Chapter 4

National policies, plans and strategies to fight climate change

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Introduction

The transformation of agriculture is taking place amid a technological paradigm shift and institutional evolution, to which Embrapa contributes by applying scientific knowledge both in technological processes and in encouraging public policies and their instruments. By means of assertive public choices, sustainable development can be effectively encouraged, thus implying a technological transformation of Brazilian agriculture to ensure greenhouse gas (GHG) emission mitigation and to promote efficient adaptation of its practices and systems to climate change. This chapter discusses how Embrapa has been contributing to achieve target 13.2 – Integrating climate change measures into national policies, strategies and planning.

Technological and organizational innovations to address agricultural vulnerabilities to climate are a significant part of agribusiness development, and, therefore, an important part of the work of Embrapa. The Corporation and its partners provide unique contributions for technological innovation and public policy design. Understanding and reducing crop susceptibility to climate factors, identifying how different production systems are exposed to climatic events and enhancing the adaptive capacity of agriculture are systematically addressed in Embrapa research programs. Consistent studies on vulnerability (Deconto, 2008) and support to construct risk management scenarios are provided to society and continuously updated, thus consolidating and transferring knowledge at different levels throughout the Brazilian territory.

Embrapa focuses on research areas and promotes training and technology transfer on different climate change related topics. Embrapa's portfolio of research projects includes seven domains and main themes and over 45 lines of research,

development and innovation for which the submission of competitive projects is encouraged. Approximately 150 projects and results are associated with these domains. Three large nationwide network projects focus on vulnerability and adaptation analysis (Program 7 of ABC Plan), namely: Simulação de Cenários Agrícolas Futuros (Simulation of Agricultural Scenarios – Scaf), which analyzes the vulnerability of agricultural crops; Impactos das Mudanças Climáticas Globais sobre Problemas Fitossanitários (Impacts of Global Climate Change on Plant Pathology Problems – Climapest), which analyzes how climate change affect plant pathology problems; and Rede AgroHidro (AgroHidro Network), which analyzes the relationships between agriculture, water resources and climate change.

Development and climate changes

The development of agriculture reveals that ways have been found to innovate and transform production processes. With an active role in this domain, Embrapa provides both technological solutions for farmers and technical knowledge for designing and implementing public policies. Basic information, information systems and support for Embrapa's decision makers have promoted good governance and the balance of public and private interests. Under the pressures of climate change, the focus is on countless global and local negotiations, many of which are advised by Embrapa.

The uncertainty and complexity of agriculture pose challenges that go beyond the inherent capacity of farmers to evaluate their production conditions. As part of its mission to generate knowledge and information, Embrapa interprets climate changes and the sensitivity of productive systems in each part of Brazil, so that technical-scientific challenges are coherent with demands. Competitive agribusiness, technically and economically efficient use of natural and financial resources, social equity and food security and quality must all be equally promoted, although this has been one of the major challenges for Brazilian agriculture (Alves, 2014).

Thus, in the coming years, agriculture will need to adapt to information technology in planning, managing, monitoring and evaluating processes. The digital transformation of agro-industrial chains and the rural reality will raise possibilities of risk transfer and management. By anticipating the need for this technological adaptation, Embrapa and partner institutions will develop technologies and innovations that will naturally address GHG emission mitigation and risk control.

Biophysical processes will be known in depth and controlled like never before in food production. Risks and opportunities will be less uncertain, and decision-making processes will be driven by a priori knowledge of production externalities. An example of a product that integrates information on climate, soil, cultivars and management is the Zoneamento Agrícola de Risco Climático (Climatic Risk Agricultural Zoning – Zarc). Started more than 20 years ago and conducted with Embrapa support, it has been one of the most important tools to encourage sustainable agriculture and food security in Brazil. Supporting risk information available for more than 44 agricultural crops, there is a close connection between empirical knowledge, meteorological monitoring and model validation and approximation, which are compared with data observed in each Brazilian municipality.

In addition, Embrapa has been acting directly to support the main governmental actions of agricultural climate change mitigation and adaptation, for example, through the Plano Setorial de Mitigação e de Adaptação às Mudanças Climáticas Visando à Consolidação de uma Economia de Baixa Emissão de Carbono na Agricultura (Sectoral Plan for Mitigation and Adaptation to Climate Change Aiming at the Consolidation of a Low Carbon Economy in Agriculture – ABC Plan) (Brasil, 2016a) and the Plano Nacional de Adaptação à Mudança do Clima (National Plan for Adapting to Climate Change – PNA) (Brasil, 2016b). Embrapa has been asked for and provided technical information, experimental data and simulation and optimization studies to support the definition of Brazilian proposals for GHG emission mitigation.

