Water issues for sustainable agriculture

Contribution to the public debate

Eau, Agriculture et Territoires (EAT) is an association of French professionals and researchers specializing in agricultural water management. The association contributes to the development and dissemination of French know-how, knowledge and best practices in this field, both in France and internationally. EAT is ICID French National committee

With this document, which summarizes a detailed report discussed in June 2024 with 70 water stakeholders including farmers and farmers representatives, Eau, Agriculture et Territoires aims to contribute to the ongoing public debate on conflicts between farmers and environmentalists over water use and management in agriculture, whether for irrigation or drainage.

We believe that a constructive resolution to this debate can only be achieved if we first succeed in defining the type of agriculture we want for our territories in the future in order to meet both our food needs, other societal demands and environmental requirements. Once this vision is clarified, dialogue between the various water stakeholders will become more effective, facilitating the development of sustainable local models and moving beyond the ideological standoffs we are currently witnessing.

Foreword

"The drawback of this [Mediterranean] climate for human life is the annual distribution of rainfall. [...] Everywhere, drought causes stoppage or decline of running water and natural watering. [...] It brings all herbaceous vegetation to a halt. [...] Irrigation with its various methods, coming from the East, will very soon have penetrated the Mediterranean zone."

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"The plains normally act as water collectors. During winter, the normal rainy season, they are destined to be flooded: to avoid this disaster, various precautions, dams and diversions are required. [...] There's not a dry river in summer that can't, in a few hours' time, regain the torrential violence of its winter waters. [...] When the water reaches the plains it does not always flow easily towards the sea. [...] Ultimately, on these low lands, the water stagnates. And the consequences are the same everywhere: Acqua, ora vita, ora morte: here, water is synonymous to death." (Fernand Braudel - The Mediterranean - La part du milieu – 1949)

With climate change [1], what Fernand Braudel wrote about the Mediterranean is now true not only for a territory that has expanded northwards, but also for many other world regions. Almost everywhere on the planet, rising temperatures are accompanied by a sustained increase in the frequency and intensity of extreme weather events - heat waves, periods of drought, and intense rainfall - which are having a serious impact on human activities and particularly agricultural production. These impacts, which are already very tangible, also affect water supply for human consumption (drinking and hygiene), other human uses of water and the equilibrium of natural environments. With the growing awareness of the imperative need to safeguard and often restore natural environments, and the necessity to share water resources equitably between all human uses and the needs of nature, questions linked to water and agriculture, or water for agriculture, now play an important role in public debate.

[1] Although the climate has never been strictly speaking "regulated", with droughts, floods, periods of extreme cold or heat that are unforeseen and difficult to predict, "disturbance" is preferred to "change" because of the increasing irregularity of extreme phenomena that will characterize the climate, a characteristic on which the scientific community agrees.

Agriculture

According to Furetière's universal dictionary of 1690, agriculture is the art of cultivating the land, making it fertile and growing fruit and plants. The Larousse defines it as all the activities carried out by human beings, in a biological and socio-economic environment, to obtain the plant and animal products that are useful to them, in particular those destined for their nourishment. So, first and foremost, we're talking about growing plants, since livestock themselves are largely fed on plants. Agricultural production, essential for human nourishment and public health, also has an economic function through its contribution to countries' GDP and exports, not forgetting non-food crops such as biomass for energy purposes, fibers used for textiles or building materials, oleochemicals or starch-based biodegradable plastics.

Water and how it is shared between different uses

Available water resources include surface water, rivers and lakes, and groundwater, which is alternately stored and released during periods of rain and drought. Even with the same amount of cumulative rainfall, increased precipitation will result in higher runoff, less infiltration into groundwater and more flooding, while longer and more intense droughts will increase de-stocking and reduce the base flow rate of rivers [2]. In some regions of the world, particularly around the Mediterranean Sea, average annual precipitation will set to fall.
This reduction in available water resources will make it even more essential for society to organize the sharing of water between different uses and to arbitrate in case of shortages. Food, hygiene and public health have priority [3], as do biodiversity and the environment in the broadest sense. However, economic, industrial and agricultural uses, as well as leisure activities such as tourism, cannot be overlooked, particularly given their impact on employment. Prioritizing the issues at stake is crucial, even more so in the context of growing awareness and mobilization of civil society regarding these issues. The main principles, determined at a national or supranational level, must be applied at a regional level within a framework of governance involving all users.

