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New Challenges for Agriculture within the Context of Climate Change

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Abstract. *Recent evolutions of the natural environment launched a number of warnings regarding the sustainability of economic growth and development. The boldest threat is the one of climate change that is foreseen as a catastrophe unless urgent action is taken in both directions mitigation and adaptation. Agriculture and food production are amongst the most important variables shaping the prospects of society for centuries. Their status was determined always by natural factors but recently the impact of economic factors is more influential. Therefore climate change is about to create important economic challenges for agriculture that call for guidelines, support, and initiative to enact changes needed for emission reduction and more importantly for increasing the adaptability of farms in all regions while preserving and improving the wealth of farmers. The paper provide a synthesis of climate change impact along with a brief review of adaptation measures already enforced and discusses the innovative solutions for adaptation that could be employed for the financial management of farms.*

Keywords: climate change, agriculture, crop insurance, weather index.

JEL Classification: O13, Q10, Q54.

Introduction

Availability of food is one of the most important drivers of development for civilization. Progress in agricultural technologies created the premises for increasing food productivity above the level provided by natural ecosystems and released the time needed for other occupations. More productive agriculture was more developed the respective community became. The recent history witnessed an important leap of food production able to support an unprecedented growth of population. Meanwhile, the availability of food mirrors more the potential for profit making from production, processing and distribution than on the production potential of agriculture. This novel structure of drivers allowed huge gaps to emerge between nations for that food is available in quantities beyond their needs and nations for that there is not enough food to acquire.

Despite important improvements of technology that increased agricultural productivity the competitive economic context canceled most of the farmers' gains by continuously narrowing their profit margins. Within the food value chain the lowest profit margin is the one of the farmer who is further pushed to increase productivity (Bran et al., 2012). This results in a continuous quest for using the best available varieties and finding the spots where climate and soil conditions allow production maximization. Farmers' ability to obtain profit depends on the fine tuning between the needs of the variety and the patterns of the environment. Therefore, any change, even small, of the climate or soil conditions although will not result in large losses of productivity will remove the profits to be obtained from production.

Climate change is a complex phenomenon that benefited from an increased attention in the last decades or so. Currently there are available detailed studies on how it is occurring, which are the causes, how the consequences will impact on humans, including the analysis of the economic and social impact made sector by sector. Nevertheless, farmers' still lack accurate predictions of weather patterns and even long range forecasts regarding the evolution of climate factors that influence their crops. Most of the farmers being at the edge of their profit margins are often reluctant in making investments that improve the resilience of their holdings toward the impact of the changing climate and prefer to be reactive addressing the weather related challenges as they occur.

A better understanding of the nature of climate change challenges faced by farmers is needed for improving the design of support measures. It is of outmost importance to focus on the economic dimension of this challenge since food production although is strongly relying on the natural environment is eventually the result of the interplays occurring within the value chain of food products. Departing from this observation we approach the climate change challenges for agriculture by explaining how farms' economy is altered by it and at what extent current support measures help farmers to improve their capacity to adapt, but also to reduce their carbon footprint.

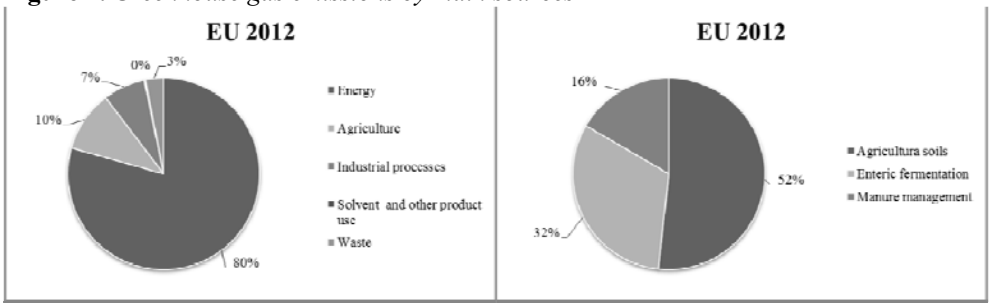
Agriculture and climate change – causes and consequences

Agriculture borrowed a number of patters that are specific for industrial production, but remained tributary to some natural processes. Machinery increased the productivity by reducing the time and effort needed for soil preparation; maintenance of crops; crop protection; harvesting, conditioning, storage, and processing of yields. Varieties developed by more and more refined genetic engineering techniques enhanced productivity of plants and animals and increased the quality of yields. Despite all these progresses, known as the green revolution, some processes cannot be altered: food products are the result of biological processes and depend on the ability of managing plants and animals in given weather conditions. Further, a high level of productivity cannot be maintained for long ranges for all crops in all agricultural regions because basic resources like soil and water became less available. These include the delayed consequences of climate change too.

