SUSTAINABLE
DEVELOPMENT
GOAL
11

SUSTAINABLE CITIES AND COMMUNITIES

CONTRIBUTIONS OF EMBRAPA

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Technical Editors

Embrapa

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

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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.

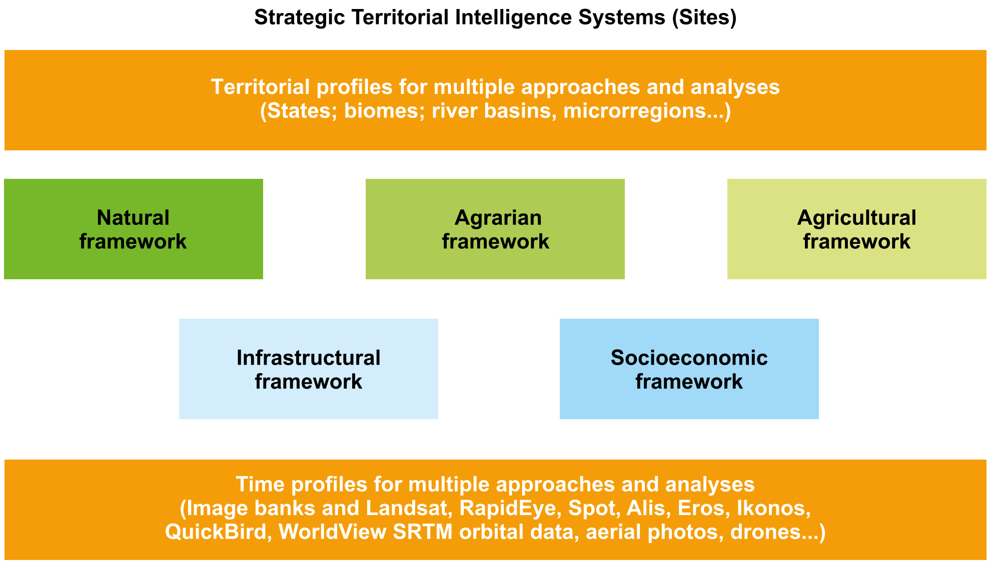

Figure 1. Main themes and territorial and time profiles structured in intelligence systems developed by Grupo de Inteligência Territorial Estratégica (Strategic Territorial Intelligence Group – Gite).

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

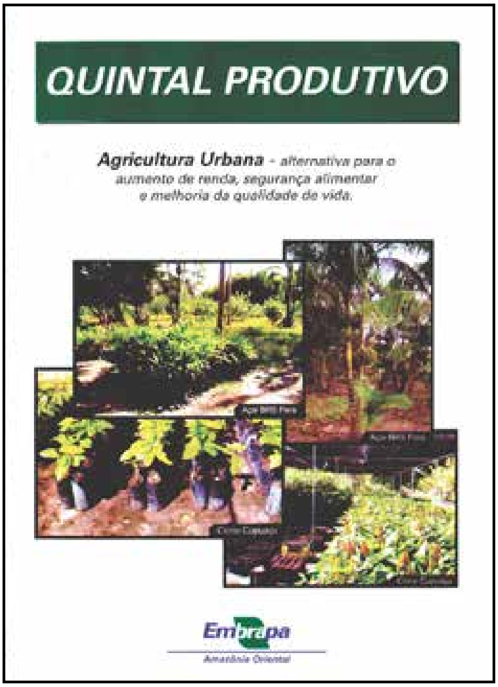

Figure 2. Embrapa textbook with information on management of fruit plants.

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.

