.

The Igstat or IG sensor can be very efficient when integrated into irrigation control instruments, because it can control water supply according to soil moisture, that is, its sensitivity to air flow in dry soil activates water dripping. The system allows irrigation in domestic or agricultural environments (Calbo et al., 2014).

Use of water desalination waste

Water desalination is an alternative to obtain higher quality water, especially in regions highly affected by water shortage. However, this process produces tailings with high concentration of salts, which can cause damages to the soil. In order to reduce the impacts of waste from desalination of brackish water in the Brazilian semi-arid tropics, three alternatives for the use of high salinity water, which is a by-product of desalination, were tested in Experimental Station fields of Embrapa Semi-arid Region, in Petrolina, state of Pernambuco. The alternatives were: a) production of Nile tilapia (*Oreochromis* sp.); b) production of irrigated salt-grass hay (*Atriplex nummularia*); and c) fattening of goat/sheep with salt-grass hay. Mean water salinity was 11.38 ds/m. Tilapia reached 518.72 g in 153 days of cultivation; salt-grass hay yield was 14,900 kg of dry matter per hectare, and sheep/goat fed with 1.5 kg of salt-grass hay gained 138 grams/day. Due to the results obtained in these studies, using water desalination tailings in the Brazilian semi-arid region is a feasible option for income generation.

The integrated use of waste from the desalinator has been the main technology adopted in the Federal government's Programa Água Doce (Freshwater Program). Launched in 2004, it has been implemented in several rural communities in the semi-arid region, benefitting around 100,000 people in 154 locations in the Brazilian Northeastern Region.

Irrigation Monitoring in the Cerrado Program

Embrapa Cerrados, with the objective of encouraging irrigation management as a routine, developed the Programa de Monitoramento de Irrigação para o Cerrado (Irrigation Monitoring for the Cerrado Program) based on research results of over 20 years. This tool is simple and allows reliable estimations of the irrigation depth throughout the crop cycle.

Vertical Compact Sorter of Fruit-Type Vegetables

The sorter is a compact vertical unit for processing and sorting fruit-type vegetables produced on a small scale and can serve small farmers or urban farmers. It is portable, does not require water for its operation and is less expensive than conventional ones. The sorting system can be adjusted according to the form and pattern desired for the chosen fruit, thus being versatile. It was developed by Embrapa Instrumentation.

Bioreactor for cloning seedlings

The bioreactor for cloning plant seedlings (Figure 13), developed by Embrapa Genetic Resources and Biotechnology, is able to multiply plant seedlings in a cleaner, safer and more cost-effective context, as well as to reduce labor, accelerate the production cycle and increase productivity.

Photos: Raul César Pedroso da Silva

Figure 13. Bioreactor for cloning plant seedlings.

It is a great option for companies in segments related to plant production such as fruit growing, production of ornamental plants, reforestation, paper and cellulose production.

The equipment also offers other advantages over traditional methods of seedling production, such as adaptability to various plant species; standardization of production; simplicity of assembly; generation of pest and disease free products and reduction of the total cost per unit produced.

The bioreactor is based on a system of glass jars interconnected by flexible rubber tubes, whereby plants receive air and nutrient solution by sprinkler or bubblier systems. This equipment contains the materials to be reproduced, such as cells, tissues or organs, and aims to produce plants in a semi-automatic way under monitoring and control of cultivation conditions and with less manipulation of crops.

Energy and territorial management

Rural or urban development occurs due to the energy mix, in domain, size and utility, of sources, processes, distribution and uses (Embrapa Agroenergia, 2010); it is thus a strategic theme in the territorial management of a country.

Oil remains the main source of energy, accounting for 38.6% of the Brazilian energy mix in 2011. In turn, energy derived from biomass (ethanol, bioelectricity, fuelwood, charcoal and biodiesel) contributed 30.5%, while the contribution of hydroelectricity was 14.7%. The expectation of the 2030 Energy National Plan, prepared by the Brazilian Energy Research Office (EPE), is that, by 2030, this outline will be maintained, with oil accounting for 30%, biomass for 26% and hydroelectricity for 13%.

