"*Koronivia Joint Work on Agriculture*"

Brazilian submission on KJWA's topics "2(e) Improved livestock management systems, including agropastoral production systems and others" and "2(f) Socioeconomic and food security dimensions of climate change in the agricultural sector".

The Government of Brazil welcomes the opportunity to submit its views regarding the fourth round of workshops of the Koronivia Joint Work on Agriculture (KJWA) in the context of the joint work between the Subsidiary Body for Scientific and Technological Advice (SBSTA) and the Subsidiary Body for Implementation (SBI) on issues related to agriculture. In accordance with KJWA's road map, this submission addresses the topics: 2(e) improved livestock management systems, including agropastoral production systems and others and 2(f) socioeconomic and food security dimensions of climate change in the agricultural sector.

Brazil is a developing country, with a continental territory, a large population and expressive environmental, edaphoclimatic, social and cultural diversity, as well as significant internal contrasts. Such diversity of conditions imposes more complexity to the challenge of facing the adverse impacts of climate change, particularly in the agricultural sector. This however has only challenged Brazil to fully commit to further investments in research, technology development and public policies that have contributed to sustainability in the agricultural and livestock sectors. As a prominent actor on scientific and technological development for tropical agriculture, Brazil has strengthened its sustainable development policies tackling challenges and planning for the work that lays ahead, focusing on an Integrated Landscape Approach (ILA). The positive results observed confirm the effectiveness of this approach both from an economic and an environmental standpoint. This outcome is due in large measure to the technologies and agricultural systems developed across the country for the various types of edaphoclimatic and regional conditions that exist in the country

I - Topic 2(e) Improved livestock management systems, including agropastoral production systems and others

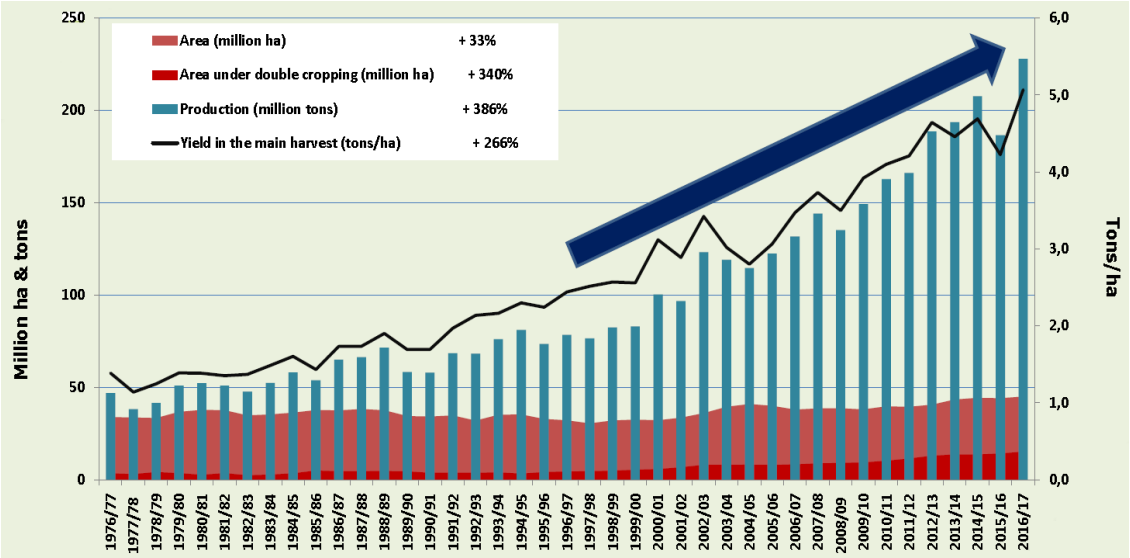
To increase efficiency and profitability and to enhance social, economic, and environmental sustainability, Brazil is investing in several initiatives that improve livestock management systems, within a long-term strategy in order to achieve effective sustainability, having an Integrated Landscape Approach (ILA) as a coordinating principle. For that, a series of public policies have been developed with an effective zoning plan, which is used to support the development and implementation of adequate technologies, the management of credit and insurance, along with environmental policies and strategies. These strategies are also aligned with *in situ* and off-site bidirectional communication strategies aimed at supporting farmers and ranchers to make better informed technical decisions, also delivering to society information on the quality of the Brazilian farmers' products, consumed locally and/or exported to the world.

