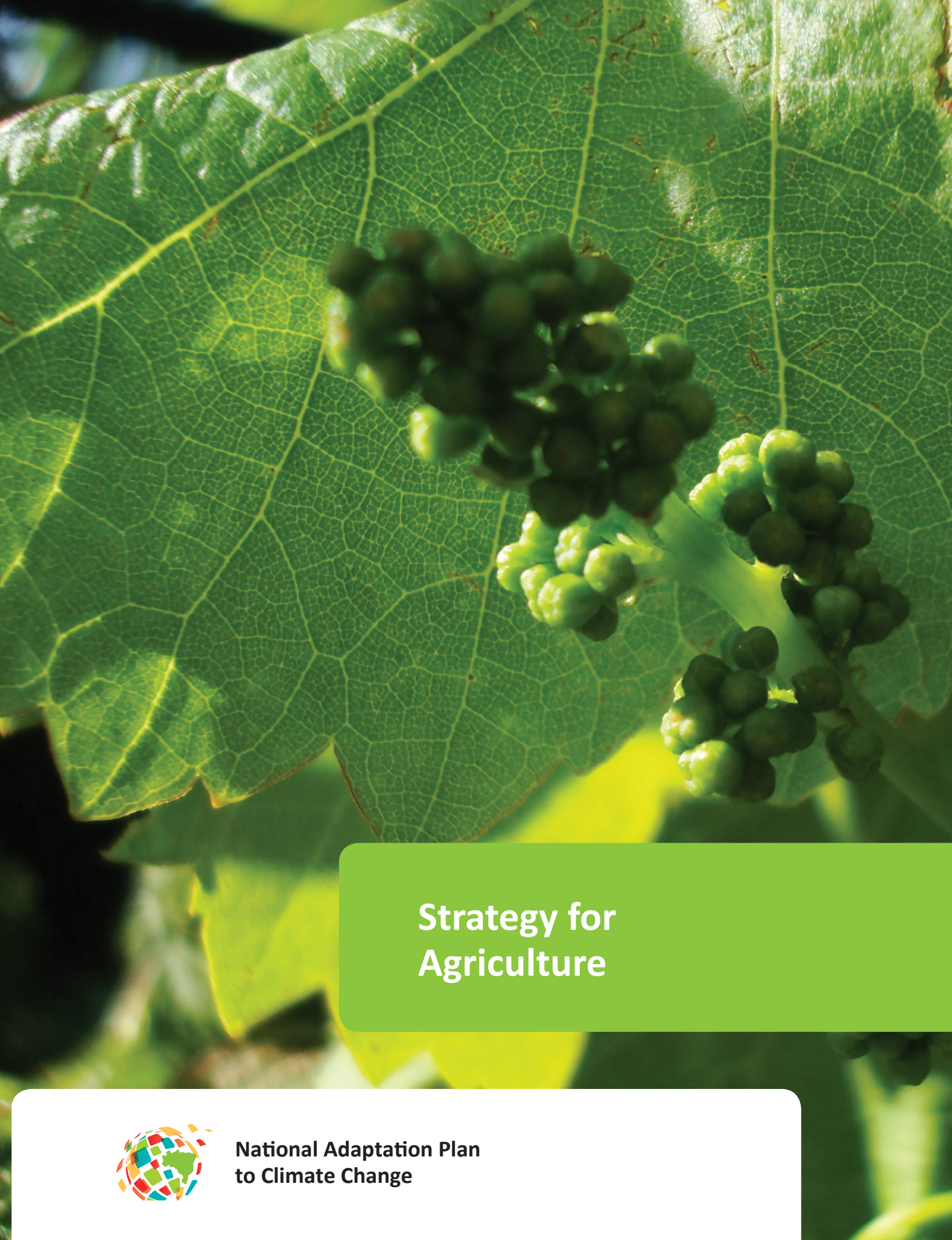

Strategy for Agriculture

National Adaptation Plan
to Climate Change

1 Strategy for Agriculture

This strategy was prepared under coordination of the Ministry of Agriculture Livestock and Food Supply (MAPA) which is the focal point for this sectoral strategy, with participation of the Brazilian Agricultural Research Corporation (EMBRAPA); the National Institute of Meteorology (INMET), the Executive Commission of the Cocoa Farming Plan (CEPLAC), the Ministry of Agrarian Development (MDA) and the Ministry of National Integration (MI). Review and strengthening of the Adaptation Programme for Low-Carbon Agriculture (LCA) Plan[1] (BRAZIL, 2012) to be implemented in the 2016-2017 period, with ample public and private-sector participation and inputs from the productive sector, research institutions and civil society, will reflect the content of this strategy.

1.1 General Objective

The aim of an adaptation programme for the agriculture sector is to foster a secure environment for decision-making on the part of farmers and public-policy managers faced with climatic uncertainties, through efficient access to information, technologies and production processes for the establishment of sustainable production systems.

This Chapter aims to examine vulnerabilities of the agriculture sector to climate change; to provide support for deployment of actions that promote resilience of agro-ecosystems; to foster technology transfers; and to provide inputs for a review of the Low-Carbon Agriculture Plan, in particular its adaptation programme, and for actions to be carried out by 2020.

1.2 Introduction

Brazilian agriculture comprises a great diversity of production systems that play a prominent role in the national economy, both through supply of local markets and maintenance of rural livelihoods, and through contributions toward national wealth. The farm sector accounts for 23% of Brazil's Gross Domestic Product (GDP) or roughly R$ 1.1 trillion and generates 35% of jobs. Some 5 million farms contribute to production of food, fibre and energy for domestic consumption and to meet demand from international markets. Since 2008, Brazil has been the world's third largest overall exporter of agricultural produce and the leading exporter of various products. Farm-sector exports have consistently been the main contributor to Brazil´s positive trade balance (BRAZIL, 2015b) thus underscoring the nation's importance as a supplier of food for the world (FAO, 2012).