At the international level, the main Brazilian proposals for GHG emission mitigation are Brazil's Nationally Appropriate Mitigation Actions (NAMAs) and Nationally Determined Contributions (NDC). In both cases, Embrapa contributed, for example, with numbers and estimates of degraded pasture areas to be recovered by crop-livestock-forest integration – ICLF (Brasil, 2013) or cultivated pastures; Embrapa also helped calculating the direct costs of adopting technology and the potential for mitigating emissions. Embrapa studies were also essential for designing the ABC Plan, the main policy of the Ministry of Agriculture, Livestock and Supply (Mapa) focusing on environmental issues aligned with natural resources territorial management.

Critical information for designing public policies

Which agricultural systems can be more resilient, mitigate more GHG emissions and should be encouraged in the National Adaptation Plan (PNA)? How different

are crops and cultivars performances in adverse climatic conditions? Which technological advances should be made as adaptations to situations of high climatic vulnerability?

New information to help answer these questions is typically expensive to be produced and cheap to be copied and disseminated. Its first version is costly, and recovering investment to produce it takes long or is even impossible. This is why climatic, agronomic and socioeconomic information for agribusiness should be fostered by state policies, such as the Políticas Nacionais de Biocombustíveis (Brazilian National Biofuel Policies – RenovaBio) (Brasil, 2017a) and of ICLF (Brasil, 2013). The crosscutting character of information in public policies also includes private sector decisions, so as to always contribute to implement productive systems suitable for breaking old paradigms due to the need to respond to climate change.

Public policies for adaptation

Public policies promote social and economic well-being by effective actions. In order to address climate change issues, Embrapa should focus on identifying, developing and adapting agricultural practices; developing and characterizing new cultivars (for a wide range of crops); designing and recommending new integrated animal and plant production systems; assessing alternatives for soil fertilization and recycling management; using irrigation and soils in a smart way; controlling pests and diseases; and introducing new technologies, especially in the context of automation and precision agriculture. Embrapa plays an important role in promoting public policies, because it is present in the most diverse Brazilian ecoregions and holds regional knowledge, structure and laboratory logistics to open Technological Reference Units (URTs) focused on technologies tailored for each ecoregional development hub.

Monitoring and assessing public and private programs

Governmental action involves integrating large plans and policies into programs and projects, which support public policy design to help defining NAMAs, ABC Plan and Nationally Determined Contributions (NDCs) of Brazil (Oliveira et al., 2018), as well as Brazil's participation in important studies, such as those of the World Bank (Gouvello et al., 2010).

Embrapa has been effectively contributing to disseminate Brazil's emissions and removals and to conduct a number of quantitative agricultural systems emission studies, thus evidencing, as a rule, lower emissions of our production systems in relation to those estimated by analyses with tier 1 or default models and factors. The work of Embrapa focuses especially on:

- Recovery of degraded pastures.
- Integration of crop-livestock-forest and agroforestry systems.
- Implementation and strengthening of no-till systems.
- Treatment of animal waste.
- Adaptation to climate change and crosscutting actions.

Emphasis should be given to monitoring the ABC Plan. In order to support emission mitigation actions in livestock, forestry and grain systems in the various Brazilian biomes, Embrapa has been encouraging network projects, such as Pecus, Saltus and Fluxus. In order to gain a deeper understanding of the relationship between livestock and climate change, Embrapa designed the international project FP7 Animal Change, co-funded by the European Union.

Embrapa has a significant number of projects for agricultural crops genetic adaptation to climate change. Emphasis should be placed on corporate initiatives such as the Climate Risk Agricultural Zoning and the Special Project on ABC Platform Governance, and projects, such as ICLF, Biological Nitrogen Fixation (BNF), Pastures, Sugar-ethanol sector, Irrigated Agriculture, Coexistence with Drought, Native Forestry Resources, Genetic Resources and Genetic Engineering in Agribusiness, to list only the most relevant portfolios on the subject.

In climate change themes, Embrapa also carries out projects to develop techniques for remote sensing and mapping of crops and degraded areas in Brazil. Its training and technology transfer initiatives are performed through field days, lectures, seminars, workshops, technical visits of farmers in pasture recovery areas, farms, events in 79 Technological Reference Units (URTs) and/or in Test and Exhibition Units (UTDs), in research centers, etc., among other strategies, such as its own YouTube channel.

Agricultural vulnerability and resilience analyses should guide the identification of areas and alternatives for production adaptation. Risk management is one of Embrapa's most important areas of strategic action, and which should be strengthened in the coming years. So is encouraging the added

value of integrated production validated by emission reduction certification standards. Embrapa projects improve the Life Cycle Analysis (LCA) of livestock products, thus strengthening effective communication in domestic and foreign markets. Embrapa develops tools that improve the technical and economic efficiency analysis of production systems, that support their management and that encourage the achievement of goals amplified by the NDC, since the Paris Agreement ratification.