Agriculture is both causing and being affected by climate change. It is more difficult to state at what extent the contribution to climate change equals its negative consequences for agriculture. Agriculture could be considered the second cause of climate change and the first to suffer from it, but there is no common ground to make this comparison. From a pragmatic point of view such analysis is not even necessary since both causes and negative consequences should be minimized. A strategic approach will consider first the technical solutions that contribute in both directions. In this respect it is relevant to reveal how agriculture is a cause of climate change and what is the nature of climate change's negative consequences for agriculture.

Since climate change is the result of growing concentration of greenhouse gases in the atmosphere the cause is usually identified as an emission source and is evaluated by calculating the net emissions of greenhouse gases.

Figure 1. *Greenhouse gas emissions by main sources*



Source: representation of UNFCCC data.

According to the bulk of the studies reporting in this field agriculture's main emission sources are: the use of nitrogen providing chemical fertilizers and livestock of cattle and other ruminants (by enteric fermentation). As long as the size of emission is regarded, based on data reported for the EU in 2012, with a share of ten percent out of the total, agriculture is the second largest contributor after the energy sector (Figure 1). Within the sector most of the greenhouse gas emissions are released by agricultural soils (52% out of the total net emissions of agriculture).

Agriculture is also an economic sector that should consider consequences due to climate change. The most common challenge is to prevent the losses caused by climate and hydrologic hazards like drought, flood, heat/cold waves, heavy snow/rain fall, and others. Estimating these consequences in quantitative terms is hindered by their unspecific nature. Thus, natural hazards caused by climate change are not different from natural hazards in general. The estimation of losses caused by natural hazards could be used instead, although these results should be interpreted carefully if climate change impact is to be captured.

For instance in the southern plains of Romania, drought is a phenomenon that occurs on regular basis and in various years farmers are experiencing severe losses. However, it is difficult to appreciate at that extent these are the consequences of climate change.

Most studies approach this subject matter by referring to the hypothesis of increased frequency and intensity of natural hazards. Taking this supposition as premise, there are built scenarios that could support adaptation strategies in different local contexts.

Climate change caused economic and ecologic challenges to be faced by farmers

Climate change is a physical phenomenon that could impact on agriculture since it is deployed in open field with limited control in many environmental factors such as light, moisture, soil fertility, temperature etc. Climate change is also an important public concern that is addressed by specific policies, strategies and governmental programs. Since agriculture is an important emission source, there are challenges rising from these programs too.

The economic challenges to be faced by famers due to climate change could be outlined by referring to indicators such as farmers' income and farm vulnerability. The ecologic challenges instead could be pictured by considering the main changes of environmental conditions that might have impact on the crop yields.

The economic challenge caused by climate change for farmers was far less investigated ecologic challenges, because the actual economic situation of farmers although depends on a great extent on the size of their crops it is also influenced by many other factors. Moreover, high crop yields are seldom indicative for a proportional level of incomes. For instance, in very favorable years, the large supply of a certain agricultural product leads to lower prices. Thus, farmers' income depends more on their capacity of negotiation then on the size of their yields, which is further related to storage facilities and other endowments.

An early study performed to assess the double exposure of agriculture to climate change and globalization launched a warning that in agriculture adaptation at farm level could be hindered by the liberalization of economic policies. Thus, famers could face a more difficult access to financial resources needed to use drought resilient varieties (O'Brien and Leichenko, 2000).

According to Antle (2009), the economic impact of climate change at farm level could be estimated by creating a model of the farm business that should consider the financial condition of the farm as a function of production income. Other aspects to be computed by

such a model are debt structure; use of financial management tools like futures markets, crop insurance and agricultural subsidies; and nonfarm income. An assessment undertaken in USA revealed that farm failure rates are lower than other failure rates (Antle, 2009).

