Supporting the adaptation of the Portuguese agriculture to climate change

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The agricultural, forestry and veterinary research permanently face important and decisive challenges. For the next decades the production of food, feed and fiber need to grow in order to meet the foreseen increased demand. It also has to be able to adapt to the change in consumers preferences and to the new processing and market requirements. At the same time the climate change is an unavoidable reality that obliges farmers and researchers to come forward with suitable technological and innovative solutions for the adaptation of agricultural, livestock and forestry production and systems to the new climate realities.

Apart from the adaptation processes, the mitigation of the emission of greenhouse gases, the increased use of renewable energy and the expansion of the potential of the circular economy, the reduction of food loss and waste are compelling topics to the agricultural research institutions. It is crucial that these issues should be included to their work programs. The change on the climate conditions also brought along new crop, forest and livestock diseases boosted by the increase and the intensification of the globalization process in the recent decades. This new reality has already significant impact on the amount and quality of the supply of these goods.

It is no longer possible to increase the supply significantly by bringing up new productive areas. The intensification seems to be the way out, but the society does not accept anymore the intensification of processes based on the solutions that worked in the past. The growth of the supply was mostly based on techniques with too high non-accepted environmental impacts. Today there is a unanimous opinion that any growth of the supply of food and fiber products should safeguard the environmental impact on the ecosystems.

On the other hand, the consumers and industries require constantly higher quality and safeguard standards. This happens both in the domestic as well as in international markets. It constitutes a strong point for the paradigm for the agricultural and forestry development research nowadays.

At the same time, new technologies should ensure its economic and financial feasibility. Sometimes we refer to it as economically sustainable solutions, meaning the ability that a technological solution has to be adopted and disseminated by farmers in the medium-term so that it ensures a positive and well-accepted level of economic return. A compromise between the environmental impact of a specific technology and its capacity to ensure the economic and financial return should then be ensured.

Briefly, we should be able to produce more, with a higher degree of quality and safeguard, increasing income and reducing costs, ensuring a higher level of efficiency of the resources used, preserving or even promoting healthier environmental conditions for the ecosystems.

This compromise is one of the most complex challenges that the agricultural, forestry and veterinary research is facing today. The outcome of the research should be evaluated by the capacity to create feasible solutions to be adopted by the "real world". Moreover, a sound technology should be the one that contributes positively to the balance of the natural resources used, that preserves or even improves the ecosystems health, allowing conditions to perpetuate their productive potential.

Therefore it is today essential that research projects integrate this compromise since the beginning. It is vital to have around the same table different scientific disciplines. It is also essential that the private perspective should be taken on board, seating farmers and the industry altogether at that same table, at the same time.

The main climate change concerns

The climate evolution in Portugal points out to the increase of general unfavorable production conditions as a result of a reduction of precipitation and the raise in temperature. The rise in the frequency and intensity of extreme weather conditions and the increased susceptibility to desertification in the Southeastern regions are part of the evolution observed in recent years. Winters tend to be less cold. Spring rainfall reduces and autumn rainfall increases. The transitional seasons become shorter, as well. Summer tends to be hotter and longer, with the corresponding increase in the number of continuous hot days without rain.

Among other factors, these new realities and their intensity changes quite remarkably from North to South and from East to West. This heterogeneity is due to the combined climate influences of the Atlantic Ocean from West, the inland of the Iberian Peninsula from East, of the Northern Africa from South and the orographic shape of the country.