[1] Available at: <www.agricultura.gov.br>.

Farming, as an economic activity, is influenced by environmental factors and highly dependent upon weather conditions (MOORHEAD, 2009). The climate is variability should be considered the main risk factor for agriculture. It has been estimated that roughly 80% of the variability in agricultural yields stems from seasonal and inter-annual climate variability, whereas the remaining 20% is associated with economic, policy, infrastructure and social issues (BRAZIL, 2015; NAKAI *et al*., 2015)

Agricultural activities are subject, directly and indirectly, to weather conditions: temperature, sunlight, rainfall, air humidity, wind speed, and to the availability of water in the soil. Oscillations in such weather variables affect the growth, development, yields and quality of agricultural crops and livestock, in addition to their effects on other components of agro-ecosystems, such as insects and other pollinators or predators, microorganisms, aquifers, etc. (GHINI, *et al*., 2011; HOFFMANN, 2011).

Aside from direct impacts on crop yields and farm animals, changes in climate patterns also impact the vectors of some diseases and insect pests and of pollinators, and may contribute toward the spread of weeds that undermine production (GHINI, *et al*., 2011; HOFFMANN, 2011). There are studies[2] underway to assess the entry of certain diseases not currently present in Brazil, but which could pose threats to Brazilian agricultural production.

Variability within climate patterns is an intrinsic factor in the planning of food production. However, climate projections for Brazil, considering possible scenarios projected in international reviews (IPCC, 2014) raise concern as to the prospect of a rise in average temperatures and of reduced rainfall (MARQUES *et al*., 2013).

Studies show that the frequency of days with extreme (high or low) temperatures, and a lower day-night temperature gradient will have major consequences for plant metabolism and animal well-being, with major impacts on production capacity (HOFFMANN, 2011; BRAZIL, 2015). Moreover, projections point to seasonal changes in rainfall distribution, with a greater concentration of high-intensity rains in the short run, replacing a more diverse spatial distribution of rains during production seasons (HOFFMANN, 2011). Such phenomena are likely to negatively impact production systems given that, in Brazil, only 5% of the area under cultivation is irrigated (BRASIL, 2015; NAKAI *et al*., 2015). In other words, 95% of the area under cultivation is subject to natural rainfall variations, both in terms of quantity and of seasonal distribution. Such changes in rainfall patterns are likely to exacerbate negative impacts, either by increased potential runoff erosion, or reduced rainfall during critical periods of the production cycle.

Climate change in Brazil poses increased agro-climate risks, stemming from reduced availability and increases in the consumption of water for agricultural crops (owing to higher temperatures). Some studies point towards a decline

2 Available at: <www.macroprograma1.cnptia.embrapa.br/climapest>

in areas of low climate risk for all crops (BRAZIL, 2015). It has been estimated that such a decline may vary from 3% to 40%, depending upon the crop and climate scenario considered. Such a decline in average water availability will lead, among other impacts, to lower yields.

The economic impacts of reduced agricultural production capacity are of grave concern. Estimated losses for the Brazilian farm sector caused by higher temperatures may amount to as much as R$ 7.4 billion by 2020, and these could leap to R$ 14 billion by 2070, thus deeply altering the geography of Brazilian agricultural production (DECONTO, 2008; ASSAD *et al*., 2013). In view of the importance of the farm sector for the national economy, the social impacts of such losses. Family farming, an important segment of domestic food production, plays a major role in generating income and quality of life for thousands of rural families. According to the latest agricultural census (IBGE, 2006) family agriculture accounts for 48% of national gross production value. This highly diversified segment has been identified as being particularly vulnerable to climate change.

The inability to produce on the part of certain agricultural systems may have negative impacts on local and regional lifestyles and economies; compromise food and nutritional security; generate social insecurity; and lead to other problems. Losses of agricultural production capacity are also likely to cause higher prices for some products, especially basic foodstuffs, such as rice, beans, meat and by-products (DECONTO, 2008; ASSAD *et al*., 2013). If, on the one hand, the decline in agricultural yields can be offset by a fall in agricultural production costs, it is nonetheless likely to have a negative impact on the population's capacity to consume such basic products, not to mention on the general behaviour of the Brazilian economy, including higher inflation rates (HOFFMANN, 2011; BEDDINGTON *et al*., 2012; IGNACIUK & MASON-D' CROZ, 2014; MARQUES *et al*., 2013).

Changing climate patterns may have an accentuated negative impact on future potential agricultural production, when compared with current production conditions. There is a growing concern as to the nation's capacity to supply food to meet burgeoning domestic demand and that of international markets (MOORHEAD, 2009; FORESIGHT, 2011; HOFFMANN, 2011). Historically, agriculture has demonstrated an intrinsic capacity to adapt (MOORHEAD, 2009). Development and adoption of technological innovations in Brazil has kept pace with socio-environmental change. Substantial investment in agricultural research has enabled Brazil to assume a position of prominence in worldwide food production. Such research and technological-innovation capacities must now respond to the challenge of developing alternatives that will enable agro-ecosystems to adapt to new climatic conditions (MOORHEAD, 2009; BEILIN, SYSAK & HILL, 2012).