Reidsma et al. (2010), by performing an assessment on European farms, conclude the followings:

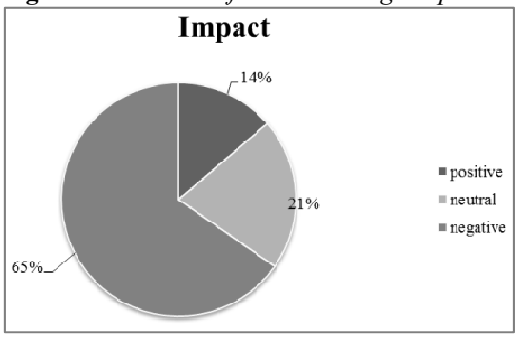
- The impact on crop yields is not directly linked to the impact on the farmers' income, because farmers react to variable conditions by changing crops' structure, inputs, and because the incomes are also influenced by subsidies.
- The actual impact of climate change on farmers' income depends for a great extent on the characteristics of farms such as intensity, size, endowment, lad use etc.
- Management and adaptation could have a significant role in reducing the impact of climate change on both crop yields and farmers' income.

It could be concluded that the economic impact of climate change on farmers could be properly assessed by constructing a framework that allow to capture the influence of crop yields on the economic performance of farms

Far more focus was granted in assessing the impact of climate change on crops by relating various changes in climate factors to a variety of crops. These studies were performed at different scales being often related to food security. Further we reveal some results that highlight how farmers perceive the threat of climate change.

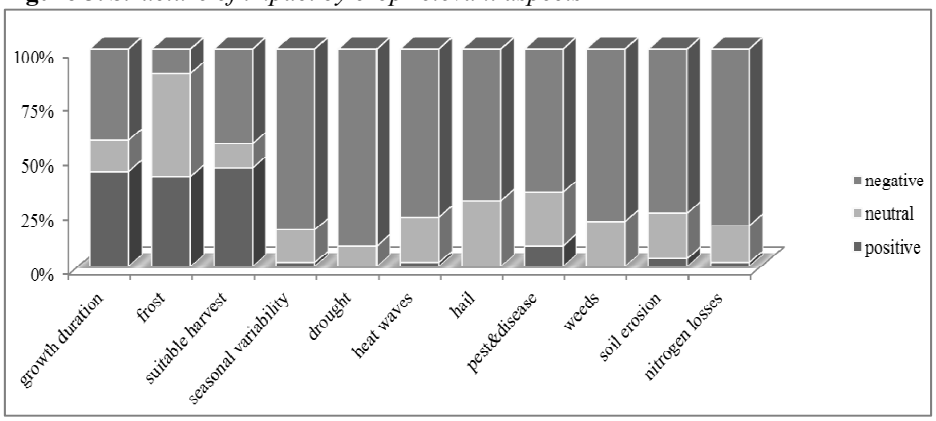
Olesen et al. (2011) reveal how farmers perceive the impact of climate change on their crops. The survey examined the opinion of farmers for the following crops: winter wheat, spring barley, maize, grassland and grapevine. The aspects considered to assess climate change impact are: growth duration; overwintering; frost; suitable harvesting; drought; heat stress; hail; pest and disease; weeds; soil erosion; and nitrogen losses. The overall impact could be considered negative (Figure 2), although the benefits of warmer weather could outrun other damages, as it the case for maize. The negative impact is much larger than the positive or the neutral one for factors such as seasonal variability, drought, heat waves, hail, pests and diseases, soil erosion, and nitrogen losses. Larger positive impact was recorded for growth duration, frost, and suitable conditions for harvesting (Figure 3).

Figure 2. *Structure of climate change impact on crops by the type of the impact*



Source: representation of results provided by Olesen et al. (2011).

Figure 3. *Structure of impact by crop relevant aspects*



Source: representation of results provided by Olesen et al. (2011).