Water and plants

Plants need soil or a soil substitute, organic and mineral nutrients, light and water to grow. Water, drawn by the plant from the soil, plays a little role in the process of manufacturing organic matter through photosynthesis and is mainly used to transport nutrients into the plant through the process of transpiration.
This water is naturally present in the soil and can be used by the roots of plants. It comes from the infiltration of precipitation, part of which is stored superficially in the soil, and can also rise from the shallow water table by capillary action. This useful stock varies according to the plant and its level of development, as roots can fetch water and nutrients from greater or lesser depths, and according to how dry the soil is. It also varies over time: it fills up when it rains and empties when it doesn't, due to consumption by the plant cover, evaporation from the surface and infiltration into deeper soil layers. The amount of water available to plants is, therefore, a function of rainfall and its distribution over time. It also depends on the nature of the soil, which determines its storage capacity. The water demand is determined by transpiration and evaporation, which depend on the functions and type of plant (some require more water than others), its vegetative stage, and increases with ambient temperature and wind strength. Some plants need water in the seasons when it rains most. For others, this need is delayed in time. These plants then draw on the reserves stored in the soil. When this reserve is depleted, it will replenish itself if it rains again, but if it doesn't rain, the plant will wilt or stop growing or even die. In this case, irrigation can be used to supplement the water supply.

[2] EXPLORE2 water futures. Messages and lessons from the Explore2 project. https://www.inrae.fr/sites/default/files/projetexplore2-synthese.pdf
[3] SDG - Goal 6 of the 2030 Agenda for Sustainable Development adopted at the United Nations Summit on September 25, 2015: Ensure availability and sustainable management of water and sanitation for all.

There can also be excess of water, with the consequence of suffocating plants if the soil remains saturated for too long, and even more so when it's submerged (except when this submergence is controlled and temporary, as in the case of paddy or certain meadows), and/or for rendering fields inaccessible. If the phenomenon occurred due to poor runoff flow, the remedy is to create drainage ditches. If the cause is insufficient soil permeability (hydromorphic soils), a drainage system is implemented using perforated buried pipelines deep enough to desaturate the soil layer used by the roots.

Farmers, therefore, have no choice but to control water to guarantee both quantity as well as quality of production. This control varies from knowledge of plant needs and useful soil reserves to techniques for providing additional water by irrigation or evacuating excess water. The need to properly manage water for agriculture is bound to increase with the rise of temperatures, increase in water requirements by the plant, reduced rainfall and extreme events such as droughts and floods becoming more frequent, both in terms of intensity and duration.

As the needs of the environment and other human uses of water must be taken into account, the link between agriculture and water becomes a challenge whose complexity increases over time. The responses to be provided and the solutions to be implemented must integrate this complexity and evolution.

Changes in the general agricultural context

After five decades of forced agricultural modernization that followed the Second World War, the 21ème century has seen the emergence of new climatic, environmental, geopolitical and economic issues, which have presented our societies, and particularly farmers, with new challenges. The environmental and social impacts of certain excesses of modern agriculture are now widely acknowledged. Simultaneously, there is a growing awareness of climate change, its anthropogenic origins—including agriculture—and its far-reaching consequences. Moreover, the acceleration of globalization and international competition has fostered interdependence, whose vulnerabilities are now being exposed by health and geopolitical crises, compelling the agricultural sector to:

-nourish a planet whose population has risen from 2.5 billion in 1960 to 8 billion in 2022, with a projection of 10 billion in 2050,[4]
-ensure food sovereignty and contribute to wealth creation in each country or community of countries,
-preserve the planet by drastically reducing the use of chemical fertilizers and pesticides, or even abandoning some of them, to maintain the soil's biological and mineral balance,
-adapt to both the inevitable increase in water requirements for crops because of global warming and the reduction in available water resources.
-play its part in mitigating the speed of climate change by emitting less greenhouse gases and helping to capture carbon in the soil,
-be the actors in their territories to achieve local excellence in terms of food, landscape and social balance within the territories.

Nourishing the planet: We need to produce enough to feed the entire population at a cost that gives everyone access to healthy food of good nutritional quality at a price compatible with economic capacity. This also implies a change in eating habits, and certainly a waste reduction.