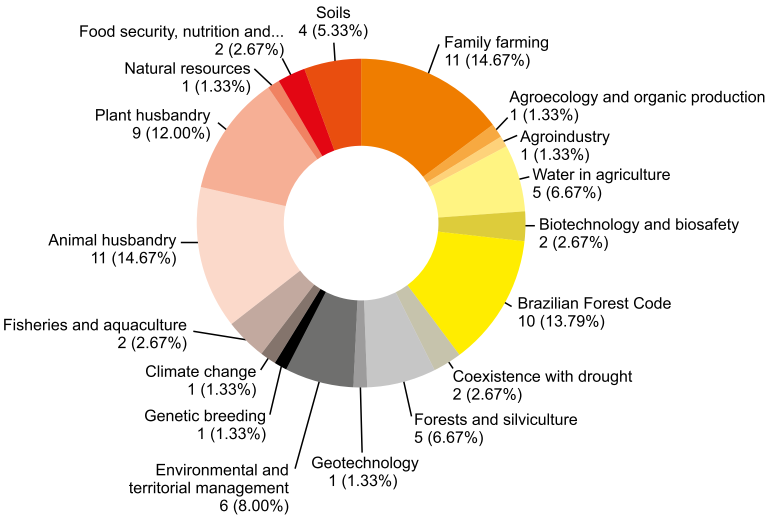

Figure 6. Softwares developed by Embrapa from 2000 to 2017, according to the categorization of themes in Gestec.

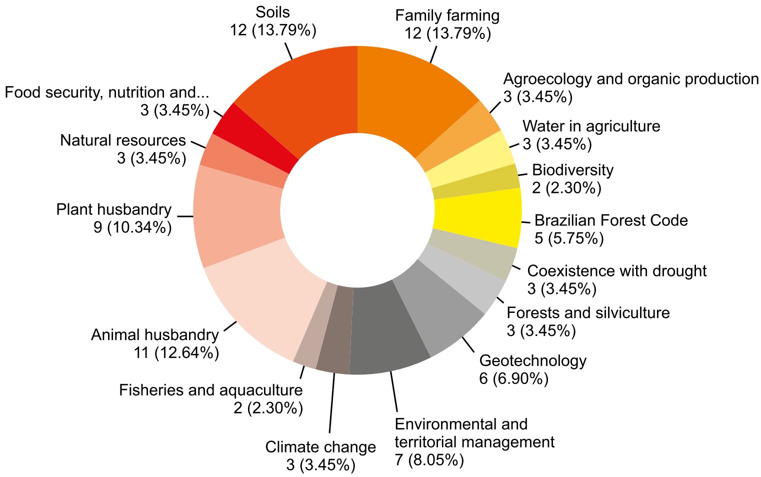

Figure 7. Web services developed by Embrapa from 2000 to 2017, according to the categorization of themes in Gestec.

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.

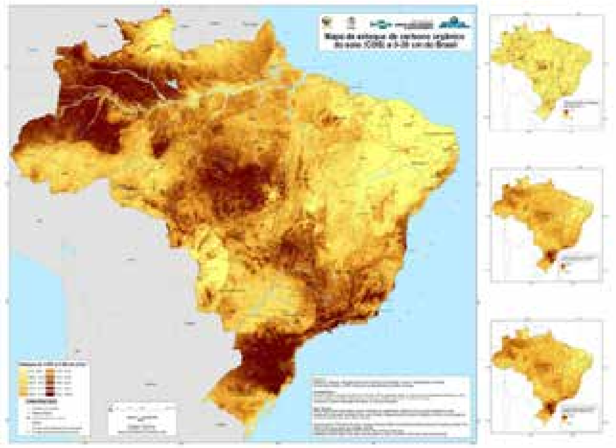

Figure 9. An example of a soil organic carbon map developed by Embrapa Soils.

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.

References

ALCÂNTARA, F. A. de; BRANCO, M. C.; MELO, P. E.; SANTOS, R. C. **Consórcio de milho e mucuna anã visando ao manejo sustentável do solo em área de agricultura urbana**. Brasília, DF: Embrapa Vegetables, 2005.13 p. (Embrapa Vegetables. Boletim de pesquisa e desenvolvimento, 13).

AMARAL, F. C. S. do (Ed.). **Sistema brasileiro de classificação de terras para irrigação**: enfoque na região semiárida. 2. ed. Rio de Janeiro: Embrapa Solos, 2011. 164 p.

BATISTELLA, M.; BOLFE, E. L.; VICTORIA, D. de C.; CUSTÓDIO, D. de O.; SILVA, G. B. S. da; DRUCKER, D. P. **SOMABRASIL**: Sistema de Observação e Monitoramento da Agricultura no Brasil. Campinas: Embrapa Monitoramento por Satélite, 2012. 11 p. (Embrapa Monitoramento por Satélite. Comunicado técnico, 29).

BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. **Zoneamento agrícola de risco climático**. Available at: <http://www.agricultura.gov.br/acesso-a-informacao/acoes-e-programas/cartas-de-servico/politica-agricola/zoneamento-agricola-de-risco-climatico>. Accessed on: Dec 20, 2017.

BRASIL. Ministério do Meio Ambiente. Secretaria de Articulação Institucional e Cidadania Ambiental. **Boas práticas em educação ambiental na agricultura familiar**: exemplos de ações educativas e práticas sustentáveis no campo brasileiro. Brasília, DF, 2012. 246 p. (Série EducAtiva, 1).

BUSCHINELLI, C. C. de A.; CALEGARIO, F. F.; RODRIGUES, G. S.; SERRA, A. L. de S.; SEMIS, J. B.; FERRARA, L.; ABRAÃO, J. B.; ADAMI, J. A.; MAZIERO, J. C. **Plano de gestão ambiental da produção integrada de morango**: contribuição metodológica para a certificação. Jaguariúna: Embrapa Meio Ambiente, 2016. 61 p. (Embrapa Meio Ambiente. Boletim de pesquisa e desenvolvimento, 67).

CALBO, A. G.; VAZ, C. M. P.; RABELLO, L. M. Controle atmomagnético de irrigação com sensores IG. In: SIMPÓSIO NACIONAL DE INSTRUMENTAÇÃO AGROPECUÁRIA, 2014, São Carlos. **Anais do SIAGRO**: ciência, inovação e mercado 2014. São Carlos, SP: Embrapa Instrumentação, 2014. p. 337-340.

CLEMENTE, F. M. V. T.; HABER, L. L. (Ed.). **Horta em pequenos espaços**. Brasília, DF: Embrapa Hortaliças, 2012. 56 p.

CLORADOR Embrapa. São Carlos: Embrapa Instrumentação, 2010. Available at: <http://saneamento.cnpdia.embrapa.br/tecnologias/Folder_Clorador.pdf>. Accessed on: Jan 16, 2018.

COMISSÃO NACIONAL DE CARTOGRAFIA. **Plano de Ação para Implantação da Infraestrutura Nacional de Dados Espaciais**. Rio de Janeiro, 2010. 203 p.

CONSUMO sustentável: manual de educação. Brasília, DF: Consumers International, 2005. 160 p.

CORBOULD, C. Feeding the cities: is urban agriculture the future of food security? **Strategic Analysis Paper**, Nov 1, 2013. Available at: <http://futuredirections.org.au/wp-content/uploads/2013/11/Urban_Agriculture-_Feeding_the_Cities_1Nov.pdf>. Accessed on: Dec 11, 2017.

CUADRA, S. V.; STEINMETZ, S.; HEINEMANN, A. B.; ALMEIDA, I. R. de. Impacto das mudanças climáticas sobre o desenvolvimento a produtividade do arroz irrigado no Estado do Rio Grande do Sul. In: CONGRESSO BRASILEIRO DE AGROMETEOROLOGIA, 19., 2015, Lavras. **Agrometeorologia no século 21**: o desafio do uso sustentável dos biomas brasileiros: anais. Lavras: Ed. UFLA, 2015. p. 377-386.

DIAS, C. **Brasil lança o mapa de carbono orgânico do solo**. Brasília, DF: Embrapa, 2017. Notícias. Available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/30179699/brasil-lanca-o-mapa-de-carbono-organico-do-solo>. Accessed on: Jan 15, 2018.

DRUCKER, D. P.; PINTO, D. M.; CARDOSO, E. C.; CUSTODIO, D. O.; VICTORIA, D. C.; ALMEIDA, B. T.; PIEROZZI JUNIOR, I.; MACHADO, C. L.; BRANDÃO, V. V. S.; BAYMA-SILVA, G.; LAFORET, M. R. C.; TAKEMURA, C. M.; OLIVEIRA, L. H. Open geodata to support agricultural research. **Geoinformatics Research Papers**, v. 5, p. 120-121, 2017. BS1002. Available at: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/166887/1/PL-OpenGeodata-CODATA-2017.pdf>. Accessed on: Jan 15, 2018.