Box 1

Concerns regarding the adaptation of the agricultural sector to climate change

Arable crops:	Diversification of cultural systems and promote the balance of crop rotation. Conservation techniques and soil protection. Monitoring the health and growth stage of the crop. Genetic improvement, definition of technical itineraries, environmental impact and protection of soil. Dissemination of irrigation techniques.
Horticulture:	Adoption of systems and efficient irrigation practices and integrated production systems. Adjusting technical itineraries and extending the production cycle. Adoption of best varieties adapted to heat and water stresses. Conversion to protected culture systems. Development of new adapted varieties. Strengthening the use of environmental control equipment in protected crops. Relocation of production. Balancing crop rotation.
Olive oil:	Adoption of regional, local and arid regions varieties resistant to rising temperatures and drought. Adaptation of cultural practices: deficit irrigation, fertilization, pest control, pruning. Prediction of the onset of disease. Preservation of intervarietal and intravarietal biodiversity and genetic improvement.
Wine:	Optimize and reduce water consumption. Health monitoring and prediction of the emergence of new pests and diseases. Adaptation of oenological strategies adapted to the new features of production. Relocation of production. Installation of more resistant to water stress grafts. Classification of vine varieties regarding maturity groups and in terms of the growth cycle. Adaptability of varieties obtained from warmer and arid geographical origins.
Fruit:	Diffusion of species, cultivars and rootstocks resistant to drought and other stress factors. Adoption of the most appropriate cultural practices of soil protection and management. Increasing the efficiency of irrigation and adoption of deficit irrigation practices. Testing of anti hail net, anti scald and shade nets Adoption of hedges to reduce wind speed effects. Effectiveness of sun protection products of the fruit in different species.

Source: Adapted from "Strategy of adaptation of agriculture and forestry to climate change", Ministry of Agriculture, Lisbon, 2013 (Portuguese only)

The combination of the diversity of production systems and its distribution along the territory, the difference of expected regional climatic evolution does foresee the occurrence of multiple and varied effects of climate change. However, actually there are some general main concerns due to the amplitude and the combined effects of those phenomena, promoting the degradation of the productive conditions and social habitability of large areas of the territory. The impact of this process can be huge for the activities located in these areas. For example, regarding forestry ecosystems, more than one half (about 60%) of the forest area is located in areas of greatest susceptibility to desertification, with special incidence of the settlements of holm oak, cork oak and stone pine.

Climate evolution of the last decades has resulted in the widening of the areas susceptible to desertification and increased dramatically over the last decades. The process of desertification represents a vulnerability that could worsen in Portugal as the expected reduction in rainfall becomes more pronounced mostly in regions that today are already susceptible to desertification. In such a process the actual low level of soil fertility and the high risk of water erosion will be aggravated.

In these cases the adaptation of agriculture and forestry to climate change and the combat against desertification process represent the two faces of the same coin. This is already a rather complex issue but we have to add to this the problematic of regional development associated to the aging and depopulation we witness in the most affected areas.

Box 2

Concerns regarding the forestry sector and climate change

Breeding and plant health:	Continuity of the breeding program for high-productivity plants dedicated to the regions that maintains or increases production capacity; launching a new breeding program specifically adapted to the regions of lower future production ability. Development of soil quality recuperation techniques. Strengthen the resilience to biotic agents. Improve the monitoring and control of diseases methodologies. Identifying the causes of the oak decline and integrated forms of protection. Availability of approved plant protection products suitable to biotic agents of main impact.
Forest fires:	Resilience of different composition and structure of forest to the change of fire regime. Improve the knowledge about the causes of occurrence of forest fires and fire behaviour. To develop innovative fire management practices.
Forest management:	Develop policy instruments which allow overcoming the constraints associated to the high level of fragmentation of property, adapted to small farms Preventing the abandonment of forests, promoting the diversification of production and income and increasing the resilience of ecosystems. To disseminate active forms of management of forest areas.
Inland waters:	Impact of the dispersion of alien and invasive species. Changes in the eutrophication process in water bodies and degradation of its ecological status. Developing techniques of bio manipulation as an eutrophication control tool, improved fishing value and the ecological status of water bodies.

Source: Adapted from "Strategy of adaptation of agriculture and forestry to climate change", Ministry of Agriculture, Lisbon, 2013 (Portuguese only)

The main short-term critical factors for agriculture to adapt to the climate change are related with the capacity of the production systems to become more resilient to the consequences of the increased climate variability (see some examples in Box 1 regarding agriculture and Box 2 regarding forestry). The effectiveness of the installed irrigation capacity, keeping soil fertility conditions, preventing the erosion process to be installed and the risk management to face to extreme weather events are important elements for this adaptation process. In addition, the new weather conditions favor the appearance of new harmful organisms to crops, forests and animals introducing or aggravating imbalances in the ecosystems. Some of these new realities can even induce the emergence of public health problems.