Sustainable Intensification: Brazil strongly invests in the sustainable intensification of production systems, associated to gains in land productivity, which involves not only a good management of the soil,

but also technologies and practices such as paddocking and grazing rotation. For the past 40 years, sustainable intensification has transformed the agricultural landscape, from extensive inefficient production areas, to well managed production systems, with better use of its resources, especially the land one. This strategy has proven to be a relevant tool, and has been fundamental, to allow a great improvement in productivity (Figure 1), resulting in relevant environmental advance in the relationship between production, sustainability and productive area in Brazil (land-sparing effect)[1]. The land intensification strategy in areas that were used for livestock avoids pressure over preserved areas encouraging the restoration of low productivity or degraded pastureland.

However, it is also important to better understand the potential and the consequences of intensifying production systems/increasing productivity considering environmental limitations [2]. There is a demand to increase pasture productivity, but the key aspect of Brazilian continual technology investment is to ensure that sustainable increase in productivity has to be linked with quality production practices and environmental sustainability. The careful implementation of public policies and the constant vigilance and enforcement of such strategies has ensured that pasture-stocking rates do not increase above the environment supports limits, therefore preserving farmers investment and mitigating the risks of pasture degradation.

Figure 1 – Evolution of area, area under double cropping, production and yield in Brazil from 1976 to 2017.



Source: Conab (www.conab.gov.br)

[1] Martha, G.B., Alves, E., Contini, E., 2012. Land-saving approaches and beef production growth in Brazil. Agric. Syst., 110, https://doi.org/10.1016/j.agsy.2012.03.001

[2] Silva, R.O., Barioni, L.G., Pellegrino, G.Q., Moran, D., 2018. The role of agricultural intensification in Brazil's Nationally Determined Contribution on emissions mitigation. Agric. Syst. 161, https://doi.org/10.1016/j.agsy.2018.01.003

An important aspect of livestock production system that has received much attention is the diversification of forage types. A diversified set of forage species to establish a pasture allows for better distribution of production and nutritional quality over time, not to mention the lower nitrogen fertilization costs of the pasture. In addition to savings, these characteristics contribute to improve soil quality. Therefore, this diversification not only considers the development of more nutritious and productive pastures, but also increases the resilience of cultivated pastures according to the specificity of the Brazilian regions. To overcome the great vulnerability of production systems with homogeneous pastures, based on only one or two forage species, Brazil has developed breeding programs, associated with sustainable management protocols, of various species of forage types, including native and endemic Brazilian pastures as important tools for livestock management[3]. The diversification of grasses has contributed to strengthen the resilience capacity of Brazilian pastures, therefore directly contributing to the capacity of livestock systems to adapt to the adverse impacts of climate change.

The breeding programs have considered a variety of forage species, especially of grasses and legumes, among other foraging families. The work considers the environmental and productive characteristics of each region, as part of the ILA, further considering the nutritional value, as well as the potential to symbiotic nitrogen fixation[4]. The latter is essential to reduce emissions in the Brazilian agricultural sector by decreasing the need for chemical nitrogen fertilization derived from fossil sources, also improving income and productivity while avoiding losses.

Interaction between plants and microorganisms: This technology has been explored in Brazil since late 1960s, with the objective of improving the absorption of nitrogen, consequently reducing the need for chemical fertilizers, and has become commercially viable since the 1980s. Two recent examples of such technologies, developed by Embrapa and partners, are AzoTotal and BiomaPhos. AzoTotal is a specific bacterial inoculant that has resulted in 15% increase of grass (Brachiaria, in this case) biomass production, and 25% of its total protein content. It is a powerful tool to restore degraded pastureland in Brazil[5]. In addition, BiomaPhos is capable of increasing plant absorption of phosphorus and maize productivity in 10%[6]. Both technologies, associated with improved foraging species, can effectively reduce Brazilian dependence of phosphorus and nitrogen fertilizers. When considering the pasturelands in the country and the amount of phosphorous immobilized in the soil, the social, economic and environmental impacts of such technologies are immense, increasing pasture restoration and decreasing production costs. It also

[3] For more information see Lopes, M.A., Faleirom F.G., Ferreira, M.E., Lopes, D.B., Vivian, R., Boiteux, L.S., 2012. Embrapa's contribution to the development of new plant varieties and their impact on Brazilian agriculture. Crop Breed. Appl. Biotech. S2, 31-46.