Notwithstanding the flexibility of agricultural systems and the supply of

technological information, there remains the challenge of facilitating access to information and adoption of currently-available technologies, processes and systems, in forms that enable attainment and maintenance of expected outcomes (MOORHEAD, 2009). There is a need to strengthen public policies that offer the productive sector instruments that enable adjustment of production systems, making it possible for them to maintain production capacity and adjust to climate-change patterns (MOORHEAD, 2009; BEDDINGTON *et al*., 2012; BEILIN, SYSAK & HILL, 2012; IGNACIUK & MASON-D' CROZ, 2014; MARQUES *et al*., 2013). Such instruments need to focus not only on motivating farmers but, above all, on fostering a secure environment capable of accommodating the necessary adjustments and enabling maintenance of sustainable and resilient agricultural production systems.

To promote national development, food security, adaptation to and attenuation of climate change while, at the same time, seeking to attain their commercial goals in coming decades, Brazilian farmers will need significantly to increase yields in areas devoted to food-production and livestock systems. Concurrently, the farm sector has responsibilities toward reducing its greenhouse-gas emissions and deforestation pressures, while restoring millions of hectares of degraded pasture land and protecting areas under environmental preservation.

1.3 Institutional and legal framework

A variety of regulatory policies and instruments apply to the management of climate variability and its effects on the farm sector. Moreover, intense research is underway with the aim of providing alternative technologies, processes and technical arrangements targeted toward environmental adaptation and sustainability.

Among the highlights is the Low-Carbon Agriculture (ABC) Plan[3], one of the sectoral plans that comprise the National Plan for Climate Change (PNMC). Launched in 2011, the ABC Plan features instruments, such as an exclusive line of credit for fostering activities targeted at increasing the area under sustainable agricultural production and thereby enabling a reduction of greenhouse-gas emissions by the agriculture sector. In addition to its commitment toward reducing greenhouse-gas emissions (GHGs) the Plan aims to encourage, motivate and support the farm sector in deploying actions to foster adaptation, where necessary, by mapping sensitive areas, increasing the resilience of the agro-ecosystems, development and transfer of technologies (especially those with proven potential for reducing GHGs) and adaptation to the impacts of climate change.

In addition to the ABC Plan, there are a number of public policies and instruments that currently address climatic uncertainties and their influence on the farm sector, many of which are already contributing toward its adaptive capacity.

[3] Available at: <www.agricultura.gov.br>.

These instruments need to be reviewed in the light of the most recent information on climate change, through discussion of their timeliness and relevance, in line with the contextualization of specific goals. Below are some highlights:

Agricultural Climate-Risk Zoning - an agricultural-policy and risk-management instrument, whereby studies that seek to mitigate climate risks are periodically updated. Information thus made available enables targeting of decisions as to the most suitable strains for planting in each region and the best time for planting, taking into account prevailing soil conditions in each region and the capacity for crop cycling. Zoning is based upon quantification of climate risks that may cause production losses, thereby assigning low and high-risk areas and their respective sowing calendars. Such information is made available for each crop year, by municipality and by crop. Adaptation of the agricultural calendar to climatic conditions enables a lowering of loss risks in the field. As of the 2015/2016 harvest, it will be possible to access the Agricultural Zoning System for Agro-climatic Risk[4] (SISZARC) to obtain updated agricultural zoning[5] information.

The Agricultural Activity Guarantee Programme (PROAGRO)[6]- instituted by Law 5969/1973 and implemented by Agricultural Law 8171/1991, both brought into effect by Decree 175/1991, and Family Agricultural Activity Guarantee Programme (PROAGRO-Mais), instituted by Law 12058/2009, are targeted at ensuring financing and the payment capacity of farmers, in face of commodity-market price oscillations. Harvest Guarantees, including a specific modality of Agricultural Insurance targeted at Family Farming, comprise a productive-sector strategy that provides guarantees for farmers faced with harvest failure caused by climate events. For example, it offers special terms for family farmers in the semiarid Northeast region that historically has suffered crop failures owing to drought or excessive rainfall. Farmers that lose over 50% of their harvests are eligible to receive financial compensation.

Family Farming Insurance (SEAF)[7] - established within the scope of a programme known as PROAGRO-Mais, is designed to defray operational costs for family farmers and is linked to the National Programme to Strengthen Family Farming (PRONAF). SEAF was launched by the Federal Government to provide greater tranquillity for farmers in tending to their crops, in response to demands for insurance offering income guarantees. SEAF has undergone modifications targeted at attending to real needs of family farmers with regard to production security, encompassing sustainable production systems, such as agro-ecology, organic crops, agro-forestry systems, among others.

The Insurance Premium Subsidy Program (PSR)[8] - aims to facilitate access to Rural Insurance, as does the Catastrophe Fund,

[4] Available at: <http://www.agricultura.gov.br/servicos-esistemas/ sistemas/Siszarc)>.

[5] Available at: <http://www.agricultura.gov.br/politica-agricola/zoneamento-agricola>.

[6] Available at: <http://www.agricultura.gov.br/politica-agricola/zoneamento-agricola/proagro>.

[7] Available at: <http://www.mda.gov.br/sitemda/secretaria/safseaf/sobre-o-programa>.

[8] Available at: <http://www.agricultura.gov.br/politica-agricola/seguro-rural>.

launched on 26th August 2010 by Enabling Law (LC) 137, that has not yet been brought into effect.

Aside from these initiatives that feature specific approaches to climatic issues, certain other policies merit consideration for their contribution toward fostering sustainable rural development. In seeking to promote sustainability, various current initiatives are targeted at strengthening resilience to climate change of agricultural production systems of different types, by means of conservation agriculture through enhancing the natural environment (particularly soils, water and biodiversity), ecosystem services and best practices for farming and conservation. The aim of the National Policy for Agro-ecology and Organic Production and its respective Plan (PLANAPO) instituted by Decree 7794/2012, is to "coordinate and implement programmes and actions that foster transition to agro-ecology, organic farming and agro-ecological production as a contribution toward sustainable development, offering the population better quality of life through supply and consumption of healthy foods and sustainable use of natural resources".