The capacity of ecosystems to adapt to the new weather conditions and the capacity of farmers to redesign their production systems are the key factors for the future of the agricultural sector in the medium and long term. To address the complexity of these issues, a good coordination between central and local institutions is needed. An active participation of both the scientific and civil society communities is essential.

During the last decades the climate change became an important element of the public policies in Portugal. Many discussion fora have been working in this area and in the framework of the Paris Summit a second governance structure for the "climate change policy" is in place. It includes three standing committees for Agriculture, Forest and Biodiversity. They aggregate a quite large number of experts, from private sector to the administration, representatives of central and regional authorities and relevant scientific institutions. Portugal is also an active partner in the international fora.

The INIAV's approach

INIAV congregates all the research capacity on the agricultural, forestry and veterinary areas of the Ministry of Agriculture. It has also the responsibility for the conservation and valorization of the national genetic resources and the support to the national and EU policies on food security, food safety and animal and plant health. It is the National Reference Laboratory for these areas. The plant and animal gene bank and other reference collections and the associated technical knowledge constitute important assets of INIAV as well.

They contribute to its strategic position to undertake applied research initiatives in many different fields. It has a quite extensive institutional work program, supported by several regional research infrastructures and laboratories distributed all over the country, allowing a deeper regional and value chain integration in its activity.

The organization of the research undertaken in recent years at INIAV followed the most common model: a work program composed by a cloud of atomized and independent short-term research projects, conceived as a result of independent initiatives of its internal or external promoters. Usually the project team has a low degree of differentiation of the scientific disciplines involved. Projects usually focus on rather specific issues.

This type of project should always exist in the research institutions. Although it is considered that a research program on climate change has to incorporate projects with larger horizons of action and with a stronger integration and differentiation of scientific disciplines. They should also be focused on a "problem solving" type of approach, defined according with the view of those who could have a direct interest on the adoption of the outcomes.

INIAV's research teams always include partners from other scientific institutions and representatives of the private sector are commonly involved. This is considered to be a very positive and balanced composition of the research teams.

The research more directly linked to the climate change undertaken by INIAV in recent years focused on the technological development and innovation in production and processing, the sustainable management of natural resources and the ecosystems and biodiversity management (INIAV, 2015). Between these areas there are quite strong interactions that lead to the interest on launching a gradual process of integration of the research initiatives.

The ongoing strategy to adapt the research work program is based upon the following axes:

- The coexistence of complementary scientific disciplines, covering a wide range of areas of expertise;

- The existence of a remarkable genetic heritage and collections built up over decades, associated with resident relevant technical and scientific skills;

- The coexistence of a network of reference laboratory infrastructures, covering a large set of scientific areas in the agricultural, forestry and veterinary fields;

- The existence of decentralized research stations and experimental farms, creating favorable conditions to the promotion of the integration of field and environmentally controlled work;

- These structures are taken as proximity structures to the regional economic agents, creating conditions to an easier establishment of working partnerships adapted to the applied research on targeted concrete issues; in some cases experiments are undertaken at the private partners premises;

- The central and decentralized structures are equipped to allow the development of a flexible knowledge transfer program, increasing on-farm and farmer-to-farmer type of information transfer regarding innovative research outcomes directly linked to innovation;