[4] For further information, please refer to: <https://www.embrapa.br/busca-de-noticias/-/noticia/50324657/pesquisa-desenvolve-forrageira-para-a-regiao-sul-que-fixa-nitrogenio-no-solo> (in Portuguese only).

[5] For further information, please check Embrapa's publication on "Inoculation of brachiaria with Azospirillum", available at: <https://www.embrapa.br/busca-de-publicacoes/-/publicacao/1085771/inoculacao-de-braquiarias-com-azospirillum> (in Portuguese only).

[6] For further information, please check Embrapa's news article on "Product with Brazilian technology can reverse dependence on foreign phosphorus fertilizers", available at: <https://www.embrapa.br/busca-de-noticias/-/noticia/45773416/product-with-brazilian-technology-can-reverse-dependence-on-foreign-phosphorus-fertilizers> (in English).

contributes to foster the awareness and education regarding the relevance of soil and environment preservation and good agricultural practices, while increasing the resilience and adaptive capacity of agricultural systems to the adverse impacts of climate change and reducing greenhouse gases (GHG) emissions.

Emissions and Integrated Systems: Brazil supports that the integrality of the production systems should be considered when implementing actions to strengthen resilience and adaptive capacity, therefore they should be assessed as a whole to inform the effective net flux of GHG gases of livestock activity. The removal of GHG that occur in pasture systems and, especially, in integrated systems should be taken into account while evaluating enteric GHG emissions balance. By adopting adequate practices and technologies, under particular conditions, it is possible to achieve a net zero flux when considering GHG emissions and removals. As most of the Brazilian livestock is produced on pasture, in single or integrated systems, this allows farmers to implement technologies and practices that can enhance the control of emissions in the system, reducing the net flux or even neutralizing the enteric methane emissions of the production systems. Brazil has intensely invested in strategies and focused in research to improve and validate its production systems, resulting not only on reduction of GHG emissions, but also contributing to animal welfare, improvement of biodiversity, environmental sustainability and adequate income for farmers and their families.

An important aspect of improved livestock management systems is that CO_2 removal related to increased soil carbon stocks, in more productive pastures, can partially offset methane emissions[7]. Further, when developing and implementing sustainable production practices, the balances between emissions and removals should be considered. The components and management practices of the production system can offset at least part, or even maybe the total of the emissions. The observed results of the recent implemented agricultural policies in Brazil indicate that pasture stocking rates of two to three animal units per hectare, with solely good pasture management, makes it possible to mitigate CO_2 emissions, as well as CH_4 and N_2O emissions. At higher stocking rates, further abatement of emissions will require an arboreal vegetation to be used in the production system, hence paving the way for the establishment of crop-livestock-forest integrated production systems (ICLF)[8].

As a form of better communicating and highlighting potential good practices, Brazil is developing, in line with IPCC recommendations and Brazilian socio-environmental legislation, a third-party certification

[7] Berndt, A., Tomkins, N.W., 2013. Measurement and mitigation of methane emissions from beef cattle in tropical grazing systems: a perspective from Australia and Brazil. Animal, 7, https://doi-org.ez103.periodicos.capes.gov.br/10.1017/S1751731113000670.; Oliveira Silva, R., Barioni, L.G., Hall, J.A.J., Matsuura, M.F., Albertini, T.Z., Fernandes, F.A., Moran, D., 2013. Increasing beef production could lower greenhouse gas emissions in Brazil if decoupled from deforestation. Nature Clim. Chan., 6, https://doi: 10.1038/nclimate2916 ; Cardoso, A.S., Berndt, A., Leytem, A., Alves, B.J.R., Carvalho, I.N.O., Soares, L.H.B., Urquiaga, S., Boddey, R.M. 2016. Impact of the intensification of beef production in Brazil on greenhouse gas emissions and land use. Agric. Syst. 143, https://doi.org/10.1016/j.agsy.2015.12.007.