EMBRAPA AGROENERGIA. **Relatório de atividades 2009**. Brasília, DF, 2010. 75 p. (Embrapa Agroenergia. Documentos, 002).

EMBRAPA. **Gite**: Grupo de Inteligência Territorial Estratégica: o que fazemos. Available at: <https://www.embrapa.br/gite/sobre/index.html>. Accessed on: Dec 10, 2017.

EMBRAPA. **Soluções tecnológicas**: WebGIS – base de dados virtual dos ecossistemas costeiros da Bacia de Campos. Brasília, DF, 2015. Available at: <https://www.embrapa.br/busca-de-solucoes-tecnologicas/-/produto-servico/2301/webgis---base-de-dados-virtual-dos-ecossistemas-costeiros-da-bacia-de-campos>. Accessed on: Jan 20, 2018.

FAO. Comité de Agricultura. **La agricultura urbana y periurbana**. Roma, 1999. 30 p. (FAO. COAG/99/10).

FARIAS, A. R.; MINGOTI, R.; VALLE, L. B.; SPADOTTO, C. A.; LOVISI FILHO, E. **Identificação, mapeamento e quantificação das áreas urbanas do Brasil**. Campinas: Embrapa Gestão Ambiental, 2017. 5 p. (Embrapa Gestão Ambiental. Comunicado técnico, 4).

FESSENDEN, M. Most plastic trash comes from farms. **Smithsonian.com**, 3 Apr 2015. Available at: <https://www.smithsonianmag.com/smart-news/most-plastic-trash-comes-farms-heres-what-were-trying-do-about-it-180954873/>. Accessed on: Dec 5, 2017.

GARAGORRY, F. L.; SOUZA, M. O. de; DIAS, J. M. C. de S. **Cenários territoriais para 15 produtos agroenergéticos**. Brasília, DF: Embrapa Agroenergia, 2012. 149 p. (Embrapa Agroenergia. Documentos, 012).

GUIMARÃES, T. G.; MADEIRA, N. R. **Sistema Filho**: fruticultura integrada com lavouras e hortaliças. Planaltina, DF: Embrapa Cerrados, 2017. 12 p. (Embrapa Cerrados. Circular técnica, 34). Available at: <https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1072770/sistema-filho-fruticultura-integrada-com-lavouras-e-hortalicas>. Accessed on: Jan 20, 2018.

JESUS, M. A. S. de; CIRANI, C. B. S.; JESUS, K. R. E. Avaliação do impacto de ecoinovações: o caso da tecnologia de biodigestores aplicada na agroindústria processadora de mandioca do Estado do Paraná. In: CONGRESSO SOBRE GERAÇÃO DISTRIBUÍDA E ENERGIA NO MEIO RURAL, 10., 2015, São Paulo. **Anais**... São Paulo: Ed. Universidade de São Paulo, 2015. 10 p.

JESUS-HITZSCHKY, K. R. E. Impact assessment system for technological innovation: Inova-tec System. **Journal of Technology Management & Innovation**, v. 2, n. 2, p. 67-82, 2007.

JORGE, L. A. de C.; MONZANE, M. R. G. Geofielder: uma solução gratuita para levantamento georreferenciado. In: CONGRESSO BRASILEIRO DE AGRICULTURA DE PRECISÃO-CONBAP, 2010, Ribeirão Preto. [**Anais**...]. Ribeirão Preto: SBEA, 2010. 1 CD-ROM.

KASTENS, J. H.; BROWN, J. C.; COUTINHO, A. C.; BISHOP, C. R.; ESQUERDO, J. C. D. M. Soy moratorium impacts on soybean and deforestation dynamics in Mato Grosso, Brazil. **Plos One**, v. 12, n. 4, 2017. Available at: <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0176168>. Accessed on: Dec. 10, 2017.

