Ministry of Agriculture, Livestock and Supply of Brazil

Brazilian Agricultural Research Corporation

Introduction

In attention to the SCF's request for identification of the needs of developing countries Parties in accordance with the outline approved at its 21st meeting particularly regarding challenges, gaps and opportunities, Brazil would like to emphasize two case studies (case 1: the Agro-Climate Risk Zoning (ZARC) and case 2: Reducing the negative impacts of climate change on agriculture with cover crops and zero tillage) which illustrate challenges and needs in terms of research, development and innovation (R,D&I) in tropical agriculture.

Case 1: the Agro-Climate Risk Zoning (ZARC)

Outline:

The Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) officially applies the Agro-Climate Risk Zoning (ZARC), developed by the Brazilian Agricultural Research Corporation (Embrapa) and partners, since 1996. Embrapa is linked to MAPA. ZARC provides the indication of climatic risks for crops considering dates of planting, sowing and genotype characteristics for each municipality. It considers, as well, historic weather series and soil type. The objective is to minimize risk of meteorological adversities during sensitive and critical crop phases and hence, minimizing chances of agricultural losses. This technology is therefore, a critical tool for decision-making support, and for planning and execution of agricultural activities.

Historically, the initial phase of ZARC was a project for climate risk reduction in agriculture. The project was originally a partnership between MAPA and Embrapa, specifically with Embrapa Cerrados. Progressively, had the participation of other Embrapa research units, as well as other Brazilian institutions, such as, the National Institute of Meteorology – INMET, Paraná Agronomic Institute - IAPAR, Santa Catarina Agricultural Research and Rural Extension Company - EPAGRI, Campinas State University - UNICAMP, and others. Official Daily Union

The ZARC application started in 1996 for wheat cultivation. Annual reviews of ZARC published in form of ordinances (rules), in the DOU (Official Daily Union), which is the Official Government publication, and published on MAPA's website. Currently, studies of climate risk agricultural zoning include 40 crops, 15 of which are annual crops and 24 are permanent crops and ZARC for cropping systems such as Corn-Brachiaria. This consortium, reaches 25 Brazilian States (Provinces). The farmers must follow the indications of ZARC to be eligible for using the Government Insurance, called

Agricultural Activity Guarantee Program (Proagro), or the Family Farming Agricultural Guarantee Program (Proagro Mais) and other subsidies of the rural insurance premium. In addition, some finance agents are already making the granting of rural credit conditioned to the adoption of ZARC.

At present, ZARC is implemented annually through coordination (MAPA); using the methodology developed by Embrapa; and application and validation also by Embrapa. The direct users are the farmers and agents linked to the Agricultural Activity Guarantee Program - PROAGRO, the Family Farming Agricultural Guarantee Program - PROAGRO MAIS and the insurance companies.

ZARC is an important landmark on use of resources accessible in the Agricultural Policy, as it subsidizes the decisions of some rural insurance programs. It aims to minimize the risks in both sides of the process, i.e. the finance agencies and the borrowers represented, mostly by farmers. It also presents direct impacts on productivity and income generation, which favors the competitiveness of Brazilian agriculture. Moreover, as its application is restricted to agricultural areas regulated by specific environmental policies, it avoids conflicts with the conservation of natural resources, making it an essential instrument for the economic sustainability component.

Impact assessment:

Currently, it is only possible to assess the economic impacts of ZARC by calculating the losses resulting from its non-adoption. No adoption of ZARC causes: (i) increased loss of compensation, as there would be no technical indication for the most appropriate planting dates. This would increase the chance of partial or total crop frustration; (ii) decrease in crop yield and as a consequence of lesser agricultural production, would have a lower than expected result. This is due to utilization of less adapted areas for agriculture; and (iii) fraud and moral risk, when the insurance beneficiary chooses to plant/sow in high-risk dates in order to cause loss and receive insurance compensation.

Embrapa publishes annually a Technology Impact Assessment Report for ZARC. Its latest edition (2018), informs that in the accumulated result (1996-2018), it is estimated that ZARC is responsible for approximately, R$ 21.8 billion (approximately US$ 5.33 billion) in savings to the federal government, given the greater certainty of investments provided by this methodology.