[4] SDG – Goal 2 : End hunger, achieve food security and improved nutrition and promote sustainable agriculture – particularly Target 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality

Enabling food sovereignty and participation in national economies: The "Dictionary of Agroecology" (https://dicoagroecologie.fr) defines food sovereignty as "the right of populations to decide on their own strategies and policies to guarantee their food security, while considering the effects on others". In developing countries, the agricultural and agri-food sector accounts for a significant share of GDP (from 15% to 40%) and employment (from 20% to 80%). The economies of most advanced countries are less dependent on it, with proportions of 3 to 4% (GDP and employment), but food sovereignty is just as essential. It is also important to preserve certain value chains that make a significant contribution to exports and, therefore, to the trade balance of countries.

Better preservation of the environment, biodiversity and natural resources: Agricultural practices must safeguard or even restore the natural qualities of soils, and particularly their fertility, without impacting the quality of water and aquatic environments. This means drastically reducing, even eliminating, the use of chemical fertilizers and pesticides, through the development of agro-ecological practices.

Adapting to climate change effects: Rising temperatures and the intensity and duration of droughts are shifting climato-edaphic zones[5] , increasing the need for irrigation, while available resources, to be shared with other uses including the natural environment, are diminishing. Adaptation will require a change in cropping choices and calendars.

Participate in climate change mitigation: Agriculture is one of the biggest contributors to greenhouse gas emissions[6], mainly through synthetic fertilizers, farm machinery and livestock farming. Agricultural water management is also a major contributor, with the construction of heavy infrastructure and energy consumption for pumping. Agriculture also has the capacity to reduce emissions by improving soil carbon sequestration.

Contribute to the life of the territories and local excellence: Rural landscapes have always been shaped by agriculture and are now being challenged by soil artificialization. These agricultural functions must be maintained and can be extended to the restoration of natural areas. Furthermore, certain crops, which are an integral part of the image of a region, have a strong impact on tourism.

Maintain viable farms: All these challenges can only be met if farmers are willing to do it. The economics of farming is, therefore, a key issue: Producers must be able to make a decent living from their work, and sales prices and value chains must enable them to be properly remunerated. This fair remuneration of producers is an essential condition for attracting youth towards this profession.
Farming costs must be kept under control, but will always require labor, quality inputs and investment in efficient technologies. The ability to invest is particularly important in the field of irrigation: these investments must enable better irrigation with less water. At the same time, farmers must be able to benefit from a water supply at a reasonable cost-related price of this service and adapted to the economics of their farms. The cost of hydraulics development must, therefore, be optimized, and financing by public funds should be conditional on making water available to the greatest number of people.

[5] edaphic: related to the soil as a biological environment
[6] Agriculture is currently responsible for 20% of greenhouse gas emissions in France (source MAAF) and 10-15% worldwide, a figure that can rise to 25-30% if we include the problem of deforestation and the impact of food processing/transportation/marketing.

Agriculture and water

Placement of irrigated agriculture in the hierarchy of water uses: In most countries where irrigation is practiced, irrigated agriculture is considered an “economic use” of water which is weighed against other economic (industry), health and social (drinking water) and environmental uses. This term implies that water contributes to the creation of value linked to food sovereignty and public health and contributes to country’s GDP and exports. On a global scale, irrigated agriculture covers 20% of cultivated land and produces almost 40% of the world's cereals (60% in developing countries - notably rice, wheat and corn), as well as a significant portion of fodder and industrial crops (corn, soya) (source FAO). Regulatory texts on shortage management refer to these different types of use.

Beyond economic activity, we must not forget the contribution made by agriculture to maintain the countryside and its population.

The top priority given to irrigated agriculture in relation to other water uses differs according to the ranking of these issues, and the response is, therefore, political in nature. This hierarchy of issues, which determines the hierarchy of water uses, evolves over time and differs from place to place, depending, for example, on the proportion of the population dependent on agriculture, which is higher in southern countries than in the north.

Excess water management: Recent repeated episodes of extreme precipitation and floods remind us about the necessity to manage surplus water. The environmental vision of wetlands, rich in biodiversity, is often opposed to maintaining the soil in a favorable dry state for agricultural activity. But this may be a kind of misunderstanding, resulting from confusion between improving the practicability of hydromorphic agricultural soils and draining wetlands that must be protected in the name of maintaining biodiversity. Reflection and debate about drainage should include this clarification.