[8] Berndt, A. - Embrapa Southeastern Livestock, 2020. Personal communication

standard for livestock products - the Certified Low Carbon Livestock Platform[9]. The Platform developed by Embrapa has the following protocols: Carbon Neutral Brazilian Beef (CNBB or CCN in Portuguese), Low Carbon Brazilian Beef (LCBB or CBC in Portuguese), Native Carbon (CN in Portuguese), Low Carbon Calf (Bezerro-CN in Portuguese) and Carbon Neutral Leather (Couro-CN in Portuguese). The label protocol, developed by Embrapa, licenses the use of the related commercial brand by partners. This certification will allow consumers to understand and recognize the production efforts of farmers to promote sustainable agricultural systems integrated in the landscape, reinforcing the strategy of an integrated landscape approach (ILA).

Further extending the potential benefits with all the relevant technologies discussed above, the systematization of integrated agricultural, livestock and/or forestry activities (ILP and/or ILPF)[10] has become one of the main technological solutions for sustainable agriculture, since they provide many technical, economic, environmental and social benefits. These technologies and practices can complement intensification strategies allowing for increased income, enhanced diversification in the production, protection of the soil and adaptation to the adverse impacts of climate change. In addition, integrated agriculture can further enhance the control of GHG emissions by allowing the farm to produce a greater volume of biomass, which is useful to maintain soil coverage and vegetated area protected throughout the year, thus achieving a better carbon balance in the farm operation.

Approximately 15 million hectares of area under integrated systems can be identified in Brazil, according to data from ICLF Network (Rede ILPF)[11] with 83% of this total area being crop-livestock integrated systems (without trees) – ICL. Analysis conducted by Embrapa on the carbon balance in areas of beef cattle in ICL and/or ICLF systems, in the Cerrado region (Savannah), have consistently indicated the high capacity of integrated systems to store carbon[12]. In such conditions, the integration of agricultural, livestock and/or forestry activities can deliver a positive annual balance (more sequestration in soil and biomass than GHG emission) of 0.86 ton $CO2eq.ha^{-1}.year^{-1}$ for ILP and 21.89 ton $CO2eq.ha^{-1}.year^{-1}$ for ICLF.

Farmers will directly benefit from the adoption of ICL systems through evident increase in soil deposition of plant residues, reduced erosion processes, and increased straw production for effective no-till systems (SPD, in Portuguese). Consequently, those integrated systems promote greater productivity of agricultural crops, better soil quality (due to the increase in soil organic matter levels, structure, sanity, greater water retention, etc.), higher grain productivity with reduced costs over time, greater additional profitability from livestock activities and generation of extra income in the winter or dry season.

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[9] More information at Embrapa: https://www.embrapa.br/en/gado-de-corte; and https://www.embrapa.br/en/pecuaria-sudeste

[10] Oliveira Silva, et al, 2013.

[11] https://www.redeilpf.org.br/

[12] More information can be found at Souza, K.W.; Pulrolnik, K.; Guimarães Junior, R.; Marchão, R.L.; Vilela, L.; Carvalho, A.M.; Maciel, G.A.; Moraes Neto, S.P.; Duarte, A.D. Integração lavoura-pecuária-floresta como estratégia para compensação das emissões de gases de efeito estufa. Planaltina-DF: Embrapa Cerrados, 2019. 12p. (Circular Técnica 39 – Embrapa Cerrados; ISSN 1517-0187).

Specifically for ranchers, ICL provides important advantages, such as: higher pasture productivity and quality (due to the nutrient residues from fertilizing agricultural crops), amortization of costs for the recovery of degraded pastures (agricultural crops pay for the costs of recovery of pastures), productive yields even in winter or in the dry season (which is the most critical advantage in the tropical region due to the typical rainfall reduction), reduced use of silage and supplementation in the drought season, with reduced production costs, higher production of meat or milk (more roughage and nutrients), and more liquidity and profitability (viability).

In relation to ICLF systems in particular, it is observed that the incorporation of trees (native or exotic) into pastures greatly increase the land sustainability potential, since they provide high diversification of products and services in the same area. More specifically, the arboreal component of the integrated systems can bring:

(i) greater diversification and intensification of the full-time use of the area and the annual environmental offer;
(ii) optimization of land use, with grain production in consortium with trees at the beginning of the system, and subsequently, the production of meat or milk combined with the production of wood and/or non-wood forest products in all stages of the integrated system cycle;
(iii) economic viability for the system that provides a potential increase in extra income from the sale of different wood and non-wood products, depending on the regional market;
(iv) windbreak function, with less drying of pastures, better water dynamics and better plant development in the inter-row space;
(v) promotion of biodiversity and environmental adequacy;
(vi) decreased deforestation pressure (land-sparing effect);
(vii) mitigation of GHG emissions (accumulation of carbon in the soil and biomass, neutral carbon certification, special credit, etc.); and
(viii) animal welfare and thermal comfort (favorable microclimate) with increased meat and milk productivity due to the reduction of thermal stress and its related consequences.