In the case of financial losses expected from reduced production, the Report informs that on a conservative basis, ZARC will be able to improve overall production by, at least, 20%, as its adoption provides an improvement in the planting standards. Considering the crops analyzed in the Report (soybean, wheat, 1st crop corn, 2nd crop corn, rice, grape and apple), from the PSR (Rural Insurance

Premium Subsidy Program) information, it is estimated that approximately, R$ 59.9 billion (approximately US$ 14.65 billion) in yield gains were generated in the period from 2006 to 2018.

In order to estimate the technological cost for farmers, the following cost components are in the calculations: labor, research and development, management, depreciation and technology transfer. Throughout the historical series analyzed (1994-2018), R$ 60,676,871.47 were recorded as total expenses (current value), of which approximately, 78% were directed to personnel expenses. It is important to note that ZARC only achieves that level of impact because it is mandatory for farmers engaged in agricultural programs. It is important to mention that these policies, such ZARC, have become continuously efficient and effective because is a robust science-based information.

To estimate ZARC's significant financial returns to society, initially considering a very simple metric, the split between benefits and total costs yields close to R$ 2 billion per year, demonstrating the huge difference between how much money ZARC saves compared with its cost of application and adoption.

Involvement of research organization:

Initially, Embrapa, together with other institutions, was responsible for defining the methods and indicating the planting dates for the Ministry of Agriculture, which in turn published the rules.

From 2003 to 2012, ZARC was under responsibility of private sector companies, and as a result, Embrapa diminished its influence on the application of ZARC, having a decrease on its costs, especially after 2009, when the last project at Embrapa focused on the climate risk.

From 2015 on, with the return of ZARC to Embrapa, there was again the formation of teams for its implementation. In this way, several Embrapa employees (researchers and administration people) devoted part of their time to perform ZARC activities, mainly regarding development of scientific data, for the best parameterization and improvement of agronomic models and data basis.

The annual Agro-Climate Risk Zoning rules result from the analysis and modeling of climate, soil and phenological (crop-related) information. The parameters are analyzed using a methodology validated by Embrapa and adopted by the Ministry of Agriculture. Embrapa as the main research organization involved with ZARC's development and implementation is responsible for developing and publishing ZARC's annual impact assessment.

Lessons learned, challenges, opportunities:

In relation to lessons learned, to improve communication of ZARC results and easy the understanding and use of probabilistic information, meetings in several regions have been helpful to clarify doubts. Additionally, the recently developed application for android mobile devices, "Zarc Plantio Certo", available at Google PlayStore in Portuguese, only, also helped with its friendly display of information.

Below are the main challenges and opportunities in which Embrapa should work to produce information and indicators for risk management and policies for agricultural development.

(i) Expand the agro-climatic risk zoning studies for crops not yet covered, such as forest and perennial crops, pastures and forages, succession cropping systems, crop-livestock integration, agroforestry systems;

(ii) To develop and adapt modeling methodologies for the systematic quantification of risk by range of yield and technological level of the production system. These adaptations will produce useful information for insurance pricing for different coverage levels (insured value), producer profiles and producing regions;

(iii) Evaluation and risk zoning for drought resilient production systems, less susceptible to adverse weather events. This could originate differentiated costs in the insurance, fostering the adoption of appropriate technologies resilient or adapted to different Brazilian climates and regions, especially those more exposed to drought;

(iv) Agroforestry systems that do not require deforestation but allow under-forest production of typical fruits, regional agricultural products and for niche market.

Future plans:

(i) Expand the agro-climatic risk zoning studies for crops or regions not yet covered;

(ii) Ongoing project to develop and adapt crop yield models for risk evaluation by yield ranges and technological level of the productive system;

(iii) Evaluation and risk zoning for drought resilient production systems;

(iv) Evaluation and risk zoning for agroforestry systems.