The 2011 data show that ethanol and bioelectricity obtained from sugarcane accounted for 15.7% of the national energy supply, while wood and charcoal accounted for 9.7% and biodiesel for slightly less than 1.0%. In order to increase the amount of energy from biomass, it will be necessary to increase the physical productivity in crops in terms of sugars, lignin and vegetable oils per unit of area and mass, and efforts should also be made to diversify and regionalize crop and forest production (Garagorry et al., 2012).

Energy forests in the Brazilian agroenergy mix

The Rede Florestas Energéticas na Matriz da Agroenergia Brasileira (Energy Forests in the Brazilian Agroenergy Mix Network – Femab) has been established under the leadership of Embrapa Forestry with partners from several sectors of society. With the involvement of a multidisciplinary and multi-institutional team, research is conducted with special focus on the establishment of areas with superior germplasms and suitable forestry technologies, on the offer of alternative forest products with higher economic returns and on the improvement of product yield and processes for converting biomass into energy. The actions aim to contribute to expand the use of renewable energy sources in the national energy mix with socioeconomic and environmental sustainability.

Solar irrigation device

Drip irrigation system, activated and controlled by solar light that saves water and energy. The technology is made with recyclable materials, does not use any type of motor and avoids waste thanks to the drip system. It is formed by four connected containers, one of which acts as a pressure source by capturing the light energy to activate irrigation. Only one of the containers needs to be replenished with water as it is used for irrigation. Options include using it combined with devices to dose the amount of water according to the crop requirement. The system can benefit both farmers and people who have a garden or vegetable garden in the city.

Final considerations

This chapter presented Embrapa actions that aim at achieving SDG 11 and aimed at improving the use and occupancy of rural and urban spaces.

Embrapa collaborates by providing basic information for participatory, integrated and sustainable territorial planning and management, such as geospatial information that is necessary for decision-making and public policy making.

We have also presented activities that contribute to the achievement of goals related to environmental sanitation and support instruments that can be used both in cities and in rural areas to promote more efficient use of resources. We highlight the work of Embrapa Agroenergy, which has provided vital technological solutions for the development of a new energy mix.

In addition, as a reference in agricultural production, Embrapa has been participating in activities of Urban and Peri-urban Farming (UPF). This has been promoting positive changes in the social, economic and environmental structure of places around and has become a trend in the cities, especially in peripheral areas where the poor population has restricted access to food.

Also noteworthy are the support systems for studies on climate change developed to help assess the climate change effects on agriculture and technologies for its mitigation.

Embrapa, therefore, provides possibilities for balance in the quality of life of the Brazilian population, for optimization of resources, greater productivity, less negative environmental impacts, more health and well-being. Embrapa perspective is to provide increasingly relevant contributions in urban and rural spaces in the pursuit of sustainability.

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Chapter 4

Cultural and natural heritage of Brazil

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Introduction

Culture is who we are and what shapes our identity. Placing culture at the heart of development policies is the only way to ensure human-centered, inclusive and equitable development. Safeguarding and promoting culture are ends in themselves and, at the same time, contribute directly to many of the Sustainable Development Goals (SDG) – safe and sustainable cities, decent work and economic growth, reduced inequalities, environment and gender equality. The indirect benefits of culture result from culturally conscious and effective implementations of development goals (Hosagrahar, 2017).

SDG 3 and SDG 4, which seek respectively to ensure a healthy life with well-being and an inclusive, equitable and quality education, will also be more effective if the cultural context and the local characteristics are taken into consideration. In addition, due respect for cultural diversity promotes peace, which is addressed in SDG 16 (promoting peaceful and inclusive societies), as it avoids unnecessary confrontation while seeking to protect human rights irrespective of cultural origins and differences.