Irrigation: the complexity of resource sharing

Issues: Without neglecting the dynamism of rural areas or GDP, we can affirm that food sovereignty, as defined by this concept in the beginning of this document, is a major issue. To downgrade this issue in favor, for example, of the exclusive preservation of water resources in France, would mean choosing either to renounce all food produced from crops requiring irrigation, or to import them, even though they are also dependent on irrigation elsewhere, ignoring the impact of such production on the environment of the concerned territories.

A global health issue linked to irrigation water in the poorest countries (livestock watering, household water supply, but also potential vector of diseases...) can also be considered within the framework of an integrated, systemic and unified "One Health" approach to human, animal and environmental health at local, national and global levels.

Advantages: As discussed earlier, irrigation is a means of securing crops which, without water from natural sources, are exposed to water deficits that can be harmful. Many rural communities have developed irrigated systems over thousands of years, including the northern regions, where they are used occasionally to ensure that production is not wiped out when the rains fail. More recently, numerous large-scale irrigation projects have been launched to prevent famine.
Irrigation techniques have evolved considerably over time, improving the efficiency [7] of water transport and distribution to the plant. In addition to rationalizing irrigation, fine-tuning it and implementing techniques to optimize inputs, agroecology techniques can increase irrigation efficiency by improving the physical qualities of the soil.

[7] Efficiency is the ratio of the quantity of water actually used by plants to the volume withdrawn from the natural environment.

Constraints: From time immemorial, irrigated agriculture has always been the first adjustment variable when there wasn't enough water to satisfy human needs. Irrigators are therefore prepared to put up with this constraint and to accommodate it. On the other hand, awareness of the need to satisfy the water requirements of the natural environment, for the benefit of biodiversity, and of the resulting regulations, is often more difficult for farmers to accept.

In any case, when water resources are under pressure, the share available for irrigation should be allocated as a priority to production aimed at satisfying food sovereignty and short cycle trade, to multi-annual crops and to contract farming. This allocation should also support the evolution of agriculture towards agro-ecology, which aims to restore soil properties, thus making greater use of water storage.

Agricultural drainage: A necessary balance between farming and biodiversity

Issues: The quote from the foreword illustrates the evolution of issues, albeit over a very long period: The unhealthy marshland evoked by Fernand Braudel is no longer a problem in Europe, where the rich biodiversity of wetlands is now a major issue.
However, the availability of agricultural land exposed to long-term flooding or insufficient natural drainage should also be considered as a food sovereignty issue.

In the southern countries, agricultural production in wetlands and floodplains remains one of the main food security challenges, raising the question of balancing agricultural production and biodiversity preservation in these areas.
Like drought, the risk of flooding or waterlogging of agricultural soils can reduce yields and even endanger crops, and floods can also cause famine.

Advantages: Drainage of hydromorphic agricultural soils, or soils that are temporarily waterlogged in winter, makes it possible to add value to land that would otherwise be unproductive.
Incidentally, by its ability to control flows, drainage can also be used to quantify the impact of agriculture on groundwater pollution: monitoring drainage water makes it possible to measure the effect of upstream practices, to measure any organic residues, chemical outputs and pesticides, and to anticipate possible pollution. To attribute agricultural pollution of downstream water bodies to drainage is to treat it unfairly since any such pollution is attributable to all agricultural practices, with or without drainage.

Where residues are present in excess quantity, the creation of artificial wetland buffer zones downstream of drainage networks ensures a purification function associated with other ecosystem services. Drainage water thus recovered can also be reused for irrigation purposes, either before reduction of the residue content (which is recycled as an input) or after reduction.

What's more, properly drained soil tillage consumes less energy than water-saturated soil tillage, reducing energy bills and, therefore, greenhouse gas emissions. Drainage also protects soil from compaction and hydromorphy.
Drainage is also sometimes necessary, especially when salts are present in the soil, to eliminate them and avoid their concentration in the soil's root horizons, which harms crop development.
Finally, as saturated soil no longer absorbs water through infiltration, agricultural drainage helps to control runoff in the event of intense rainfall, to the benefit of downstream areas and steam courses, whose floods it helps to cushion.

Constraints: The main constraint regarding agricultural drainage is the preservation of wetlands rich in biodiversity.

European regulations are precise and demanding in this respect, particularly concerning the surface area relevant to drainage, including flow control, buffer retention and discharge into the natural environment.

What kind of irrigated farming systems for tomorrow?