Livestock Outcome and Products: Based on its experiences, Brazil defends that sustainable Livestock production can have a positive effect on the environment, contributing to the conservation of biodiversity, genetic resources and food and nutritional security. In well-managed systems there are still relevant contributions to ecosystem services, increased carbon in the soil, nutrient cycling and landscape maintenance.

Livestock products are undoubtedly important for human consumption, as shown in recent WHO and FAO Food Security publications[13]. Brazil is aligned with this position and defends the right of any individual to access livestock products to compose his/her diet. Eggs, milk, cheese, meat and fish are part of the diversity of Brazilian diet and cultural traditions, as it is for most of the societies in the world. Therefore, it develops public policies to ensure that these products come from sustainable production system, assuring, in this way, safety and nutrition to consumers, while promoting just and adequate income to

[13] HLPE. 2017. Nutrition and food systems. A report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security, Rome

farmers, allowing the reproduction of their livelihoods as well as the maintenance of sustainable agricultural landscapes. The dissemination of these benefits to developing and developed countries is extremely important.

Risk management: A series of risks can affect the livestock chain, and Brazil has been taking measures to map and reduce such risks, in particular: (i) mapping the climate and the adverse impacts of climate change, (ii) the generation of scenarios, and (iii) the implementation of the Climate Risk Agricultural Zoning (ZARC) at the landscape level. In this regard, Brazil has developed the Future Agricultural Scenario Simulator (SCAF) and its derived projects. These initiatives work on crop model adaptation or development for the Brazilian tropical conditions and are used for managing governmental rural credit and insurance (the ZARC initiative) and current and future vulnerability analysis (ZARC and SCAF initiatives). Specific simulation models and methods for risk, vulnerability and adaptation analysis were developed for grazing production systems to improve and support livestock management, mitigate production risk and support management and public policy actions.

The recent national experience has shown the importance of managing direct or indirect risks related to climate. In the case of livestock, most pastures are in marginal areas and are most likely affected by climate variations. In this regard, Brazil is working to develop more efficient and accessible methodologies and tools, besides the ones that are already in place, given the importance it has allow small and medium-sized farmers to also have access to information tools and risk management technology. Access to these new technologies is most important for small and medium-sized cattle farmers, once they improve their financial sustainability and their competitiveness.

The improvement of livestock production systems, especially the adoption of Integrated landscape Approach (ILA), including better foraging, soil management, and adequate animal stocking, has proven to provide a considerable increase in resilience. Production systems that periodically face drought seasons are maintaining their production throughout the year, intensifying the production/area, reducing production per area, hence, environmental pressure. The adoption of sustainable production systems is an important aspect of increasing resilience and reducing the vulnerability, regarding potential climatic risks and uncertainties.

II - Topic 2(f) Socioeconomic and food security dimensions of climate change in the agricultural sector

Agriculture is a critical sector when considering food security. Access to food, distribution and nutritional security are all aspects of food security that start with food availability. Agriculture is responsible for providing food availability, inasmuch its production capacity is highly dependent on edaphoclimatic conditions and climate variation, it is evident that food production is highly threatened by climate change.

Agriculture also strongly influences socioeconomic development. Farmers income, and livelihoods maintenance, local and national economies, social security and peace are many of the direct and indirectly influenced factors by the agriculture sector. Further, economic and social capacities are essential to positive feedbacks, adequate decisions, and coherent actions in context of uncertainties, and those are exacerbated by climate change. Guaranteeing the maintenance of production capacity of agricultural

systems is at the core of socioeconomic development. This maintenance, however, is threatened by climate change and can be also positively or negatively impacted by actions in response to it.

Strengthening resilience and adaptive capacity of agricultural production systems is urgent in order to gather positive results from the efforts to guarantee food security and sustainable socioeconomic development. The history of agricultural technology development in Brazil, considering the challenges and characteristics of tropical agriculture, guided the recent policies dedicated to the climate change challenges. It considered the specific vulnerability of the agricultural sector to the adverse impacts of climate change and guided the work to promote sustainable and resilient agricultural production systems, and hence contribute to food security and socioeconomic sustainability.