The Law for Protection of Native Vegetation (Law 12651/2012) also provides policy guidelines for structuring sustainable agricultural production systems. It sets general rules for protection of vegetation and for Areas of Permanent Preservation (APPs) and Legal Reserve (RL); commercial forestry and provision of forestry raw materials, traceability of forestry products, control and prevention of forest fires, and economic and financial instruments are its objectives. Foremost among these instruments is the Environmental Regularization Programme (PRA) established by Decree 8235/2014, which sets procedures for regularization of APPs, RLs and Restricted Use (UR) areas, entailing processes of recovery, restoration, regeneration or compensation. It also orients rural landowners and freeholders on how to bring their properties into compliance with the PRA, beginning with registration on the Rural Environmental Register (CAR). Other related actions are foreseen in the National Policy for Integration of Farming Livestock and Forestry (ILPF) (Law 12805/2013) and the Agricultural Policy for Planted Forests (Decree 8375/2014).

The National Water Resources Policy (PNRH) and the National Water-Resources Management System (SINGREH) (Law 9433/1997) provide for decentralized and participatory multiple-use of water by Public Authorities, users and communities. They also aim to reduce climate risks inherent to agricultural activities, especially in regions susceptible to low or irregular rainfall distribution. Foremost among the management instruments provided for in the PNRH are Water Resources Plans, licencing of rights to use of water resources, and the National Water Resources Information System (SNIRH).

The National Irrigation Policy (Law 12787/2013) aims to encourage sustainable expansion of the area under irrigation in Brazil, to increase agricultural yields and, consequently, improve the competitiveness of Brazilian agribusiness

while, at the same time, reducing pressures to bring new areas under cultivation. The law also characterizes the building of dams and dykes for irrigation as being of public utility. Among the basic premises of the policy is integration of sectoral policies for water-resources, agriculture, environment, electric-power, environmental sanitation, rural credit and insurance and their respective plans, with priority for projects that promote efficiency and multiple use of water resources. This includes the National Irrigated Agriculture Information System and the National Programme to Combat Desertification (PAN-Brasil) which identifies areas susceptible to desertification and establishes priorities for public and private actions.

In the light of average annual rainfall figures for most of Brazil's regions, incentives for water production and storage could ensure sufficient water supplies for human and livestock consumption, electric-power generation and for a significant increase in areas under irrigation throughout the country. Even in situations entailing the building of dams, when no other technical solution or alternative location is available, irrigated agriculture constitutes an economic, environmental and socially sustainable activity and is thus considered to be of public utility and social interest. The water crisis that has afflicted Brazil, and particularly its Central-West and Southeast regions in recent years, has been partially attenuated by a network of small reservoirs which, though insufficient to ensure minimum needs, have made it possible for various municipalities to reserve quantities for human water supply and livestock consumption. This includes reservoirs built for private irrigation projects which, nonetheless, have served as sources of public water-supply for communities in the direst situations. Reservoirs that supply public irrigation projects in the Northeast region often provide water supply for human and animal consumption in situations of water scarcity. Upon coming into effect, the Law for Protection of Native Vegetation ushers in a massive process of restoration of APPs and reforestation of riverbanks, with the aim of preventing silting of water bodies and improving drainage in river basins. A review of the legislation covering construction of small and medium-size dams and measures to cut through the bureaucracy for obtaining water-storage, water production, and water use rights is needed. In view of the importance of these measures, a partnership among farmers and federal, state and municipal authorities is needed to promote actions designed to induce water production in rural areas, by means of a sustainable policy for water management, production and storage.

The Agricultural Decision-Making Support System (Sisdagro[9] /INMET); the Simulation of Future Agricultural Scenarios (SCenAgri/EMBRAPA); and the Brazilian Agriculture Observation and Monitoring

[9] Available at: <http://sisdagro.inmet.gov.br:8080/sisdagro/app/index>.

System (SOMABRASIL[10] /EMBRAPA) are the main information and planning instruments used for these purposes and all take into account growing sensitivity to climate uncertainty, while seeking to furnish information to enable better decision making on the part of farmers and public-policy managers.

1.4 Qualitative vulnerability analysis

Agricultural systems, in view of their total dependence upon climate, are constantly developing strategies to meet challenges and minimize the impacts of climate variability. There are, consequently, a number of instruments available for assessment of the sensitivity of production systems to the vicissitudes of climate variation. Such instruments have been recalibrated to assess new potential scenarios and to orient research, policies and other instruments for fostering the sustainability and competitiveness of the farm sector.

The Agricultural Zoning Model for Climatic Risk and Vulnerability is a Brazilian public-policy instrument, launched in 1996, whereby each Brazilian municipality is assessed according to the probability of its achieving no less than 80% of an economically viable harvest.

Another important system is the Simulation of Agricultural Scenarios (SCenAgri) developed by EMBRAPA, which brings together information on climate, soils, water and the characteristics/needs of crops, based on field data collected throughout Brazil. The Agricultural Decision-making Support System (Sisdagro/INMET) provides farm-sector users with support for agricultural planning and management decision making. This system provides users with weather information gathered at the INMET weather-station network and data obtained from numeric weather-forecast models on such variables as: temperature, rainfall, relative humidity, wind speed and direction, and sunlight. This model is still under development and, in its second phase, is expected to incorporate climatology-based tools to enable functions such as analysis of the most favourable dates for planting. Another feature that the system will offer is predictions as to future development of harvests, based upon seasonal weather behaviour forecasts.