The evolution of agriculture, which began in 1950, has resulted, particularly in the richest countries, in the establishment of a model based on an extremely strong rise in the size of farms and plots of land, a tendency to specialize agriculture into large production basins, almost total mechanization, intensive use of inputs and, where useful, extensive use of irrigation, all aimed at maximizing production. This trend is quite general, although there is considerable diversity, particularly in terms of farm size, intensification of production and use of inputs.

However, this " production-driven " model has shown its limits. The consequences can include over-consumption of resources, particularly water, soil impoverishment, excessive use of fossil fuels, fertilizers and plant protection products, leading to pollution and health problems, and a resetting of landscapes at the expense of biodiversity. It can also lead to over-specialization of production, excessive stock building and speculation, to the detriment of satisfying the needs of the poorest or the fair price for farmers.

However, it shouldn't be generalized to all types of production, to all territories, and all farms. There is a diversity of agricultural models which must be encouraged. Research has also made it possible to identify alternative practices whose agronomic and economic effectiveness has been demonstrated. Combined with the development and implementation of innovative technological solutions, these practices should help to improve the overall performance of agriculture.

Irrigation and drainage must be prioritized to develop more suitable models that are environment and public health friendly, contributing to less greenhouse gas emissions, resilient to climate change, more frugal in terms of natural resources, more diverse and allow better viability for farms. The models to be promoted must also enable producers' independence by reducing their dependence on external factors. Irrigation is a tool that serves this necessary robustness. But, in any case, the growing pressure on available water resources and the inevitable need for public funds must lead us to prioritize irrigation in the general interest rather than for the benefit of a few.

Agroecological transition solutions are based on improved fundamental knowledge of cultivated ecosystems (soil, plants, animals and the organisms that surround them, whether pathogenic or symbiotic), agroecology proposes a promising framework for reflection and innovation. It proposes several levers for ensuring agricultural production while reducing the use of synthetic inputs, preserving soil and water, and restoring the role of human beings in agriculture.

Crop diversification: This diversification, from plot to landscape, contributes to biodiversity and the reduction of input use. This framework provides a link between animal and plant production in the territories but also enhances the coexistence of all organisms present in ecosystems. These developments will lead to more diversified production and will go hand in hand with the desirable evolution of diets.

Conservation agriculture: Conservation agriculture, officially defined by the FAO in 2001, is based on three main principles: (i) maximum soil coverage, using crop residues or a sown cover, (ii) no-tillage except at the sown ridge, and (iii) diversification of cultivated species through long rotations and associated crops. This conserves organic matter and biodiversity in the soil, thus enhancing its fertility. The absence of ploughing reduces soil compaction, improves water retention and reduces tractor emissions of CO2. The cover protects against erosion.

Implementing agroecology implies profound changes in relation to conventional agriculture, changes involving the intensification of human labor and requiring technical and financial support. These changes are undoubtedly easier to integrate in food-producing systems where labor is easily available. On the other hand, in countries where labor is scarcer and more expensive, the conditions for profitable farming have yet to be established.
However, agroecology is not limited to techniques and practices, and its systemic aspect needs to be emphasized. As a production system, its implementation will extend gradually, and the share of conventional agriculture will remain significant for a long time. What's more, raising soil carbon levels will take decades. The transition process must, therefore, take account of this " overlapping " between the two systems.

Water management appears to be a fundamental lever in the transition to agroecology. In large-scale farming areas [8], many farmers can testify to the ability of irrigation to promote diversification of their cropping systems. Irrigated farms are generally smaller than rain-fed systems, and their crops are more diversified, with irrigation enabling the cultivation of intermediate cover crops, oilseeds and nitrogen-fixing crops. Areas where irrigation is possible are also more favorable for settlement of new farmers (young).

The question will remain, however, whether agroecology as a production system can replace conventional agriculture in nourishing the planet and providing the non-food production required for the energy transition. Does "intensive agroecology" exist? Although research suggests that agroecology can be highly productive, will it eventually represent 100% of agriculture?

Solutions provided by hydraulic infrastructures and unconventional resources

Since time immemorial in many parts of the world, the irregularity of rainfall has led mankind to store water when it rains so that it is available in dry periods. Storage during flood periods also helps to maintain low water levels in rivers and plays an important role in flood protection. This need to cushion extremes is even more crucial given that the intensification of rainfall events increases runoff to the detriment of infiltration and, hence, the recharge of underground aquifers.
The feasibility of infrastructure to transfer water from where it is abundant to where it is scarce should also be considered.
The decline in naturally available resources should also lead us to examine the benefits of resorting to so-called "unconventional" resources, such as the desalination of seawater or brackish water, with the major drawbacks of energy requirements and its ecological footprint, or the reuse of treated wastewater, provided it is not essential to the environment, for example when it is used to support low-water levels.