The changes and increasing uncertainties driven by climate change exacerbate the inherent complexity of the food system. The geographical distribution of food production, environmental and cultural landscapes, cultural traditions, organization of societies, economic and social stability are some of the aspects that are directly affected by those changes. These are important elements to take into account when considering vulnerabilities, adaptation and the sustainability of the solutions to face climate change. If in some cases these impacts could open development opportunities, more often they disrupt economic processes, local traditions and social structures. The diverse landscape of agricultural systems and the livelihoods that depend on them, create a mosaic of realities, that need to be considered in its complexity, in order to establish a picture that makes sense, and can support a healthy socioeconomic development and, as well, guarantee food security.

In order to address this complexity, it is central to consider an Integrated Landscape Approach (ILA) for policy development and implementation. No single element defines the problem or solves the issue. The result of an integrated and systemic approach might consider different combinations and interdependencies, exclusive to each environmental, social and economic context. Further, no single element can be considered to evaluate the conditions and sustainability of a system, requiring a deeper understanding of logic and principles of sustainability, and the unique characteristics of each reality.

In Brazil, the implementation of tropical agriculture technology has been carefully tailored, taking into consideration the socioeconomic and food security dimensions of climate change in the different regions of the country, analyzing the particularities of different types of agricultural systems that exist in the sector. Over the past decades, the results of this cohesive set of investments in public policies and science and technology development have allowed the intensification, diversification and improvement of efficiency in the use of land, water, inputs, energy and labor, contributing to the land-sparing effect.

Regarding the characteristics of tropical agriculture, and the large diversity of environmental, technical and social conditions and traditions encountered in Brazil, an important aspect of its National Plan for Adaptation and Mitigation in Agriculture (the ABC Plan) was the development of subnational plans (States ABC Plans). These State ABC Plans are connected to the national policy, contributing to its achievement, but are developed and implemented according to the local conditions, environmental and technical characteristics, priorities and capacities. It is the national responsibility to support subnational states in their implementation capacities, that is very different across the country.

A further characteristic of the ABC Plan, is that its lines of actions, and its various programs (recovery of degraded pastures, no till, integrated production systems and so on), consider not only the environmental and agricultural aspects that allow for better production, control of GHG emissions, and better use of resources; these set of technologies are promoted because they also have proven to be more resilient to climatic variability, most especially, because they improve production efficiency. A stronger resilience allows for production under uncertain climate, hence for food availability and contribute to food security. Production efficiency improves the use of resources and diminishes environmental impact, and most important, allows for higher profitability, allowing for more stable livelihoods, communities and society. Any response to climate change must be sensitive to income and economic fluxes. This characteristic of the set of technologies that is proposed by the ABC Plan is the central reason for the success of the plan, as it motivates not only the adoption of sustainable practices, but also the maintenance of these practices in the long run.

The observed modifications of geographical distribution of agricultural production systems driven by climate change are a concern and are taken into consideration in the discussion of adaptation solutions. The establishment and maintenance of productions systems, as well as the environmental and cultural landscape defined by these systems are directly affected by the variations in precipitation frequency and intensity, the diversity of pests and diseases and the occurrence of new pathologies, and the higher frequency of extreme events, such as droughts, floods, short and sporadic dry spells and others. This modification reflects directly on agriculture sustainability and on social, economic and food security dimensions.

Economically, climate change adds pressure on farmers and ranchers, where food production is the main family income, directly affecting the reproduction of livelihoods. Further, it affects national economies, as there is an impact on the capacity for commodity production, hence on national and international markets and economic transactions. The responses to climate change, established nationally and internationally, potentially affect farmers and their livelihoods, and therefore should be taken carefully into consideration, in order to allow effective balance among environmental, social and economic sustainability.

Socially, by affecting the capacity to maintain production systems, climate change can have an impact on livelihood and community stability and on the maintenance of cultural traditions and landscapes, that, although subjective, are an essential part of local and national identities. Further, the stability of rural communities is directly related to the stability in urban areas, potential conflict, social unrest, among others. Finally, the disruption of culturally and technically established food production systems threatens food security, as the production landscape and the balance among the diverse production capacity and food availability are consequently disrupted.