Notwithstanding the solidity of these systems, each instrument needs to be assessed and, if necessary, strengthened to operate in a context of climate uncertainty (VERMEULEN *et al.*, 2013). The number of crops analysed needs to be expanded, the impacts assessed in greater detail and, above all, evaluations need to consider close interdependence among productive elements. An evaluation of the negative impacts of climate changes on these systems is needed, as is also identification of the characteristics that imbue such systems with resilience.

The entire agricultural system depends upon and is exposed to vicissitudes of climate and of climate change. All elements of the system are susceptible

[10] Available at: <http://mapas.cnpm.embrapa.br/somabrasil/webgis.html>

to climate variability and are highly sensitive to climate change. It is therefore essential that adaptive capacity of the sector be reinforced, thereby enabling the productive sector to make better decisions for structuring production systems, making them sufficiently resilient to the effects of climate uncertainties. The proposed adaptation programme for the agricultural sector is focused primarily on reinforcing its adaptive capacity, through promoting of instruments, technologies and processes that enable farmers and other stakeholders to proceed with their activities with the necessary security.

1.5 Guidelines

The consequences of climate change on rainfall distribution, temperature and other factors that influence crop cycles may result in smaller harvests and lower quality products. Aside from causing great losses for farmers, these changes may jeopardise food security and the very presence of farmers on the land. Adaptation needs to be a component of public policies for facing up to climate change, strategies for which entail investing in greater agricultural efficiency, in promoting diversified systems and in the sustainable use of biodiversity, land, and water resources, in support of a process of transition, reorganization of production, guarantees of income generation, research (into genetic resources and cross-breeding, water resources, adaptation of production systems, identification of vulnerabilities and modelling) among other initiatives.

Thus, the Agriculture Adaptation Programme must aim to create a safe environment for decision-making on the part of farmers and public-policy managers, in response to the challenges of climate uncertainty, through efficient access to information, technologies and production methods so as to establish sustainable production systems in face of possible adverse scenarios for Brazilian agriculture over the coming decades. This programme, based upon the premises presented in this Strategy, needs to be assembled in a participatory manner, between 2016 and 2017, with the involvement of experts and representatives of civil society, within the context of a review of the ABC Plan (BRAZIL, 2012).

To guide construction and management of the Agriculture Adaptation Programme, the following **guidelines** shall be considered:

1. The Agriculture Adaptation Programme is to be coordinated by government ministries with the appropriate technical sectoral competence, and its implementation shall entail shared responsibility with other ministries and institutions related to the sector.

2. The Agriculture Adaptation Programme is an integral component of actions for responding to the challenge of climate change on the part of the farm sector, and is to take the form of coordinated and synergistic action for mitigation of concerns about GHGs targeted at jointly increasing sustainability of the sector, within the Sectoral Plan currently in place under the PNMC the ABC Plan

3. Adaptation measures shall attend to the needs of crops in face of the various possible changes in climate structure, including rising temperatures and higher thermal gradients, water intensity and distribution, etc. The first premise is that the sustainability of agricultural systems (in the broadest sense, encompassing agricultural crops, livestock and forestry, as well as various types of integrated systems) must be achieved and guaranteed through intensive application of knowledge for improvement of processes.

4. It is acknowledged that development of an adaptation strategy needs to be based upon the best available information sets and that its effectiveness depends upon how its implementation is structured and its continuity over time ensured, through constant review and improvement, with structured investments in science and technology.

5. The focus of actions for agriculture are initiatives and instruments that enable and motivate farmers to structure and maintain sustainable production systems, on a variety of scales, using various types of technology, labour and marketing arrangements. Aside from development of suitable technologies, two main actions shall be pursued: establishment of an Agricultural Climate Intelligence Centre, and development of the Monitoring and Agricultural Risk and Vulnerability Simulation System, based upon currently existing and deployed instruments.

6. Geographic Area of Implementation: National – agriculture is the most basic and central activity throughout Brazil, and is susceptible to changes in climate patterns. The Programme must thus entail discussion of structural and crosscutting actions at the federal level, while also establishing local action strategies.

7. Regional Strategy: specification of regional goals shall be based on mapping of vulnerabilities, opportunities and/or investments, and on the social profile of each region, with acknowledged priority for actions targeted at family farming. As with deployment of the ABC Plan, the specificities of each region and state need to be developed through construction and subsequent review of state-level LCA Plans, under the responsibility of State Management Groups, currently active in all states and municipalities, for purposes of local implementation and management of the ABC Plan.

8. Assimilation of risk management into sectoral policies: these already address issues relating to climate risk, which is considered an intrinsic factor for the agricultural sector. Assessment of such policies, in a context of climate change, needs to take place within the context of a more detailed discussion of the Agriculture Adaptation Programme, with a view to appraising its relevance, possible gaps and antagonisms, and strategies for strengthening its effectiveness.

A number of challenges must be met before these guidelines and the drafting and deployment of the Adaptation Programme for the Agricultural Sector can effectively be brought into effect. Some of these challenges stem not from issues of programme governance nor do they relate to the ministries responsible for implementation but, rather, demand a deeper understanding of the new agricultural production paradigm, induced by the threat of climate change and not as yet assimilated by the institutions concerned.