Culture also relates to climate, as addressed in SDG 13, because there are activities based on local knowledge of the environment, that is, people exploit natural resources based on this traditional knowledge.

In this sense, the Brazilian Agricultural Research Corporation (Embrapa) has gathered some important efforts to strengthen the protection and safeguarding of Brazilian cultural and natural heritage, which relates to target 11.4 of SDG 11. These actions relate directly to the recognition of inclusive, safe, resilient and sustainable human settlements. They are inclusive because they recognize ways of life maintained for centuries and some for millennia by several peoples around the world, safe because their essence involves security and food sovereignty of traditional peoples and communities, so that agrobiodiversity is maintained mainly by the inherent resilience of distinct social, ecological, cultural and agricultural systems that contribute greatly to sustainability.

Protection and safeguarding of world cultural and natural heritage

Indigenous agricultural systems and some foods derived from them (Figure 1) can be seen as intangible cultural goods, as social functions and cultural meanings have been attributed to them through historical, social and symbolic processes. Traditional farming practices constitute the social, cultural and environmental identity of a particular group, indigenous people or traditional community.

Photo: Paulo Luiz Lanzetta Aguiar

Figure 1. Sample of agrobiodiverse foods.

Knowledge involved in a particular agricultural practice is usually created and shared as part of processes of survival, appropriation and transformation of natural resources that take place where these peoples live and coexist. Events such as celebrations, feasts and rituals associated with selecting, planting, harvesting, preparation methods and consumption of agrobiodivesity involved in a given system stand out.

In this way, these traditional farming systems belong to cultural and symbolic systems associated with knowledge and practices that are transformed and adapted, so as to keep the dynamic conservation to maintain these systems. Below we present some actions related to the recognition of these unique systems, with which Embrapa is involved by contributing to activities of planning, dynamic conservation, dissemination and due recognition of their contribution to agrobiodiversity.

Embrapa actions

Participation in the registration of Traditional Farming System of Rio Negro

The Sistema Agrícola Tradicional do Rio Negro (Traditional Farming System of Rio Negro – SAT-RN) was registered by the Instituto do Patrimônio Histórico e Artístico Nacional (Institute of Brazilian Historical and Artistic Heritage – Iphan) as Intangible Cultural Heritage of Brazil in December 2010 (Dossiê, 2010). The SAT-RN registration dossier describes the traditional farming system as a set of unique knowledge of space management, cultivated plants, associated material culture and related ways to eat food. The term system reveals that the domains of knowing and doing are interdependent. It includes several processes at different ecological, biological, sociocultural and temporal scales that transcend the domains of material, social and economic life and that serve symbolic and productive functions.

For the ethnic groups that inhabit the Rio Negro area (23 ethnic groups that speak 19 different languages), *manivas* (cassava seedlings) are part of the goods that the bride takes when she goes to live with the groom's family. Thus, with the *manivas* (Figure 2) originating from other ethnic group, the women (mother-in-law and daughter-in-law) carry out a complex cross-fertilization process, culminating in the generation and germination of botanical cassava seeds. Plants that grow in these small cultivated areas, as the result of such care, are called *donas da roça* (area owners) and are carefully treated, because they bring renewal. *Dona da roça* is a plant with fully differentiated genotype and phenotype, which is very relevant in the case of plants such as cassava, which are usually propagated by vegetative means (part of plant – seedlings – clones). The aforementioned action started in 2011 and is related to the appreciation of indigenous peoples knowledge about expanding and conserving agrobiodiversity of different crops, especially *brava* cassava (*Manihot esculenta*), which is considered the heart of this cultural heritage.

Photo: Síglia Regina dos Santos Souza

Figure 2. Manivas sample.

Representatives from the Headquarters of Embrapa and Embrapa Western Amazon joined workshops in which the conservation of agrobiodiversity was the main theme. They both reported techniques for ex situ, in situ and on farm conservation held at Embrapa and learned from indigenous people about techniques used for millennia for expanding diversity of cassava, the main Brazilian native plant, which is of fundamental importance for food security.