The modifications of the agricultural landscape might be inevitable in some cases. However, it is crucial that the impact of these transfers is considered. Most importantly, when searching for technical solutions to strengthen resilience and adaptive capacity, there needs to be a conscient effort to develop and propose solutions that can be integrated in the local environmental and cultural landscape identity such as ILA strategy.

When proposing state level ABC Plans, the development of tailored solutions and technical proposals is central. The participation of farmers and other local stakeholders is also essential to establish feasible solutions. This large participation, although increasing the complexity of implementation and monitoring, allows for a better acceptability of proposals, and occasional novelties and changes that need to be incorporated. Respecting local solutions is at the core of any sustainable and effective public policy.

To overcome the uncertainty generated by climate change, scientific technologies and strong public policies are essential elements to face the climatic challenges on agriculture. However, the development of technologies (Research, Development & Innovation – R,D&I component) and the implementation of public policies should be directed to empower farmers, large or small, to make adequate decisions in situations of risk. The establishment of early warning systems is, of course, essential. However, it is also important that individual farmers have the capacity to access the information and understand what the potential consequences are.

Along with training and capacity building, public policies should include effective contingency actions to guide farmers in their actions in uncertain and threatening conditions, in order to overcome situations of loss and damages, and alleviate consequent economic negative outcomes. Training, capacity building and technical assistance to guide the adoption of sustainable technologies for agriculture production are some of the essential elements of the ABC Plan, and have proven to be effective to support farmers and their surrounding communities, to overcome the climatic challenges and guarantee food production, hence contributing to food security, and allowing for the maintenance of farmer's income. The capacity to maintain food production is essential for food security. Therefore, when considering the elements that contribute to food security, along with access and distribution, affordable prices to consumers, the discussion should also consider the production capacity. This element is not only the physical capacity to produce farm goods (land, soil, good practices, biodiversity, water management), but also the capacity of farmers to make decisions and to maintain their livelihoods. Farmers should, then, be at the central focus of any policy, as they are, not only the public that will receive the services of these policies, but also the agent of change and of the maintenance of sustainability, and environmental and cultural landscapes. For that reason, a central aspect of the ABC Plan, and related policies, is to strengthen the instruments that will give all the needed support to farmers, in order to enable them to make the adequate decisions.

Reliable, available and understandable information is at the center of this challenge and it is the government's responsibility to implement an information system that can assure farmers the access to the best information available. Along with the ABC Plan, other policies such as the Agricultural Climate Risk Zoning (ZARC), the Family Agriculture Insurance and the Rural Insurance Premium Grant Program, are examples of policies that support farmers in a context of risk, allowing for an integrated risk management, also relevant in the context of socio-economic and food security dimensions. They focus on understanding the current and future vulnerability and promoting means to reduce these vulnerabilities by facilitating credit and insurance to all farmers, including smallholders as well as commodities producers[14].

[14] Information regarding all of these initiatives can be found through <http://www.agricultura.gov.br/>.

In order to address the challenges driven by climate change, agriculture needs to consider a complex set of elements. The connections among environmental, technical, socioeconomic dimensions are close, and all of them, eventually, will contribute to food security. This complexity, however, brings along the difficult task to gather and organize the necessary information, managing it adequately in order to guarantee an effective and transparent process of communication towards farms and towards the wider society. The ABC Plan is advancing the development of a Climate Intelligence Program, where an information Center – CICLAg – will be responsible for integrating indicators and building scenarios, which can then be prioritized and pursued as a long-term vision or used to steer the implementation of public policies.

The ability to have an operational intelligence center as part of an adaptation strategy will provide tools to break down technical-scientific and political-institutional knowledge barriers, providing decision makers a more palatable set of parameters among which to decide, contributing to reduce the impact of climate change on social, economic and food security dimensions. This information platform delivers to both rural producers and urban consumers information and knowledge for a better decision making on their activities. Further, it is also essential to evaluate the institutional capacity to support farmers in their decision-making, with the adequate information, as well as actively support their recovery in the aftermath of negative climatic impacts. The center will ideally gather, systematize, integrate and aggregate intelligence to the large volume of data available in the databases dispersed in the different institutions. It will also integrate this information with tacit knowledge that is not yet registered or published on traditional bases, in order to add value to the knowledge already registered and / or made explicit. In that way, this information will be easier used to support farmers' decision-making.