Negotiations and institutional ability to adapt

Embrapa has actively contributed to international negotiations, which resulted in plans and programs such as ABC Plan, Carne Carbono Neutro (Neutral Carbon Meat) (Suleiman, 2016) and the PNA. Specifically within the latter, two national strategies for adapting Brazilian agriculture to climate change were supported by Embrapa. Assuming that actions within PNA connect emission mitigation policies and strategies, two strategic targets must be included in the agenda of Embrapa: a) the development of an Agricultural Risk and Vulnerability Monitoring and Simulation System; b) Center for Agricultural Climate Intelligence for Climate Risk Management in Brazilian Agricultural Policy.

These targets improve the adaptation of agro-industrial systems, thus enhancing the industry's capacity and competitiveness in terms of biotechnology, new inputs, recycling and crop technologies, and integration of processes with higher value-adding potential, by means of certification, management and risk transfer.

Putting in operation sector policies and strategies for adaptation to climate change requires modernization, enhanced competitiveness, integrated risk management and value delivery. Food safety and nutritional quality of food are ensured by large-scale, quality production that suits sustainable development in its different dimensions. Such efforts must occur simultaneously at local, regional and national levels. This understanding must be systemic and should encourage Science & Technology networks that facilitate information integration and sharing. In tune with policy management, it is necessary to foster the ongoing digital transformation in agriculture by introducing new means for data and metadata acquisition, processing, sharing and security between private and public institutions, as well as between users and companies.

Some of the main technical lines of interest are:

- Developing big data storage, retrieval, analysis and synthesis systems (Crawford, 2011).
- Organizing and cataloging data and their respective metadata.
- Agroecosystems modeling, simulation and optimization.
- Monitoring by remote and orbital sensors.
- Integrating environmental, socioeconomic, legal and technological information, among others.
- Developing applications in "Internet of Things" (Santos et al., 2016) (interconnecting autonomous devices/sensors and people), "Artificial Intelligence" (Byrum, 2017) (complex problem solving) and Blockchain (Ge et al., 2017) (safer legal and commercial transactions).

The main products should be:

1) Monitoring, Risk Assessment and Agricultural Vulnerability System: it aims at designing indicators, information integration, result simulation and scenario analysis. It is expected to be an information bank that integrates and sums up different scale big data, including local, regional and national programs and actions. Information will be available and will be especially relevant for result dissemination and observation, such as the case of interactive platform MapBiomas.

2) Computational algorithms: they aim at providing technical and economic assessment of agroecosystems in different contexts and regions. These solutions, implemented through simulation, optimization, data assimilation and artificial intelligence, will allow analyzing mitigation and adaptation strategies and supporting public policy design.

3) Result communication and visualization system (Data visualization, 2018): it aims to make available to different public and private sector actors useful information to support decision-making regarding climate change, in particular as regards to indicating agricultural production models and assessing the impact of adopting these models to redesign public policies. Information generated should support public policies in international negotiations, induce demand for relevant scientific data production and, finally, assist in discussing commercial litigations or technical non-tariff barriers.

4) Storage, curation, data processing and information retrieval infrastructure: it aims to establish rules for security, access control and information use. This infrastructure should use modern means of communication and information exchange that allow the integration with other research networks and databases, so as to guarantee broad access to information in a secure way, through collaboration at the individual and institutional levels.

Final considerations

Various changes have been affecting agriculture, whether in terms of technology, consumer perception and demand, or changes caused by climate change. In this context, scientific knowledge is essential for decision-making in public and private sectors, for designing encouraging policies to promote the establishment of new practices and technologies to guarantee sustainable agriculture.

Embrapa has been effectively dealing with climate change-related issues and has been contributing significantly to technological innovation and knowledge production. Through its research projects, Embrapa provides society with consistent studies on agricultural vulnerabilities and produces knowledge to expand its adaptive capacity. Thus, Embrapa fulfills its role of consolidating and transferring knowledge to farmers living in practically all the municipalities of Brazilian states.

Knowledge provided by Embrapa affects the farmers decision-making and has been leading to countless innovations in information technology, computer simulation, Big Data, "Internet of Things", artificial intelligence, among others areas. Brazilian agricultural policy relies on Embrapa to maintain its plans, programs and projects connected with the productive reality and to keep encouraging sustainability and food security. Embrapa's interaction with governmental technical staff is essential for successfully designing and managing ABC Plan and of National Plan for Adapting to Climate Change (PNA). International negotiations and Brazilian proposals for greenhouse gas emission mitigation – NAMAs (Compromisso..., 2014) and NDC (Brasil, 2017b) – are directly supported by Embrapa studies that quantify, model and analyze emission factors.

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