Case 2: Reducing the negative impacts of climate change on agriculture with cover crops and zero tillage)

Outline:

Knowledge-based agriculture has been essential to the development of the Brazilian agriculture, particularly for annual crops such as maize, soybean and common beans covering today approximately 40 M ha. Agriculture is strongly climate-dependent and the impacts of climate change on agriculture include decreased annual rainfall, hot minimum temperatures, erratic dry spells in the rainy season or frequent annual downpouring rains. These events will be more commonly observed in tropical and sub-tropical regions of Brazil with some variations. As part of the soil preparation before sowing, intensive soil tillage using disc plough followed by several passes of harrowing or heavy harrowing leads to uncovered soil surface prone to water erosion and decrease of soil carbon and nitrogen. Uncovered soil surface shows high variation in temperature making the soil cooler in hot days. It is well known that nitrogen fixation is reduced under high soil temperatures (Shiraiwa et al., 2006 – Plant Prod. & Sci. v.9). Avoidance of soil ploughing (zero tillage or minimum tillage with chisel plough) combined with crop rotation with grass cover crops (eg black oat in the south and brachiaria or pearl millet in central Brazil). These agricultural practices are being used since 1985 covering approximately 30 M ha. The use of grasses as cover crops in rotation or mixed with annual crops promotes carbon sequestration and provide year-round soil cover and water infiltration. When used with liming and gypsum application crop rotation with cover crops under zero tillage allow plant roots to grow deeper in the soil favoring water absorption at depth increasing the plant capacity to survive long periods of drought.

Embrapa, regional agricultural research institutes (eg IAPAR, IAC, EPAGRI), extension service (eg EMATER, CATI) and farm coops (eg COCAMAR, COAMO, COMIGO) have been working together to promote soil and water conservation at the microcatchment level in several regions in Brazil.

No-tillage is a conservation farming system, in which seeds are placed into otherwise untilled soil by opening a narrow slot, trench, or hole of only sufficient width and depth to obtain proper seed placement and coverage. No other soil tillage is done. Although direct seeding is sometimes used synonymously with no-tillage and it is increasingly being used to place seed directly into undisturbed soil, some direct seeding equipment especially in Europe causes extensive soil disturbance at seeding that buries or mixes crop residues with the soil. Such techniques should rather be characterized by the umbrella term of mulch tillage and should not be used synonymously with no-tillage (Derpsch et al. 2011).

A no-tillage system is only successful if there is an adequate amount of residue mulch on the soil surface (minimum of 6 t/ha of dry matter). The coupling of cover crops with no-tillage is intended to provide not only improvements on soil chemical and physical characteristics, but also a range of benefits to the farm towards low- cost and less-risky production in a long term including less use of pesticides.

Annual crops under zero tillage with crop rotation including cover crops are commonly implemented on farms of the both central and southern Brazil in both Atlantic Forest and the Cerrado biomes. Cerrado is a neo-tropical savannah. Ferralsols and Alfisols with varying texture from clayey (>70%) to light soils (<40% clay). The climate varies from Cwb to Aw according to the Köppen classification with a rainy summer and dry winter seasons of annual rainfall ranging from 1200 mm to 1600 mm. Summer dry spells of 15 to 25 days are commonly observed.

This system is consolidated and used by farmers all over Brazil and can be used on both large areas and small farms. What explains this rapid growth of this system are the several advantages over conventional tillage, in terms of greater sustainability of agricultural production, with lower cost of tillage, greater infiltration and storage of water, drastic reduction of erosion and siltation of water sources, and enabling crop farmers to plant the following crop at the right time.

Monoculture is inconsistent with zero tillage due to the need for mulching and crop rotation, which will be useful for weed and pest control with less pesticides. Crop rotation and mixed farming has become essential for nutrient cycling and soil quality with less GHG emissions. In contrast to monoculture, integrated farming systems are a production strategy that combines crop, livestock and forestry activities in the same area and may be conducted in different ways: (1) integration of crop–livestock (agropastoral system), (2) crop–forestry (silvoarable system), (3) livestock–forestry (silvopastoral system) and (4) crop–livestock–forestry (agrosilvopastoral system). The choice of which to use depends on the economical and geographical characteristics of the region, access to financial incentives, farming facilities and farmer's skills, production strategy as well as cultural aspects.

At the end of the rainy season, forage seeds are placed into soil 2-cm underneath the crop seed, usually maize. Maize grows together with the forage grass but much faster. After maize harvest, forage grass receives sunshine and finish surface cover allowing for grazing 40 days later. Pasture for both beef – or dairy cattle can last for 2-3 years before grain crops are back to the same area.