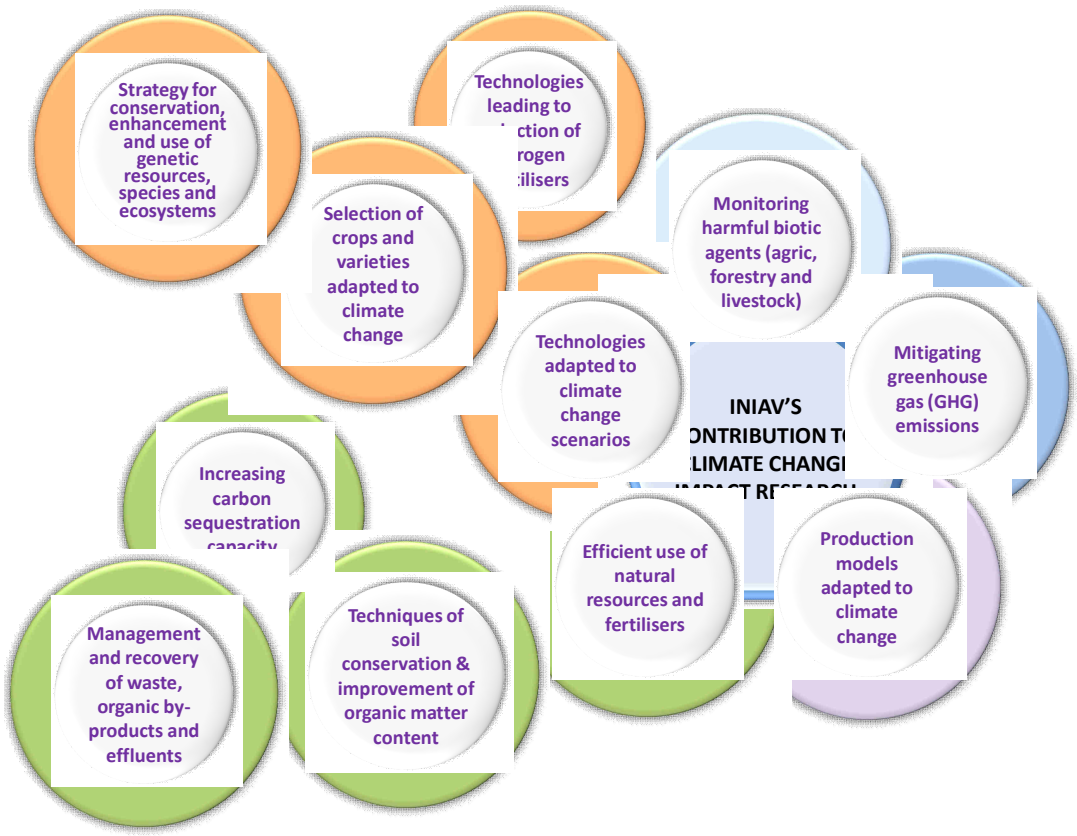
- The promotion of a deeper integration of the research work program with universities and laboratories regarding high technological research dedicated to specific technological innovation, complemented by a national wide network of experimental fields evolving different types of institutions dedicated to regional development issues in the framework of a common work program;

- The promotion of a higher level of integration of the work plan with different regional realities, from arid and semi-arid Southern regions up to Northern regions of the Mediterranean, sharing expertise and knowledge and testing adapted technological solutions.

Key research areas

The design of the research program is based on five research areas: the development of technologies adapted to climate change scenarios, the promotion of a more efficient use of natural resources, the monitoring of harmful biotic agents, the mitigation of greenhouse gas emissions and finally the research on farming systems adapted to climate change (see Figure 1).

Figure 1
Initial thematic decomposition of the research program on climate change



Several areas of special pertinence are identified. The conservation, enhancement and use of genetic resources, species and ecosystems was considered to be the key activity that should be safeguarded to allow the selection of crops and varieties adapted to the new climate conditions. Lowering the use of nitrogen fertilizers is an important element for the type of technological development. The balance of nitrogen and salts in the soil, the decrease in dependence of nitrogenous fertilizers, the biological fixation of nitrogen achieved through the symbiosis between plants and bacteria and the use of bio-fertilizers in grass using micro-organisms that promote plant growth and health, are the examples of ongoing technological research work in this domain.

The second case refers to the efficient use of natural resources. The management and recovery of waste, organic by-products and effluents and the increase of the carbon sequestration capacity are research topics that conduct to the development of techniques of soil conservation and improvement of its organic matter content.

The third area refers to the prevention, fight and control of new diseases of plants and animals and to the weed chemical and bio control technologies. Apart from the research of already established health problems, there is continuous work to be done to prepare new pests and disease emergence and to identify the most suitable control techniques. Pests and diseases that usually had a secondary role tend now to become major health concerns. In this field it is also important to be able to monitor the geographical distribution and incidence of the most important pests and diseases considering different scenarios of climate change.