It is therefore important that consideration and debate should focus on selecting the best strategies for meeting the following challenges:

a. Prepare technicians and farmers to adopt systems and technologies that contribute toward adaptation to climate change;

b. Stimulate compliance of technicians and farmers, by showing the advantages of participating in the transition process for diversification of production systems and of adopting technologies which enable greater resilience and adoption and use of renewable-energy sources, from an economic, social and environmental standpoint;

c. Reduce the risks and minimize the impacts of climate change on agriculture by means of the National Plan for Reduction of Risks and Disasters, considering possibilities for contracting agricultural insurance and other agricultural-policy instruments;

d. Provide training and enhance skills, in the short and medium-term, with a focus on climate change and sustainability in agriculture;

e. Strengthen technical-assistance and rural-extension activities, with a view to preparing the productive sector for the effects of climate change, and provide guidance for adoption of adaptation measures that, preferably, also target mitigation of GHGs;

f. Strengthen actions for containment, reduction and prevention of desertification and dune formation, with a view to minimizing impacts and recovering the productive capacity of afflicted areas, by applying principles of soil conservation, sustainable management and use of water;

g. Develop and modify farming technologies so as to enable adaptation, ensuring that they are available to farmers;

h. Promote and develop diversified production systems, with a focus on increasing the resilience and efficiency of farming systems and the need to adapt to climate changes identified on vulnerability maps, with a view to fostering environmental sustainability, including control of GHGs (through synergistic adaptation and mitigation actions), income generation, and improved living standards;

i. Create production mosaics, based on integrated crop-livestock-forestry systems, in areas of production, forests, native vegetation and ecological corridors, resulting in an increase of regional resilience and in the use and conservation of natural resources (biodiversity, water, soil) in compliance with current legislation;

j. Establish and adapt procedures of financial agents to ensure they operate with modalities that incorporate adaptation/mitigation actions, including funding of diversified systems, sustainable use of biodiversity and of water resources, and sustainable energy generation and rational use;

k. Develop and make available technologies, by means of RD&I programmes that encompass integrated management of natural resources (biodiversity, water and soil), genetic resources, biological safety, renewable energy, and development of agricultural inputs and pesticides that do not degrade the environment, etc.;

l. Ensure access to federal, state and municipal agriculture-related climate information sources.

1.5.1. Development of the Agriculture Adaptation Programme

To achieve national development, food security, adaptation and attenuation of climate change, as well as its commercial goals over coming decades, Brazil must significantly increase food and grazing-crop yields while efficiently managing inputs and natural resources. Production increases must be achieved through improvements in sustainable production methods and higher yields while, at the same time, reducing deforestation, restoring millions of hectares of degraded pastureland and adapting to climate change.

Adaptation measures must incorporate advances in adoption of new agricultural production models and paradigms. Possible adaptation approaches include: a focus on decentralised production, solutions that better address local needs, diversification of local sources of food supply and greater attention to nutritional quality, genetic improvement to develop drought-resistant varieties, transition to more integrated production systems, expansion of access to efficient irrigation technologies, and management tools for conservation of natural resources.

Application of new agricultural management practices can contribute toward overcoming problems caused by extreme weather, for example, frosts that damage coffee plantations, or adoption of drought-tolerant varieties of non-irrigated crops. The development of new agricultural technologies, in addition to reducing GHGs, can result in higher yields.

Initially, the Agriculture Adaptation Programme will concentrate on actions already underway to assess their impact. The ABC Plan and its Adaptation Programme will undergo review during the course of the 2016/2017 growing season. This review, under coordination of the Ministries of Agriculture, Livestock and Food Supply (MAPA) and of Agrarian Development (MDA) through the National Executive Committee of the ABC Plan (BRAZIL, 2012) and with extensive public participation, will give continuity to the procedure used in drafting of the ABC Plan, with inclusion of more detailed assessments, definition of priorities, setting of more specific goals, targets, timeframes and distribution of roles.

This review of the Adaptation Programme shall take into account recently concluded

surveys, weather-projection variables relating to agricultural production, and available information on vulnerability of the sector to projected climate forecasts. The starting point for this review and new proposal will be the content of the current ABC Plan (BRASIL, 2012) that will thenceforth incorporate new elements and priorities stemming from plenary discussions. The aim of these efforts is to generate, manage and disseminate basic environmental information and to facilitate access to the technological information necessary for expanding the array of alternatives and processes in support of farmers. The review is expected to last about one year, beginning in 2016, involving evaluation of actions in progress and subsequent discussion and proposal for actions targeted at strengthening new lines of action, and is due to be completed by early 2017.

The starting point of the work is the ABC Plan monitoring system and, in particular, the Multi-institutional Platform for Monitoring Agricultural Greenhouse-Gas Emissions (ABC Platform) established through a partnership between EMBRAPA and members of *Rede Clima*. It involves public research and teaching institutions engaged in the monitoring, reporting and verification (MRV) of mitigation and adaptation activities, including analysis of satellite images, as proposed under the ABC Plan (BRAZIL, 2012).

Actions from different sectors should be considered to enable the agricultural sector to climate change adaptation. Review of the Plan and efforts to strengthen its Adaptation Programme must focus on priorities to be pursued by 2020 under the next phase of the ABC Plan, when another evaluation of work fronts will be carried out. Structural and crosscutting approaches imbue the adaptation process with greater impact and merit priority, in view of the sensitivity of farming to weather conditions.

Two central features of the adaptation programme relate to the goals set for the farm sector, listed as NAP goals and reported in Volume I:

1. Establishment of the Climate Intelligence Centre for Agriculture that focuses on assessment of climate risk in the planning and development of Brazilian Agricultural Policies; and

2. Development and implementation of the Agricultural Risk and Vulnerability Monitoring and Simulation System.

These features have crosscutting effects in several areas and enable mapping of needs and setting of priorities for a diverse array of adaptive measures, thereby adding to the effectiveness of the Adaptation Programme. Both these features are under direct responsibility and governance of MAPA and EMBRAPA, respectively.