LASSO, P. R. O.; VAZ, C. M. P.; OLIVEIRA, C. R.; BERNARDI, A. C. C. Caracterização de resíduos de construção e demolição reciclados (RCD-R) para utilização como corretivo da acidez do solo. In: SIMPÓSIO INTERNACIONAL SOBRE GERENCIAMENTO DE RESÍDUOS AGROPECUÁRIOS E AGROINDUSTRIAIS, 3., 2013, São Pedro, SP. [**Anais**... S.l.: s.n., 2013]. Available at: <https://ainfo.cnptia.embrapa.br/digital/bitstream/item/125777/1/ag-uso-02-PauloLasso.PDF>. Accessed on: Jan 10, 2018.

MAGDALENO, F. S. O território nas constituições republicanas brasileiras. **Investigaciones Geográficas**, n. 57, p. 114-132, 2005.

MELO, L. P. Os benefícios da agricultura urbana e periurbana para a sustentabilidade da cidade de Macapá-AP. In: CONGRESSO LUSO BRASILEIRO PARA O PLANEJAMENTO URBANO REGIONAL, INTEGRADO E SUSTENTÁVEL, 7., 2016. **Pluris**: contrastes contradições complexidades: desafios urbanos no século XXI. Available at: <http://www.fau.ufal.br/evento/pluris2016/files/Tema%204%20-%20Planejamento%20Regional%20e%20Urbano/Paper1342.pdf>. Accessed on: Feb 2, 2018.

MICHEREFF FILHO, M.; GUIMARÃES, J. A.; LIZ, R. S. **Recomendações para o controle de pragas em hortas urbanas**. Brasília, DF: Embrapa Hortaliças, 2009.11 p. (Embrapa Hortaliças. Comunicado técnico, 80).

NIGUSSIE, A.; KUYPER, T. W.; NEERGAARD, A. de. Agricultural waste utilisation strategies and demand for urban waste compost: evidence from smallholder farmers in Ethiopia. **Waste Management**, v. 44, p. 82-93, Oct 2015. DOI: 10.1016/j.wasman.2015.07.038.

NOGUEIRA, S. F.; SILVA, G. B. S.; ANDRADE, R. G.; VICENTE, L. E. Geotecnologias para o monitoramento dos níveis de degradação das pastagens no Brasil. **MundoGeo**, v. 15, n. 72, p. 60-64, 2013.

OLIVEIRA, P. A. V. **Projeto de biodigestor e estimativa da produção de biogás em sistema de produção**. Concórdia: Embrapa-CNPSA, 2005. 8 p. (Embrapa-CNPSA. Comunicado técnico, 417).

OLIVEIRA, S. R. de M.; ZURMELY, H. R.; LIMA JÚNIOR, F. A. de; SANTOS, H. G. dos; MEIRELLES, M. S. P. **Sistema de informação de solos brasileiros**. Campinas: Embrapa Informática Agropecuária, 2008. 8 p. (Embrapa Informática Agropecuária. Comunicado técnico, 93).

PESSÔA, C. C. **Agricultura urbana e pobreza**: um estudo no município de Santa Maria – RS. 2005. 87 f. Dissertação (Mestrado em Desenvolvimento Sustentável) – Universidade Federal de Santa Maria, Santa Maria.

PIRES, A. M. M.; MATTIAZZO, M. E. **Avaliação da viabilidade do uso de resíduos na agricultura**. Jaguariúna: Embrapa Meio Ambiente, 2008. 9 p. (Embrapa Meio Ambiente. Comunicado técnico, 19).

PIRES, V. C. Agricultura urbana como fator de desenvolvimento sustentável: um estudo na Região Metropolitana de Maringá. **Revista Pesquisa & Debate**, v. 27, n. 2 (50), p. 69-84, dez. 2016.

RODRIGUES, G. S.; CAMPANHOLA, C.; KITAMURA, P. C. **Avaliação de impacto ambiental da inovação tecnológica agropecuária**: AMBITEC-AGRO. Jaguariúna: Embrapa Meio Ambiente, 2003. 95 p. (Embrapa Meio Ambiente. Documentos, 34).

RODRIGUES, G. S.; RODRIGUES, I. Avaliação de impacto ambiental na agropecuária. In: GEBLER, L.; PALHARES, J. C. P. (Ed.). **Gestão ambiental na agropecuária**. Brasília, DF: Embrapa Informação Tecnológica, 2007. p. 286-310.