In a workshop held in 2015, in Santa Isabel do Rio Negro, indigenous people learned about in vitro (ex situ) conservation techniques used by Embrapa and requested a survey of the accessions of cassava germplasm from the Rio Negro in Embrapa herbariums and germplasm banks. The survey identified 26 accessions collected in the region and preserved in Embrapa distributed as follows: 2 accessions in Barcelos, 6 in Manaus, 3 in Novo Airão, 16 in Santa Isabel do Rio Negro and none in São Gabriel da Cachoeira. This reveals the enormous importance of working on cassava germplasm conservation together with indigenous populations that belong to this intangible cultural heritage, which is the Traditional Farming System of Rio Negro.

Giahs/FAO Program and technical cooperation between Embrapa-Iphan-FAO

International recognition of the role of traditional knowledge for innovation led the United Nations Food and Agriculture Organization (FAO) to launch an initiative for a global partnership on the conservation and evolutionary management of ingenious systems of global agricultural heritage (Globally Important Agricultural Heritage Systems – Giahs). Giahs are remarkable systems of land and landscape use characterized by a wealth of globally significant diversity and evolved as part of the adaptation of a community to its environment, needs and aspirations towards sustainable development.

Giahs became a FAO corporate program in January 2016. It was built on the goals of the 2002 World Summit on Sustainable Development and in response to global developments that undermine the foundations of family agriculture and traditional farming systems. This initiative seeks to identify and safeguard these systems and associated landscapes (representing an area of 5 million hectares in the world) as well as agricultural biodiversity and its knowledge systems, as they ensure to humanity a vital set of social, cultural, ecological and economic services.

According to Koohafkan and Altieri (2011), these traditional farming systems are associated with heterogeneous and unique landscapes that are managed by an estimated 1.4 billion people, mostly of which are family farmers, peasants, traditional communities and indigenous peoples. They are essentially sustainable systems that provide multiple goods and services, food and well-being for millions of poor, small-scale farmers. These authors estimate that 30% to 50% of household food consumed in developing countries come from these systems, thus ensuring local food security. The existence of numerous Giahs around the world testifies to people's creativity and ingenuity in using and managing finite resources, biodiversity, ecosystem dynamics and ingenious use of the landscape physical attributes, which are translated into traditional knowledge, practices and technologies (Koohafkan; Altieri, 2011). Whether they are recognized or not by the scientific community, these ancestral systems are the basis of contemporary and future innovations in agriculture. Thus, they can be considered repositories of intergenerational wisdom because of their high adaptability to change. Still according to Koohafkan and Altieri (2011), these more or less intensely managed farming systems, crops and associated herds are heavily protected or buffered against changes such as environmental disturbances and climatic storms due to the rich biodiversity maintained by human care.

Giahs has already recognized more than 40 sites in countries such as Bangladesh, China, Japan, Kenya and Tanzania. In Latin America, we have Chile and Peru. Brazil, as Mexico and Ecuador, does not have a Giahs site, but potential sites have already been identified. Some of these are: Traditional Farming System of Rio Negro and systems adopted by *veredeiros* (wet grasslands inhabitants), *pantaneiros* (Pantanal inhabitants), *vazanteiros* (floodplains inhabitants), *faxinalenses* (communal rural area inhabitants), *geraizeiros* (Minas Gerais Cerrado inhabitants) and evergreen collectors are part. The dynamics of production and reproduction of the various domains of social life within these traditional farming systems, along with personal and historical experiences, mold identities and contribute to biodiversity conservation, thus being part of the Brazilian intangible cultural heritage.