The following table shows goals and initiatives of the strategy for agriculture, as presented in Volume I of this NAP:

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk

Sectoral and Thematic Strategy: Agriculture

Goal 3.1	Initiatives	Responsible
Develop and deploy an Agricultural Risk and Vulnerability Monitoring and Simulation System.	Organize information collected from climate and agricultural observation systems.	EMBRAPA
	Enhance methods for modelling and estimation of climate risk.	
	Enhance the monitoring of impact on major production systems.	
	Develop the Agricultural Risk and Vulnerability Monitoring and Simulation System, utilizing and optimizing legacy systems.	
	Regional Vulnerability Analysis (development of indices, medium and long-term vulnerability indicators), climate-risk maps (local, regional and national), classification of the regions of Brazil in terms of climate risk for the main agricultural activities; propose a vulnerability scale; identify priority areas.	
	Identification of adaptation measures for efficient water use, phytosanitary management, integrated with development of methods and crops, with a view to increasing agricultural resilience in priority areas.	
Indicator/ Monitoring:	Number and frequency of analyses undertaken.	
	Number of parameters evaluated.	
	Agricultural Risk and Vulnerability Monitoring and Simulation System deployed.	
	Number of systems and models made available.	
	Percentage of the territory classified by a vulnerability and climate-risk scale.	
Impact:	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change.	
	Collaborate with national food and nutritional security authorities in facing up to increased frequency of extreme events, improving readiness, adaptive capacity and resilience of farm sector.	
	Assist with the planning of exports.	

Objective 3. Identify and propose measures to promote adaptation and reduction of climate risk

Sectoral and Thematic Strategy: Agriculture

Goal 3.2	Initiatives	Responsible
Establish a Centre for Climatic Intelligence for Agriculture, for application of climate risk analysis in Brazilian Agricultural Policy.	Establish an inter-institutional working group involving the key players (INMET, EMBRAPA, MAPA, MCTI, MDA, MI, MMA, IPEA, IBGE, INPE, and ANA).	MAPA
	Integration of the Agricultural Risk and Vulnerability Monitoring and Simulation System with national monitoring and early-warning networks (CEMADEN and CENAD).	
	Draft a work plan: analyse current and potential scope for generation of information by existing monitoring networks; define technical requirements for the development of platforms and systems to guarantee compatibility with existing platforms; assess current demand for information; define methodologies, design flows and processes, etc.	
	Develop support systems for the inputting of secondary data.	
	Set up a system for spatial and integrated analysis of social, economic, environmental and institutional vulnerabilities.	
	Set up a system for prioritizing vulnerable regions and land-use planning.	
	Create the Climate Intelligence Centre for Agriculture – Communications and Early-Warning Network.	
	Develop Contingency Plans and provide support for Brazilian Agricultural Policy.	
Indicator / Monitoring:	Versions of the Agricultural Risk and Vulnerability Monitoring and Simulation System harmonised with other early-warning and monitoring networks.	
	Climate Intelligence Centre for Agriculture- Communication and Early-Warning Network consolidated.	
	Number of systems and models made available.	
	Percentage of the territory classified by the vulnerability and climate-risk scale.	
Impact:	Application of climate-risk assessment in planning of actions of Brazilian Agricultural Policy.	
	Establishment of a secure business environment for decision-making of farmers, government and investors.	
	Improve predictability of agricultural insurance planning.	
	Ensure appropriate and effective investment of resources for adaptation of agriculture to climate change.	
	Collaborate with national food and nutritional security authorities to face up to increased frequency of extreme events, and improve readiness, adaptation capacity and resilience of the farm sector.	
	Assist in the planning of exports and agricultural commodity negotiations with futures markets.	
	Support for agricultural zoning policies.	

1.6 Adaptation measures for the farm sector

The following Table presents adaptation measures proposed in the ABC Plan (BRAZIL, 2012) including actions already underway and some additional themes. There are seven major areas of activity that involve information systems targeted toward different publics (researchers, public-policy managers and the productive sector), land-use monitoring information, research in various fields, financial instruments, mechanisms for rural development and public policies for strengthening the sector in the context of climate change. The measures proposed are quite general and should be discussed, detailed and prioritized and responsibilities defined, by region and production system, in terms of phasing and execution timeframes, during review of the Agriculture Adaptation Programme.

Table 1. Adaptation measures proposed for drafting of the Adaptation Programme for Agriculture

Intensified acquisition and use of information
Establish basic environmental information systems, based upon currently used technologies and new technological options so as to promote resilience and adaptation to the negative impacts of climate change. Such systems should entail intensified acquisition and use of information, with actions related to networks, systems, platforms and other forms of data and information gathering for analysis and the developments proposed in other topics (i.e., biophysical components of the agro-ecosystem, water resources, and regional skills, among others). Moreover, systems are necessary for providing outcomes in terms of knowledge advancement and scientific and technological development for enhancement of production systems, using a broad concept of information management and universalization of access to developed or adapted knowledge.
Land use, zoning of risks and identification of vulnerabilities, modelling, simulation and design of integrated scenarios
Deployment of the Climate Intelligence Programme for Agriculture should be intensified, in conjunction with the National Plan for Reduction of Risks and Disasters, as provided for in the ABC Plan (BRAZIL, 2012). This Programme incorporates regionally-based climate behaviour studies with development of indices, climate-risk maps, and medium and long-term vulnerability indicators referent to different local, regional and national-level climate-change scenarios to serve as a basis for early-warning systems and contingency plans relating to extreme climatic events and their effects.
Research and thematic areas
Regard the advance of knowledge and scientific and technological development for improvement of knowledge-production systems, based upon a broad concept of information management and universalization of access to developed or adapted knowledge, as an innovative output in itself. Analyses and technical-scientific developments relating to specific themes seek to increase efficiency and resilience of production units and systems, with a view, under biotic and abiotic pressures arising from climate change, to increasing productivity and ensuring sustainable use of natural resources. The following themes are considered priorities for research and technological development projects:

Water resources and use of water in agriculture: Involve development and/or adaptation of technologies for sustainable use and increased efficiency of water use in agricultural production systems, especially efficient irrigation systems; increase abstraction, use and storage of water for agricultural use and reduce rainwater losses (water reservation bill - PL30/2015); promote soil and water conservation technologies in production systems and compliance with restoration and conservation standards for APPs and RLs, avoid pollution of water bodies and promote maintenance of rainwater in the system.