SANTOS, E. **Primeira fábrica de fertilizante organomineral com tecnologia Embrapa e Calderon Consulting inaugura em 2017**. Brasília, DF: Embrapa, 21 dez. 2016. Notícias. Available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/19061639/primeira-fabrica-de-fertilizante-organomineral-com-tecnologia-embrapa-e-calderon-consulting-inaugura-em-2017>. Accessed on: Dec 5, 2017.

SEMINÁRIO DA REDE AGROHIDRO, 4., 2016, Brasília, DF. **Água e agricultura**: incertezas e desafios para a sustentabilidade frente às mudanças do clima e do uso da terra: anais. Planaltina, DF: Embrapa Cerrados, 2016. 289 p. Available at: <http://ainfo.cnptia.embrapa.br/digital/bitstream/item/152016/1/Agua-e-agricultura.pdf>. Accessed on: Dec 12, 2017.

SILVA, C. N. Política de ordenamento do território e de urbanismo. **Apogeo**: revista da Associação de Professores de Geografia, n. 21, p. 31-51, 2001.

SILVA, D. F. **Quintal produtivo**: agricultura urbana: alternativa para o aumento de renda, segurança alimentar e melhoria de qualidade de vida. Belém, PA: Embrapa Eastern Amazon, [2007]. 1 folder.

SILVA, F. A. M. da; AFFHOLDER, F.; CORBEELS, M.; EVANGELISTA, B. A.; MALAQUIAS, J. V. Uso do modelo STICS para avaliar os impactos das mudanças climáticas sobre a produção de grãos de milho no cerrado brasileiro. In: CONGRESSO BRASILEIRO DE AGROMETEOROLOGIA, 19., 2015, Lavras. **Agrometeorologia no século 21**: o desafio do uso sustentável dos biomas brasileiros: anais. Lavras: Ed. UFLA, 2015a. p. 407-417.

SILVA, G. B. S. da; NOGUEIRA, S. F.; CUSTÓDIO, D. de O.; ALVARENGA, S. V. A. **Tutorial para consulta de dados no webgis do projeto GeoDegrade – Desenvolvimento de geotecnologias para identificação e monitoramento de níveis de degradação em pastagens**. Campinas: Embrapa Monitoramento por Satélite, 2015b. 7 p. (Embrapa Monitoramento por Satélite. Circular técnica, 31).

SILVA, W. T. L. da; MARMO, C. R.; LEONEL, L. F. **Memorial descritivo**: montagem e operação da fossa séptica biodigestora. São Carlos, SP: Embrapa Instrumentação, 2017. 27 p. (Embrapa Instrumentação. Documents, 65).

SILVA, W. T. L. da; NOVAES, A. P. de; MARTIN NETO, L.; MILORI, D. M. B. P.; SIMÕES, M. L.; HANEDA, R. N.; FIALHO, L. L.; LEONELLI, F. C. V. **Método de aproveitamento biossólido proveniente de lodo de esgoto residencial através de processo de compostagem seguido de biodigestão anaeróbia**. São Carlos, SP: Embrapa Instrumentação Agropecuária, 2004. 50 p. (Embrapa Instrumentação Agropecuária. Documents, 13).

TEIXEIRA, L. B.; GERMANO, V. L. C.; OLIVEIRA, R. F.; FURLAN JÚNIOR, J. **Processo de compostagem a partir de lixo orgânico urbano e caroço de açaí**. Belém, PA: Embrapa Amazônia Oriental, 2002. 7 p. (Embrapa Amazônia Oriental. Circular técnica, 29).

TOMMASELLI, J. D. G. **Gestão do território**: energia e meio ambiente. São Paulo: Ed. UNESP, 2012. 83 p.

VALENT, J. Z.; OLIVEIRA, L.; VALENT, V. D. Agricultura urbana: o desenvolvimento de um projeto social. **DRd – Desenvolvimento Regional em debate**, v. 7, n. 2, p. 4-19, 2017.

VICTORIA, D. de C.; PAZ, A. R. da; COUTINHO, A. C.; KASTENS, J.; BROWN, J. C. Cropland area estimates using Modis NDVI times series in the state of Mato Grosso, Brazil. **Pesquisa Agropecuária Brasileira**, v. 47, n. 9, p. 1270-1278, 2012.