

Food and sustainability challenges under climate changes

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Abstract

Plants are permanently impacted by their environments, and their ability to tolerate multiple fluctuating environmental conditions varies as a function of several genetic and natural factors. Over the past decades, scientific innovations and applications of the knowledge derived from biotechnological investigations to agriculture caused a substantial increase of the yields of many crops. However, due to exacerbating effects of climate change and a growing human population, a crisis of malnutrition may arise in the upcoming decades in some places in the world. So, effective, ethical and managerial regulations and fair policies should be set up and applied at the local and global levels so that Earth may fairly provide the food and living accommodation needed by its inhabitants. To save some energy consumption, electric devices (for e.g., smartphones, laptops, street lights, traffic lights, etc.) should be manufactured to work with solar energy, whenever available, particularly in sunny countries where sun is available most of the time. Such characteristic will save energy and make solar energy-based smartphones and laptops less cumbersome in terms of chargers and plugging issues.

Keywords: climate change; food crisis; human population growth; environmental stresses; abiotic stress; biotic stress; sustainability; environmental sustainability; food production; plant breeding; sustainable energy; renewable energy.

The vital needs of humans and animals (food, oxygen, clothing and shelter) are definitely based on, or associated with, the immense diversity of plants on Earth. Plants, in turn, are permanently impacted by their environments, and their abilities to tolerate fluctuating environmental conditions largely depend on plant varieties, growth stages, stress period and intensity. Over the past few decades, biotechnological progress and scientific innovations such as the development of extensive and economical irrigation methods, the use of fertilizers and pesticides and the application of biotechnology knowledge caused significant increases in the yield of some cereal crops. However, due to exacerbating climate change, deforestation and a growing human population, a possible critical food and malnutrition crisis may arise in the upcoming decades, at least in some places in the world. Anthropogenic activities, unsustainable practices and irresponsible management of food and natural resources are part of the cause. The desertification of cultivable lands will worsen and climate change will threaten biodiversity in Europe ([Araujo et al. 2011](#)). Balancing the

use of land and water while conserving biodiversity will be an important scientific and public challenge, too ([McLaughlin 2011](#)).

The preference of the youth for office-based technology jobs at the expense of agriculture and field works might be another hindrance to alleviating the challenge of food production. As such, there is an urgent need to set up genuine and efficient solutions to sustain environmental resources and to feed growing human populations. To avoid mass hunger, global food production should be doubled by 2050 ([World Food Programme 2009](#)). However, under the pressure of unpredictable and uncontrollable climate change, the production of food of an acceptable quality and quantity will be challenging for scientists, farmers and policymakers. The remedial solutions are not necessarily only technical, based on techniques and scientific approaches only, but also include a panel of efficient policies, smart management, human cohesion, and, most importantly, a reduction of food wastes that represent a considerable percentage of food losses annually. The costs of household food wastes are particularly substantial in developed and developing countries. For example, a loss of food of about \$165,6 billion per year was estimated in the USA ([Buzby and Hyman 2012](#)) and about US\$2,7 billion in South Africa ([Nahman et al. 2012](#)). At a global level, about one third (~ 1.3 billion tonnes) of the food produced worldwide gets lost or wasted annually, according to a recent report by the Food and Agriculture Organization ([FAO 2011](#)). Such considerable losses are due, at least in part, to insouciant consumer behaviours and a lack of efficient infrastructure and coordination between different players in food production, conservation, and consumption chains. Food losses may also be caused by endemic plant diseases (animal, bacterial, viral or insect infestations), difficulties in food distribution, and corrupt practices of traders and bandits.

To remedy these issues, a combination of old and new approaches should be an integral part of the solution. An effective application of biotechnology advancements for breeding new plant species irrigable with seawater ([Moustafa 2015](#)) and adaptable to environmental fluctuations is of primary importance to increase plant productivity and ensure sustainability ([Moustafa 2015](#)). Although debates on genetically modified crops still divide opponents and proponents of sustainable development, efforts should be expended to engage a rational dialogue on the acceptance of biotechnology applications ([von Grebmer and Omamo 2007](#)) and eventually change the public stereotypes of genetically modified organisms (GMOs) that could offer a worthwhile contribution to sustainable agriculture and food supply ([Raymond Park et al. 2011](#)). Regionalism is another effective approach to promote resilience and decrease dependence on external variables such as the long-distance transport of food, and to increase internal capacity to withstand natural and man-made disruptions ([Ruhf 2015](#)).

Fair procedures and policies should also be applied to ensure equal food distribution and economical conservation. It would be crucial to opt for a sustainable production system with regard to the environment towards reducing waste in food, water, land and energy. To

diminish food losses, tax legislation on food wastes/wasters could be applied to deter consumers from wasting. In particular, food authorities could impose 'waste taxes' that can be applied to food wasters in their establishments. Consumers could thus be seen paying a 'waste tax' proportional to the food they waste when they eat their meals or take away the uneaten food home, or distribute it to poor people or animals farms. The benefits of such a policy are several for the consumer and stakeholder, helping to (1) save costs and reduce the impacts of food and related-industrial wastes on the environment, (2) help reduce efforts and costs spent by public authorities on waste management, (3) reduce hunger issues and increase tax benefits (5) save recycling and cleaning costs and energy, and (6) save some food costs for the consumer themselves. The introduction of comprehensive environmental and ecological ethics when dealing with environmental resources could also have multiple benefits at environmental, ethical and political levels ([Crozier and Schulte-Hostedde 2015](#)). At worst, the wasted food can be used to feed animals rather than being burnt or thrown out.