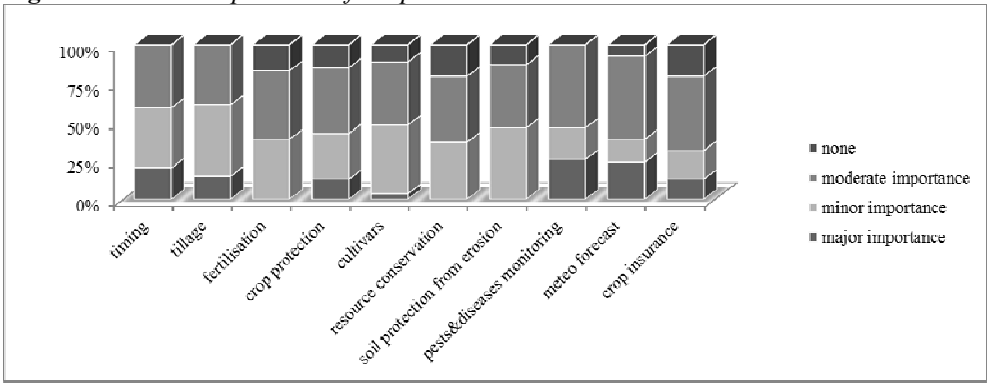
The physical impact of climate change on crop yield should be assessed by taking in account two timeframes: short term impact and long term impact. The short term impact of climate change resembles with the one of climate variability and is considered manageable by most of the farmers who are accustomed with such events. On the other hand, the long term impact raises novel concerns since reactive measures applied only at farm level cannot compensate the persistence of lower productivity for many seasons. Such effects could be addressed by changing the structure and even the system of production, having access to irrigation infrastructure, and financial support schemes that compensate for both lower productivity of crops and funds needed for investments. For instance, in Romania, the adaptation to climate change in the Bărăgan Plain, one of the most important agricultural areas, necessitates a significant improvement of the irrigation infrastructure (Sima et al., 2015).

Adaptation to climate change in agriculture by financial measures. Case study: crop insurance

The short term impact of climate change on agriculture does not create serious financial issues for farmers, although there is acknowledged that the vulnerability of farms could vary greatly as function of a range of variables that include position, crop structure, market access etc.

Building on the premise that sooner or later climate change will impact by production losses serious enough to threaten the income of farmers, they should be more careful in providing a proper financial management. It could be of relevance to add that farmers focus mainly on preventing the physical impact of climate change than on the financial management of the potential losses. The results of the survey applied by Olesen et al. (2011) show that more farmers consider of major importance pest and disease monitoring (14%), meteorological forecast (13%), and timing (11%) than crop insurance (7%). However, 26% of farmers perceive crop insurance of moderate importance (Figure 4).

Figure 4. *Relative importance of adaptation measures*



Source: representation of results provided by Olesen et al. (2011).

According to Smit and Skinner (2002) the financial management that could improve the resilience of farms against climate change by reducing the risk of income loss will consist in:

- Crop insurance: more specialized crops and farms with low off-farm incomes are most likely to use this measure;
- Crop shares and futures: involves the use of securities, shares, and other financial options;
- Income stabilization programs: such programs are developed usually by governments in collaboration with professional associations;
- Household income diversification: is not a climate change specific reaction, although it could have an important role in mitigating its impact.

According to Anton et al. (2013), there are three types of crop insurance:

- individual and multi-peril yield insurance;
- area-yield;
- weather index.

Individual yield insurance addresses the losses caused by a single type of climatic hazard. The insurer makes the payment after a careful assessment of the observable yield losses. The most common insurance of this type is against hail. The multi-peril yield insurance addresses more climatic hazards. It is uncommon in the range of private insurance because the assessment of losses is too expensive due asymmetric information that increases the risk of adverse selection and moral hazards. Nonetheless, such insurance is available within governmental programs. Since climate change could modify the distribution of crops and the likeliness of risks, the administrative costs of multi-peril yield insurance could prevent their availability even for governmental programs.

The area-yield crop insurance uses the aggregate yield of a certain area to calculate premiums and payouts. In such system could participate more farmers and each will pay/receive similar premiums and payouts. The system avoids the verification of farmers' production histories, using instead information of the area-yield that is easily available. Against the climate change challenge, this type of insurance contributes as incentive to adaptation.

An innovative approach for crop insurance is the so called index insurance. In this system the payouts are made based on a meteorological index correlated with agricultural losses. The main novelty is the fact that the system considers calculated losses instead of using observed losses. In calculating the index it is selected a climate parameter that exhibits the strongest correlation with the size of the yields. The most common parameters are temperature and rainfall.

Its benefits consist in reducing the moral hazard, adverse selection, and avoiding the high cost of verification. The main issue of weather index insurance is that it provides a flat payout that would not cover some basic losses caused by climate variability. This and other drawbacks of the system could be reduced by improving the indices then meteorological data are not readily available, associate insurance with other services, correlate indices with agricultural systems (Vermeulen et al., 2012).