In order to open up spaces and to foster research and development on a theme that responds to the great global challenges of resource conservation and on traditional practices linked to agrobiodiversity, as well as to recognize the intrinsic value of related traditional knowledge and to create an institutional space to accommodate submissions and designations of Giahs sites in Brazil, the Embrapa-Iphan Technical Cooperation Agreement (ACT) was signed in May 2016. The ACT aims to strengthen and develop safeguard plans for systems related to agrobiodiversity, thus enabling the construction and necessary development of methodologies for inventories of traditional knowledge on agrobiodiversity, on environment use systems, on agriculture and food strategies and on peoples and traditional communities. The Embrapa-Iphan technical cooperation, besides providing the exchange of experiences, information and technologies, enables the improvement and technical training of the staff of both institutions, and contributes to the institutional development of public management by implementing joint or mutually-supporting actions in common interest activities.

Some initiatives arising from the work plan of this Embrapa-Iphan Agreement are worth highlighting in the context of Embrapa contributions to the recognition of traditional farming systems natural and cultural heritage. Among them is the initial selection of potential Giahs sites. Interviews were conducted with representatives of the Krahô indigenous people (state of Tocantins), fishermen/extractivists from Bailique (state of Amapá), *caiçaras* (inshore small-scale fishermen from the states of São Paulo and Paraná), *quilombolas* (rural African-Brazilian community farmers in the state of São Paulo), and evergreen collectors (state of Minas Gerais).

The traditional farming system of the evergreen flower collectors (Figure 3) was selected to receive a small financial contribution from FAO to prepare its first Giahs application dossier in Brazil.

Photos: João Roberto Ripper

Figure 3. Evergreen collectors, Serra do Espinhaço, state of Minas Gerais.

BNDES Award for traditional farming systems

Another relevant initiative to be highlighted within the Embrapa-Iphan Agreement is the Prêmio BNDES de Boas Práticas para Sistemas Agrícolas Tradicionais (BNDES Good Practices for Traditional Farming Systems Award) (Figure 4). It is an initiative of the Brazilian Development Bank (BNDES) in partnership with Embrapa, Iphan and FAO Brazil. This award recognizes the central role played by culture in maintaining traditional farming systems, since it is traditional knowledge shared by the communities and their respective cultural dynamics that sets the value of these systems and determine their possibilities for sustainability and reproduction (Banco Nacional de Desenvolvimento Econômico e Social, 2018).

The award recognizes 15 good practices of safeguarding and dynamic conservation of Traditional Farming Systems (SATs) either fully or partially completed. The award also aims to increase Brazilian SATs visibility; encourage and strengthen joint actions and community networks on SATs for its acknowledgement and maintenance of practices for knowledge transmission between generations; set the grounds for designing and implementing specific public policies, since award applications provide a sample of initiatives for

Figure 4. Banner of BNDES Good Practices for Traditional Farming Systems Award.

Source: Banco Nacional de Desenvolvimento Econômico e Social (2018).

the safeguarding and dynamic conservation of SATs within Brazil; and look for, recognize and record SAT good practices, in order to set the grounds for institutions to disseminate among the award audience and to encourage the development of public policies and international tools aimed at traditional peoples and communities.

In 2018, 15 actions to safeguard and preserve SATs in Brazil were awarded. The top five received a gross value of BRL 70,000, and the remaining ones received a gross amount of BRL 50,000.

An award ceremony and training event was held at Embrapa Headquarters in June of 2018. The winning SAT social groups/communities were granted funds to send one or more representatives to attend the ceremony and training.

Private Reserve of Natural Heritage

Some Embrapa Units have transformed their research centers into a Reserva Particular de Patrimônio Natural (Private Natural Heritage Reserve – RPPN), which allows preserving natural ecosystems. It is worth mentioning the Reserva do Caju (Figure 5), a RPPN that occupies part of the experimental field of Embrapa Coastal

Photos: Saulo Coelho Nunes

Figure 5. Embrapa Coastal Tablelands experimental field, in Aracaju, state of Sergipe (A), and Reserva Ambiental do Caju, in Itaporanga D'Ajuda, state of Sergipe, on the edge of the Vaza-Barris River, partially within the experimental field of Embrapa (B).