There is a consensus on the **imperative need to combine improvement of supply and sobriety of demand**: the implementation of hydraulics projects, which are costly for the community and whose environmental impact is never negligible, must be conditional on an acceleration of the transition to agroecology towards greater sobriety in water and inputs, through the contractualization of long-term commitments to save water and protect the resource.

Particular attention needs to be paid to integrate the risk of resource scarcity in the infrastructure design, which may, for example, provide service only for 9 years out of 10 or even for 4 years out of 5. Rather than reducing expenditure by satisfying a lesser need, it is the culture of risk and risk management that appears necessary by substituting adapted management for crisis management. This approach is similar to that of flood protection planning, whose overall effectiveness is based on the combination of ordinary protection and the ability to manage extreme situations.

[8] Cereals (wheat, barley, maize, etc.), oilseeds (sunflower, rapeseed, soya, etc.), protein crops (peas, broad beans, etc.), potatoes and beet.

The need for subsidies implies public governance and the greatest benefit possible of these developments, both in the short term and far-off deadline. One of the prerequisites for sustainability is that projects be backed up by long-term prospective studies, in terms of both the requirements to be met, the state and evolution of available water resources, environmental and social impacts, and economic feasibility. Priority should also be given to collective and, if possible, multi-use developments that can meet the multiple challenges of water management. However, as such developments require large amounts of public funding, they should only be considered after all avenues for improving existing water management have been explored.
In addition to the investments to be made, how they are managed is crucial for their sustainability and must be considered as a decisive factor in the project. In this respect, the French Water User Association [9] and Regional Development Company [10] models are internationally recognized and used as an example. The question of energy should not be overlooked either, particularly for the pressure required for more precise application of water to improve irrigation efficiency.

Irrigation and drainage for the sustainability of agricultural activity

To implement these changes and also to cope with the effects of climate change, farms will have to adapt and change their practices while ensuring their financial sustainability.
The innovative techniques to be developed and implemented will have a cost that must be amortized. Equilibrium can only be found by transforming the system, not just the practices and techniques.
A further source of complexity is the volatility of prices for agricultural inputs and products. The example of inflation following the invasion of Ukraine has shown just how unpredictable these prices can be, with the sudden disinterest of consumers for organic products and the resulting difficulties for the producers concerned.

We also need to create the conditions that will make farms attractive to young and new farmers. From this point of view, meteorological uncertainty as a result of climate change does not encourage risk-taking and, therefore the entry of new farmers who will have to invest money. Hydraulic developments and water management can be an effective way of making farming more secure by reducing these risks.

Relocalization: It's clear that if agriculture is entirely and exclusively dependent on global markets, countries, and not just the less wealthy, will lose their supreme choice of feeding their population and thus their food autonomy. Maintaining agriculture in the territories also has an impact on employment and helps people to settle there, making territories more dynamic and attractive and limiting the rural exodus that contributes to overpopulation and precariousness on the outskirts of major cities, which is particularly problematic in the megacities of southern countries. One way of achieving this is to give priority to short supply chains, for those products that allow it, including local specialties.

Regarding livestock farming, intensive, industrialized, globalized models and animal-based production must be reduced. Complementarity between animal and plant production must be optimized at the farm or local level.
Agricultural activity must also be based on a balance between food and commercial production for urban populations or export. A return to more local production also aims to reduce the energy cost of transport and to recreate a link between consumers and farmers. This requires consumer acceptance of the seasonality and

[9] ASA: Association Syndicale Autorisée: the name given to water user associations in France, based on specific regulations.
[10] SAR: Société d'Aménagement Régional. Structures created in the 1950s-60s to participate in the planning and management of regional development. These companies implemented development projects in regions deemed to be priorities, by getting involved in regional planning and the management of major infrastructures.

geographical disparity of certain products (fruits and vegetables), and sometimes paying a slightly higher price for less efficient local production.

Irrigation is a factor favoring relocalization of production: the creation of storage facilities, or even the transfer of water from basins where it is in abundance, makes it possible to secure local production and avoid costly energy imports... and have an important water footprint at production sites.