The management of water is of a great concern because the risks of both water scarcity and flooding are likely to increase under climate change in the upcoming decades ([Doorn 2015](#)). To reduce water and energy wastes, most, if not all, light and water sources in public and private establishments should function with ON/OFF auto-switchable devices that turn the water and energy sources on and off according to needs. In agriculture, using the trickle (drip) irrigation systems that rely on porous pipes with small bleed holes that run alongside the creeps and deliver water slowly and directly to individual plants is an efficient way to save irrigation water. Modern urbanism might need to be deeply rethought resulting in more energy conserving buildings. Photovoltaic panels can be generalized for homes, private and public buildings and eventually placed not only on roofs, but also vertically on building walls that face the sun to produce as much energy as possible. Electronic devices such as mobile phones, portable computers, street lights, traffic lights, etc., should be adapted to work with solar energy, whenever available, and to store it for later needs (for e.g., at night or dark conditions). In particular, smartphones and laptops functioning with solar energy do not only result in energy saving, but also in making these devices much less cumbersome in terms of plugging and wiring issues, especially at travel where users can take advantage of the availability of sun and, thus, the need to bulky chargers and wires will be reduced. New sustainable energy sources based, for example, on synthetic carbohydrates from CO₂ can also be explored ([Moustafa 2014](#)). In fact, carbohydrates are the core of the process of energy production using plants as a raw material (such as maize and sugar beet). Microorganisms decompose the complex sugars (carbohydrates) that compose plant tissues and ferment them into bioethanol. Thus, synthesizing fermentable organic matter (or sugars), through an artificial photosynthetic system, can be a worthy path to explore to generate sustainable energy and reduce CO₂ emission in the atmosphere. Although this might appear hardly feasible under the current state of technology, nothing prevents future technological advancements to be developed in this direction to produce clean and safe energy from synthetic carbohydrates.

Sports and major consuming energy-events ought to be organized at times when the sun shines and/or during the temperate seasons, when the needs for energy are minimal. Another potential regulation would be to prevent super- and hypermarkets from wasting food just because the validity date is approaching or has passed some days ago, since validity dates are usually approximate, but not absolute deadlines, particularly for hardly perishable foods (i.e. low soluble-sugar and low water-content foods). Planting fruit trees and/or vegetables in urban parks and spaces alongside with, or instead of, non-crop plants might also be an option worth considering.

Finally, it should be emphasized that there is food for everyone on this immense and rich planet, but to use it decently we need a thorough revision of current policies of food production, conservation, distribution and trade laws towards more human equity and fairness. Ethically, the supply and access to food ([Künnemann 2006](#)) and water ([Hall et al. 2014](#), [Marks 2014](#)) should not be a matter of scientific research only, but a question of human rights, too. Food science should also be an integral part of the research proposals aiming at the 2050 challenges, and the scientific focus on how to better ensure food security should be similar to, if not higher than, the focus on how to control major human diseases ([van der Linden and Foegeding 2015](#)). Works in fields and agriculture activities should be encouraged and valorized at financial, social and technical levels to attract more juvenile workforces to invest in this vital sector. To do so, smartphone applications, for example, might be developed to remotely link agriculture and the new technology together, so that young people would be attracted. Smart applications can be developed, for instance, to observe periods of different treatments and agricultural operations (irrigation, harvesting, fertilization schedules, etc.) and to warn of predictable environmental changes, so that appropriate procedures can be taken at critical moments. The food challenge is critical enough so that each effort should be taken seriously at local and global levels. Although the contribution of some steps may appear minute at individual or local levels, the additive outcome at the global level would be considerable if we all act locally and think globally. In the upcoming session of the Conference of Parties (COP 21) on climate change, scheduled for next month in Paris (November 30 – December 11, 2015), legally and ethically binding commitments to reduce CO₂ emission should be issued, followed up regularly for each country and respected; otherwise the outcome of any regulation would be inefficient to alleviate the consequences of climate change.

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Figure caption:

Feeding a growing human population while sustaining the main environmental resources (water, food, land and energy) is an important challenge for the future. Comprehensive sustainable and ethical plans should be set up and applied at local and global levels. Preventive and curative procedures can include, for example, an enhanced research to increase plant productivity, an ecological desalination of seawater, an adoption of new clean and sustainable energy resources (combining solar and wind energy, artificial photosynthesis etc.). Public policies based on human cohesion, ethics and smart management should also be issued to reduce all kinds of wastes/misuses of natural resources and food by, for example, imposing solid taxes on wasters at all levels (home, restaurants, public and private establishments...etc.) to discourage wasters from wasting.

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