Tablelands in Itaporanga D'Ajuda (Aracaju, state of Sergipe). This was the first Embrapa Unit to have a federal RPPN.

It was recognized by the Instituto Chico Mendes de Conservação da Biodiversidade (Chico Mendes Institute for Biodiversity Conservation – ICMBio). After making this reserve official, this Embrapa Unit now has a 763.37 ha area – out of the total 910.81 ha of the farm –for permanent conservation.

Located on the edge of the Vaza-Barris River, near its mouth, the reserve holds a rich and exuberant essence of the Northeastern coast diversity, including several animal species and vegetation remaining of the Atlantic Forest, wetlands and coconut trees. In the surrounding area, there are traditional communities whose livelihood comes from activities such as artisanal fisheries, which rely on environmental preservation of the region.

Final considerations

Brazil has the largest biological diversity in the world, which is closely related to the processes and practices of traditional peoples, whether they are indigenous, riverine, *quilombola* or others, who are included among Embrapa clients.

In relation to nature conservation, natural resources sustainability is directly linked to the use of territories holding biodiversity, either to meet current needs or to keep a reserve for future uses. Sustainability comprises not only the protection of natural resources, but also the defense of interests and living conditions of social subjects that depend directly and/or indirectly on the protection of such resources (Silva; Souza, 2009).

The actions described in this chapter reveal the contributions of Embrapa to the global agenda in which recognition of, appreciation for and conservation of global natural and cultural heritage relative to traditional farming expressed in highly agrobiodiverse, dynamic and ingenious systems are key issues. Supporting and joining a program like Giahs in Brazil is an important step for Embrapa in facing the complex issues related to climate change, land use, the market, conservation of traditional farming systems, landscapes, agrobiodiversity, food and nutritional security and traditional knowledge. For this, Embrapa has established partnerships to develop research and technologies to strengthen traditional farming systems preservation and conservation and to guarantee cultural goods associated with agrobiodiversity.

There are various challenges related to target 11.4, and the actions described in this chapter provide a small range of possible paths and solutions developed by Embrapa to address the complex scope of this goal.

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Chapter 5

Advances and future challenges

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Introduction

In this book, the contributions of Embrapa to achieving SDG 11 were presented in detail in four chapters regarding actions that contribute to the construction of inclusive, safe, resilient and sustainable human settlements and cities.

Embrapa played an important role in providing technological solutions to Brazilian society, especially to managers, who are in charge of strategic decisions.

Advancing unplanned urbanization over rural areas has been causing several negative environmental impacts, such as forest destruction and changes in water resources. Poor or non-existent basic sanitation services are common in cities and in the countryside and pose risks to human health and the environment. To change this and other realities, planning, territorial management, food production and clean energy, as well as the proper use of water, are of utmost importance.

Highlights of Embrapa

The integrated perspective of territorial intelligence comprises the multiple dimensions of the development process: environmental, agrarian, agricultural, rural, urban, cultural, socioeconomic, etc., which can lead to the proper functioning of the Brazilian space.

Embrapa collaborates with knowledge, such as decision support systems, softwares, applications, agricultural and hydrological models, technological solutions for food production, monitoring tools and platforms. This is of strategic importance for all sectors of society, whether in urban or rural areas.

Embrapa Territorial, an Embrapa Decentralized Unit (located in Campinas, state of São Paulo), provides data and information on the national territory so as to strengthen governance actions on public and private management of agricultural production chains and to anticipate future challenges based on territorial intelligence. In addition, all Embrapa Units contribute by providing knowledge to foster sustainable development.

Information available in the databases of Grupo de Inteligência Territorial Estratégica (Strategic Territorial Intelligence Group – Gite) offers summaries and diagnoses for any Brazilian state or region on five themes: natural, agrarian, agricultural, infrastructural and socioeconomic frameworks. Gite services have been supporting the planning, implementation, monitoring of actions, the evaluation of policies and public and private investments, in several production chains and geoeconomic regions. Such information is used by governments to carry out concrete actions at the municipal, state and federal levels.