On the mitigation of greenhouse gas emissions the work program established as a priority the research on livestock emissions. It includes the study of the most important origins of this type of emission, the metabolic responses related to environmental temperature changes, conducting experimental controlled studies to obtain additional amounts of methane enteric emissions mitigation. The improved digestive efficiency and the study of alternative food for mitigation of emissions of greenhouse gases is one area of study that is currently under development.

Finally, there is a great interest to develop the capacity to move from the activity-based research to a farming system approach. This is a quite complex area of study that requires the availability of specific adherent and feasible data that still has to be improved. Nevertheless, the study of the impact of drought periods on the structure and income level of both intensive and extensive production systems is needed. The development of a standardized assessment of the ecological footprint of the main agricultural production systems could be a relevant step forward to better understand the expected behavior of the farming systems. This could allow the identification of political measures to promote the adaptation of those systems to more suitable environmental impact.

This initial design of a research program should be viewed as a first step and it is expected that it will be shaped accordingly with other research initiatives. The plasticity of its shape is a main element of its conceptualization.

The timeframe that is necessary to develop feasible results in the research on these domains is unavoidably long. The common "three year projects" are not adapted to the majority of the cases. Due to biological constrains, the study on the reaction of plants, animals or ecosystems to different weather conditions requires long periods that overpass the logics and the rationale behind the financial support policy programs dedicated to research. The development of a new variety of an annual crop, resistant to a certain disease or adapted to a probable level of lack of irrigation requires at least 6 years. After such a period we still have to do some extra work to ensure or confirm the outcomes. If we move to the fruit, olive or vineyard sectors the timeframe increases significantly. The study of forestry and agro-forestry ecosystems needs even longer periods of time.

Due to these reasons the financial support of a research program on climate change and agriculture should be adapted to those biological conditions. There is no unique solution to this problem. The funding of such a work program has to ensure a wide range of financial sources, using each of them in the most appropriate circumstances.

This is a quite exigent framework, as it needs a multiple coordinated actions with very different partners and sponsors. The achievements are most of the time independent on from one another and the financing inflow are obtained within different time lags. This means that a step-by-step type of approach and a high level of flexibility are needed to build such program.

Final remarks

The importance of the agricultural and forestry sectors to the Mediterranean communities, the strategic importance they have regarding economic and social development, boosted the societal concern about the persistent changes of the climatic conditions observed in recent decades. The scientific community should be able to improve the effectiveness of the efforts regarding the resilience of agriculture and the rural societies to those changes.

This improvement could be achieved by the combination of different factors. At a Mediterranean level, an international higher coordinated approach of the national research work plans could allow benefits for the countries involved. The complementary of scientific and technical knowledge and experiences would allow a better understanding of the process in its multiple sheds. The Mediterranean region is a "living laboratory" where several climatic realities and societies highly dependent of agriculture and forest co-exist. It should be noted that there is an important dependence of food imports in this region too.

The case of Portugal is somehow paradigmatic due to its climatic diversity as pointed out above. Its relevant experience in the development of adapted technologies to new climatic conditions could be enhanced and enlarged if it integrates and shares its working plan with other Mediterranean research institutions.

This can be seen as a way to adapt the scale of the resources to the scale of phenomena that represents a common major concern. The approximation of the existent "knowledge capital" and of the work plans at the highly qualified research structures disseminated around the Mediterranean can positively contribute to develop a shared scientific effort to better face the complexity of a common challenge.

An increase on the level of integration of the research projects is also recommended in order to handle the higher level of complexity of the object studied. Climate change is a multifaceted societal issue and a societal approach should then be considered on the organization of the research activity. This leads to a greater interest to incorporate the views of the beneficiaries in the research strategy definition as well as in the composition of the research teams.

The commitment of both private and scientific communities on medium term research programs and on its interim periodic evaluation could have a very positive influence to the increase of the effectiveness of the research investment at medium term. It will tend to increase the problem solving perspective of the projects ensuring a better capacity of the outcomes adoption.

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