Combat desertification: By means of mapping of sensitive areas and technologies for addressing on-going desertification processes, and strategies for preventing new ones, with established goals and verification by competent agencies;

Pest and disease management: Develop prospective studies on risks of occurrence of pests and diseases as a consequence of climate change, including new management techniques and incorporation of new pest and disease emergence projections, through the Pest Risks Analysis (ARP) system, alongside aspects of animal health and well-being, biological-control strategies, and other approaches with little or no environmental impact.

Genetic resources and improvement: To provide diversity and production alternatives for farmers, a greater variety of species, crops and breeds must be identified, researched and adapted to new climate circumstances and threats. Possible actions involve: strengthening of collection programmes, conservation and sustainable use of genetic resources and plant and animal enhancement, with emphasis on adaptation to the biotic and abiotic factors prevalent in forecast warming and water-shortage scenarios; structuring of the national network of phenotype platforms to streamline genetic research, with a focus on adaptation to address various crops, the geography of Brazilian agricultural species and forests, and establish a long-term network of experiments to identify and quantify the combined abiotic stresses (heat and drought) effects of higher CO2 concentrations and possible interactions with native plant species, in representative areas of the various Brazilian biomes, among others. Such actions must encompass not only activities conducted by research institutions, but also field work and grass-roots initiatives.

Adaptation of production systems for economic, social and environmental sustainability: Evaluate the efficiency, resilience and adaptive capacity of current systems and, consequently, promote their economic, social and environmental sustainability; conduct (attributional and consequential) life-cycle analyses of the main Brazilian agricultural products; evaluate inclusion of production systems in the global production environment from a systemic and agroindustry perspective, taking into account items such as diversification and use of native and natural materials directly related to risk and insurance management, supply chains and warehousing systems, including assessment and prevention of losses and logistics, among others.

Financial instruments: Two major working approaches should be developed, as provided for in the ABC Plan (BRAZIL, 2012). Initially, coordinate with financial agents to attend to the financial demands of the different Brazilian regions and their priorities, in accordance with the mapping/ identification of vulnerabilities. Another important approach is improvement and expansion of rural insurance coverage and of other instruments for prevention and compensation of agricultural climate losses in support of adaptation actions, through integrated and synergic approaches for reducing sectoral greenhouse-gas emissions.

Rural development (technology transfer and technical assistance): An important working approach entails formulation and structuring of models or new rural-development elements that include innovation and transfer of new technological options that promote resilience, adaptation and sustainability in face of the deleterious effects of climate change. This approach is based on strengthening of technology transfers derived from the outcomes of actions proposed in the previous topics, among others. More significant than technology is the scope of this approach, i.e., the tools and information technology transfers that provide means of access to developed and adapted technologies. To this end, the development of user-friendly information systems shoulod be pursued, along with strengthening and restructuring of the Rural Technical Support (ATER) system and training of its technical staff.

Public policies and normative instruments: Adaptation measures should also include development of public policies targeted toward fostering a secure environment, in favour of sustainable development of the Brazilian farm sector, promoting efficiency and environmental, social and economic sustainability of national farm production. These are essential for ensuring food security in face of new challenges imposed by climate change. Current public policies need to be strengthened and, whenever possible, integrated. Discussions on regulation frameworks for payment to the farm sector for environmental services need to be pursued, so that appropriate instruments can be deployed. Among the trends provided for in the ABC Plan (BRAZIL, 2012) is a review of rural insurance, in view of potentially negative impacts of projected climate changes. There is also a need to inform the general public, through awareness-building campaigns, of the contributions of agriculture to adaptation to and mitigating of climate change, and of efforts and outcomes of the adaptation plan, as a means of broadening its acceptance, and also campaigns for promoting consumer awareness.

1.7 Interdependence with other sectors

Maintenance of the productive capacity of Brazil's farm sector directly impacts its capacity to ensure food security for Brazilian society. Warehousing and distribution policies are conditioned by the sector's productive capacity which, in turn, is impacted by the choices and behaviour of consumers (mostly losses). Access to food of sufficient quality or quantity is directly related to sanitary aspects of agricultural systems that have a direct impact on social resilience, and are an essential requisite for public health. The contribution of agricultural systems to health also takes the form of environmental services provided by farms.

The establishment of sustainable production systems contributes to the maintenance of biodiversity. Enactment of the Forestry Code (*Codigo Florestal*) marked a highpoint in efforts of the productive sector to ensure conservation, especially through establishment of Legal Reserve (RL) and Permanent Protection Areas (APPs) that are certain to have a positive impact on maintenance of natural resources, especially water availability. Moreover, related legislation is likely to stimulate the adaptive capacities of the sector. Also of importance are regulations and standards that govern access to genetic resources and research into new cultivars, breeds and productive varieties. Access to the outcomes of such research is of special importance in order to ensure new areas for agricultural development, necessary for maintenance of productive capacity.

The farm sector is highly dependent upon water availability in various stages of the production cycle. It is reliant upon water-resources regulations, abstraction quotas, and licences for storage and sustainable use - including the reuse.

Transport logistics and infrastructure, including the quality of highways and other transport modes, strongly impact farm-sector decision-making, as they affect access to inputs, the cost of moving harvests to markets, the final quality of products and the prices offered to consumers.

Adaptation of the agricultural sector is heavily impacted by and has strong impacts upon other related sectors, including industry, energy, among others.