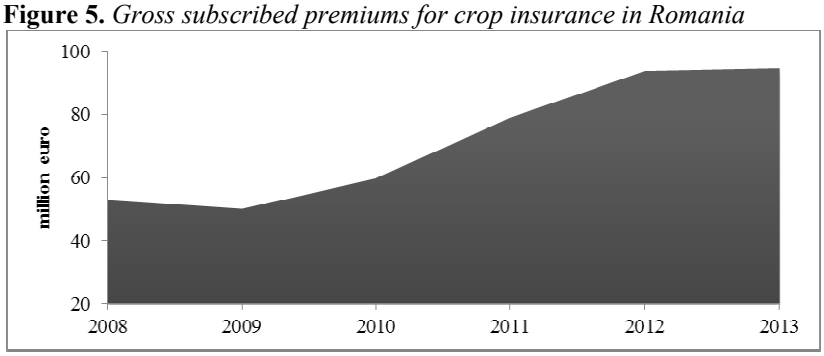
The system was developed for addressing the needs of the most vulnerable farmers from developing countries who face not only income loss, but also famine and who otherwise would not have access to insurance due to the lack of financial resources. Nevertheless, it is currently applied in Canada, Australia and Spain too (Anton et al., 2013). Meanwhile, the European Commission also assesses the possibility to use such weather index insurance, which is considered appropriate for the critical public infrastructure (EC, 2013).

Crop insurance in Romania has a long tradition because climate variability created yield losses all along the history. Most of the field area of Romania, where cereals are the main crop, has a temperate continental climate that accustomed Romanian famers with drought and dryness for long ago. As contrasting with this tradition is the current state of private agricultural insurance. According to recent assessments this represents only 2-3% of the insurance market (Nan, 2014), its development being hindered by the incidence of common crop insurance preventing factors (moral hazard, adverse selection), but also specific ones, like the followings:

- crumbing of land property;
- lack of agricultural consultancy and extension services;
- lack of support on the behalf of government and banks;
- low performance of agricultural holdings in terms of productivity;
- high proportion of elderly population in rural labor.

Despite these drawbacks, the market of crop insurance is covering around 30% of the crops (UNSAR) and is predicted to grow providing more options for farmers to manage the impact of crop yield loss.

Figure 5. *Gross subscribed premiums for crop insurance in Romania*



Source: representation of UNSAR data.

The total volume of premiums subscribed for crop insurance reached almost 100 million euro in 2013 (UNSAR, 2013).

Further, more and more studies point the opportunity of adopting innovative crop insurance solutions, the use of which could overcome the main barriers in this sector (Nan, 2014; MADR, 2014; Mitu, 2007). Thus, in Romania the data needed to calculate weather indexes is available since the National Meteorological Administration operates in 159 stations and keeps historical records of daily and monthly meteorological data since 1961. These data allow calculating heat, drought, rainfall and mixt indexes. The Ministry of Agriculture and Rural Development also investigates this possibility and a model of how the weather index insurance could be applied is already designed (MADR, 2014).

Conclusions

Agriculture is the economic activity with the longest history and that have an influential impact on the development of civilization and accumulation of wealth. Nonetheless, agriculture also carries the burden of low value added. In contrast with the technological progress that supported unforeseen increases in productivity, agricultural value added did not grow. On the contrary, it has shrunken and within globalization the profit margin of farmers continues to become narrower. Climate change is one of the greatest environmental threats to be faced by humankind that could unleash catastrophic events with unpredictable evolutions. Agriculture is in the forefront of economic sectors and has to face directly the adverse weather conditions that will accompany climate change.

Considering the economic context and the productivity loss it was questioned how farmers could manage the impact of climate change. More focus was given for the financial management of farms and how crop insurance might improve their resilience. The physical impact of climate change and the technological adaptation measures are well known in both theory and practice. Farmers prove that they are aware about climate change and that they have a range of solutions to address most of them. Less well explored is the economic impact of climate change on farm level. This impact is considered manageable, although farmers' vulnerability ranges between wide limits.

Crop insurance is one of the most traditional and widespread financial management measures that could be employed by farmers. Nonetheless, traditional insurance products like individual yield or multi-peril yield prove to have costs that are two high to be afforded by the most vulnerable farmers. Moreover, area-yield type insurance although could reduce costs, in case of extreme weather is too expensive even for governmental programs. A great deal of expectation is related to the so called weather index insurance that was initially designed to support farmers from developing countries. This is also true for the Romanian market of agricultural insurance, although it is in a very early stage and consists only of traditional crop insurances.

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