Of important notice is Embrapa experience in using simulation models to evaluate the effects of different technologies or environmental conditions and in making available spatial data that can support studies and assessments of changes in weather patterns or in conditions of land use and cover.

Also highlighted are Embrapa efforts to find alternatives, products and processes for energy production and for rational use of water and to support urban and peri-urban farming especially by offering training courses and by conducting research studies on the theme, thus contributing to food production and well-being and health in the cities.

Future challenges

The path to achieving SDG 11 is long, and Embrapa has already identified trends, challenges and opportunities as a way to define strategies for action.

Among the various challenges and opportunities already identified, Embrapa will continue to focus on: a) developing innovative agricultural risk management systems by integrating climatic, technological, socioeconomic, environmental and market aspects; b) developing new production systems that include rural multifunctionality and integrate food, fiber and energy production into non-agricultural economic activities (e.g. rural tourism and ecosystem services); c) developing innovative digital tools that allow remote monitoring and constructing scenarios to support management institutions and production process players in making decisions on land use and regional water resources; and d) improving regional analyses on new technological, social, economic and demographic trends, in order to reduce the “social differentiation” process.

Brazil commitments to the COP21 Sustainability Agenda requires the continuous increase in biodiesel rate in the blend with diesel. This increase must take place with guaranteed biofuel quality in accordance with nationally and internationally defined criteria. Limitations due to microbial contamination and storage stability require special attention from researchers so that they can help to foster development and transfer of knowledge and technologies necessary to guarantee biodiesel quality (Souza Júnior et al., 2017). There are several opportunities for greater efficiency and competitiveness for the biodiesel and bio-kerosene production sector by means of diversifying raw materials and products used. According to researchers from Embrapa Agroenergy, the use of waste and co-products as raw material for producing both biofuel (from other production chains, in addition to the soy chain and animal production) or higher value-added bioproducts (using waste and co-products of the biodiesel and bio-kerosene production chain), meets this set of opportunities. This diversification may include using waste and co-products from other agricultural, agro-industrial and urban waste production chains, which are not yet directly related to the biofuel production chain. An example would be the production of “biocrude oil” from floating sludge from sewage treatment plants, which is previously refined for biofuel and other higher value-added bioproduct production (Souza Júnior et al., 2017).

Regarding forest biomass for energy, in which case Brazil has a competitive advantage in the world context, it is necessary to address the following challenges: the lack of developed germplasm adapted to different areas of Brazil; gaps to increase forest crop productivity in single and integrated systems; low technological level of traditional methods for converting wood into energy; few technologies to generate more complex energy products for specific purposes.

In 2017, the Brazilian government launched the Plano Nacional de Internet das Coisas (National Internet of Things Plan) (Produto 8, 2017), detailing policies and strategies for implementing technologies to connect devices and equipment. Priority areas are: health, smart cities, industry and rural areas. According to the plan, it is expected that these policies will be implemented already between 2018 and 2022. Using IoT in agriculture is still beginning. However, there is great potential for doing business, reducing costs and increasing productivity. Some challenges in this area are:

- Feasibility of business models that capture complex relations involving great multidisciplinarity and different types of companies in search for providing profitable agribusiness solutions for all players.

- Creation of IoT-based collaborative technological laboratories for advanced research in sustainable agriculture, so as to allow the use of IoT in the countryside and to promote training for its use in the rural environment. An important issue is integrating, adapting and training family farmers in this new reality.
- Integration and use of open standards that allow data and information communication in all domains, especially in rural areas.
- Sharing of data through a middleware platform that integrates different data sources.
- Presentation of public policies for the IoT in agriculture sector, whether in terms of economic incentives or regulatory matters.

Thus, Embrapa, together with partner institutions, expects to increase its value delivery to Brazilian society by means of producing impacting results that contribute to positive and consistent changes, both in rural and urban areas in Brazil.

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Embrapa

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