To fully implement and achieve the goals expected for the Climate Intelligence Program, however, some relevant challenges will need to be considered over the course of the next few years:

(i) there is large volume of data already available, but dispersed in Brazilian institutions;
(ii) integration of actions between data-generating institutions to facilitate governance and access to data and specialists;
(iii) data integration and intelligence to support national decisions and policies that support international climate change policies;
(iv) establishment of baselines and corresponding metrics and gauges for monitoring and tracking progress in reducing GHG emissions, change and rational use of land, landscape ecology, reduction of food waste, agricultural, environmental and social vulnerabilities, sustainable agricultural practices, among others; and
(v) development and support of regional policies to strengthen sustainable practices in the trinomial 'society-environment-economy' in biomes, such as the payment for environmental services, stimulating local production.
(vi) Alternative practices and means of overcoming periods of high impact to their activity due to unexpected events.

Along the information platform, to tackle climate change impacts on agricultural socio-economy and its adaptive and resilience capacity some concerning areas of work that demand further attention could be grouped into three economic basic classes:

- **Resources -** conservation and enrichment strategies for soils and water resources must be implemented; training of labor and development of agriculture 4.0 technologies for vulnerable populations; allocation of costs and investment credit inside and outside properties, areas of production, marketing and logistics of products and supplies.
- **Systems -** regenerative and resilient systems; protected agriculture and urban15 and peri-urban agriculture; local production and networks of high value-added agri-food systems; smart cities with rural planning, not just urban.
- **Products -** adding value to products referring to attributes of sanitary, nutritional quality, animal comfort and social and environmental impacts of production, creating chains for indications of origin and denomination of origin, sustainable production seals, as well as the promotion of biodiversity for food and nutrition as a means to foster sustainable entrepreneurship and to generate economic use for native species.

The ABC Plan combines technology, best practices, the understanding of the interdependencies and the integration of the systems' elements and the communication with farmers and the society as a whole, in an integrated landscape approach (ILA). This has allowed Brazil to promote and disseminate the implementation of more resilient agriculture practices that enhance the adaptative capacity of the agricultural systems while contributing to control GHG emissions, to reduce pressure for opening new areas with native vegetation, and to improve the agricultural landscape, both considering its environmental and cultural characteristics. Beyond the environmental benefits, those systems resulted in improved social-economic conditions in the rural environment, due to the intensification in rural extension, qualification and continued training that has resulted in better remuneration, and increase in the quality of products. They also have contributed to reduce environmental impacts and to improve resilience of agricultural processes. In this context, all these technological and management advances are key elements that promote socioeconomic improvement in rural environment and in agricultural sector.

Other policies related to socioeconomic and food security as part of social development policies are being conducted by the Brazilian Ministry of Citizenship (https://cidadania.gov.br), such as the national cash transfer program to fight extreme poverty (*Bolsa Família*); A School Lunch Program (*Programa merenda escolar*), that is supported by local farmers to provide the products for lunches at schools; the national program aimed at offering low-cost meals to public restaurants (*Programa Restaurante Popular*); and the national network of food banks. Additionally, another ongoing initiative is the National System for monitoring drought and its impacts in agriculture, coordinated by the National Center for Monitoring and Early Warning of Disasters (CEMADEN) along with Civil Defense.

These efforts are essential to achieve food and nutritional security but not enough to fulfill its dimensions that go beyond the production system - including its efficiency, diversity, capillarity, for example - and even beyond the agricultural sector. Other important dimensions of food security that must be considered in interaction with other sectors should include logistics; food losses and waste reduction at every stage

[15] Some of the topics that require a better understanding concerning the urban environment and its relation to agriculture are: waste; new forms of production and consumption; use of Biofuels and renewable / clean energy; GHG and particulate emissions; forms of environmental pollution; land occupation and landscape; and public policies for the recovery of less favored regions: basic sanitation, vulnerable areas, among others.

of the agri-food chain; strengthening short food supply chains; quality assurance and diversification; market and trade; access to food; and population income for buying food.

The 2030 Development Agenda represents a guiding tool for the planning of long-term actions and public policies, which may help Brazil to effectively reach sustainable development. It also favors the fight against climate change, while seeking to strike a balance between human prosperity and the protection of the planet.