Impact assessment:

In the Cerrado region, the introduction of the no tillage system in the soy and corn plantations represented an important decrease in the environmental cost. In the case of soy, the no-tillage raises the cost of production by 0.47%, but it causes a reduction of (-81.22%) in the environmental cost. As to corn, the costs of no-tillage are (-5.92%) lower than conventional tillage and cause a reduction in the environmental cost by (-29.43%) (Rodrigues, 2005 – Rev. Econ. Sociol. Rural v. 43).

Regarding economic performance of farming system with crop rotation, such systems are based on the diversification of income-generating activities, with revenue entry in different terms. It shows a return greater than the opportunity cost of the land. Revenues from agricultural crops accounted for approximately 85% of the amounts spent on the implementation crop-livestock-forestry system. Thus, soybean and corn crops under zero tillage are key to pay off the debts created in the beginning and thus balance the cash flow of the system allowing more time to safe establishment of the tree component (Pacheco et al., Journal Agric. Sci. Technol.B7:374-385; Pacheco et al. 2017, Comunicado Técnico 405. Embrapa Florestas: Colombo.16p.).

Involvement of research organization:

Embrapa has been involved in the generation and development of the technology together with state governmental organizations, farm coops and private companies. In the last few years Embrapa has also been involved in organizing public policies for the implementation of zero tillage systems and integrated crop-livestock-forestry systems nationwide as part of the Brazilian iNDC on low-carbon agriculture.

Lessons learned, challenges, opportunities:

In the beginning adoption was difficult due to a novel management practice demanding different skills to manage weed control and sowing time of different crops in rotation. Problems were solved by gradual adoption of cover crops in rotation with cash crops and avoidance of soil ploughing. In general, starting with 10 to 20 ha was recommended. Secondary effects happened when farmers have gotten confident with the technique and begun to eliminate contour terraces. This has led to high water losses by runoff and causing soil erosion again.

Adoption of cover crops in combination with zero tillage has enabled us recovery of degraded pastures nowadays starting with integrated crop-livestock systems covering about 11 M ha and culminating with integrated crop-livestock-forestry systems.

Future plans:

Improve the National Plan for Low Carbon Emission in Agriculture (ABC Plan), which is one of the sectorial plans devised under the National Policy on Climate Change and aims to reduce greenhouse gases (GHG) emissions in agriculture, improve the efficiency in the use of natural resources, and increase the resilience of production systems and rural communities, combining it with the set aside area and the hedge forest along the river and lake benches.

Concluding remarks:

As seen above, Brazil has developed some innovative technologies fully adapted to its tropical reality. However, as the challenge of climate change increases in complexity, new research areas ought to be explored and closely considered as priorities. In that sense, gaps and demands for future investments in R,D&I have been identified, including the development of methods and approaches for assessing adaptation needs, adaptation co-benefits and resilience as well as for evaluating the socioeconomic dimension of the impacts of climate change in the agricultural sector.

Brazil believes that some of the elements that should be taken into consideration for further research, implementation, and financing aiming to achieve a sustainable agriculture production and intensification are:

1. Further develop advanced analytical and experimental techniques.
2. Continue to improve techniques and practices that contribute to enhance the control of GHG Emissions by agricultural systems.
3. Enhance vulnerability assessment including the use of mobile two-way communication technologies.
4. Enhance technologies and practices that contribute to the adaptation of agricultural systems to climate change.
5. Enhance monitoring and evaluation of socioeconomic and environmental co-benefits of sustainable agriculture at the landscape level.
6. Integrate existing data banks and advance in metadata analyses to support decision making and evaluation of public policy implementation performance regarding adaptation.
7. Expand the use of drones as well as automated remote sensing equipment to enhance the resolution of data acquisition on diverse types of crop, crop systems and integrated crop systems.

8. Advance in the use of modern molecular biology to generate crops and animal breeds that will better tolerate salinity, water stress, heat and pests with increased production.

Stronger and higher investment in science and technology will remain crucial and, in light with the principles and provisions of the UNFCCC, the opportunity that the SCF might provide will certainly play a relevant role for increasing awareness and fostering the universalization of sustainable practices.