Non-food agricultural production: Irrigation also allows quantitatively improving non-food production, either directly or by increasing the value of by-products, which can replace production with a high carbon impact or fossil fuel (biomass for energy purposes, fibers used for textiles or building materials, oleochemical products, starch-based biodegradable plastics, etc.). Nevertheless, in this field, more than in the case of food crops, the contribution of water use to the general interest must be assessed as objectively and democratically as possible.

A necessary transition to be implemented

Throughout the world, agriculture has no choice but to make the transition to a model that is more nature-friendly and interacts with human beings. In the face of the urgent challenges of climate change, this transition must not be postponed. However, it must consider the capacity of the agricultural sector to evolve, both in terms of production and value chains, which are highly dependent on consumer systems.

This transition must not be seen as a return to agriculture as it was before, with the drudgery of agricultural work and living conditions that are far more difficult in rural areas than in the city. Recent technological advances, such as the Internet of Things (IoT), remote sensing, artificial intelligence, low-cost sensors, or simply mobile telephony etc., must be harnessed to improve agricultural systems while responding to new constraints. These technologies must encourage and support changes in farming practices. Production systems have to change radically, and crop diversification has to replace specialization, sometimes with deep consequences for existing irrigation systems. Value chains have to be reorganized, and new ones have to be set up. The skills of all stakeholders have to evolve, new investments will be required, and in general, the economic model(s) of agriculture, particularly irrigated agriculture, resulting from this transition, remains to be established. It will, therefore, be a complex process, with a considerable risk of trial and error and failure at first, and the consequent need for adaptability. It's going to take time. All the more reason not to lose it.

There can be no universal, global transition model. Priority must be given to the territorial scale, as this is the only one that considers inescapable specific local character and is the most suitable for consultation between all stakeholders and public support. This territorial approach must, however, be situated within global, national, regional and international frameworks, which consider the issues at stake at each of these scales for all categories of use.

The transition must therefore be driven by political will, based not on popular emotion but on a vision underpinned by scientific foundations, which determine the range of possibilities. It must also be conducted in a spirit of consultation and collaboration with the agricultural world and other users, rather than confrontation: participatory research into new ways of working, and the search for convergence between issues and visions of the future. It must be financed by the public authorities, and first and foremost by the CAP [11], because farmers cannot bear the associated risk alone.

Finally, there exists a reciprocal relationship between the expected evolution of production, processing and marketing systems on one hand, and changing consumer habits on the other.

[11] Common Agricultural Policy

We, therefore, need to integrate several complementary dimensions beyond the laws of demand and supply. From school onwards, we need to educate people about the place of agriculture and water management in society, raise awareness of the global, social, climatic, environmental and economic impacts of their food choices, inform them about both product quality and origin, and at the same time introduce strict rules on traceability and consumer visibility. Concerning water and the impact of our food on resources, this education and awareness-raising will have to be based on effective communication of tangible scientific knowledge that can stand up to the dogmatic rhetoric and even misinformation that is conveyed increasingly by social networks.

Finally, in terms of regulations, a more flexible, differentiated-as-appropriate application, justified by specific local conditions, may sometimes be necessary for agricultural transition, in terms of both irrigation and drainage, without this flexibility being a pretext for not changing practices. In France, stringent regulations can make it impossible to meet local consumer demand and paradoxically give a competitive advantage to irrigated agriculture in remote countries with less water available. It is also important to avoid restrictions or bans being hampered by the absence of alternative solutions, leading public authorities to take ambiguous or even contradictory decisions (banning, then re-authorizing certain molecules, for example).

Geopolitics: different problems in different regions and countries and solutions that go beyond the scope of agriculture

While the challenge of food sovereignty must be translated into national public policies - or supranational policies, particularly in the case of Europe - giving greater importance to local production and short supply chains, certain regions of the planet will remain much more favorable to production that cannot be relocated closer to consumers. Wheat, for example, will continue to be produced in high latitudes, while coffee, cocoa and tropical fruit will remain in tropical zones. The physical, economic and social availability of water for irrigation, as well as the risk of flooding, will contribute to setting limits to agricultural diversification in certain regions. The same applies to the impact of climate change on agriculture, which varies greatly depending on the latitude. Finally, we do not know the long-term effects of the inevitable rise in energy access costs in the coming decades on agricultural production, transport and food processing.

Large-scale agricultural trade will, therefore, continue, but it will be important to measure its environmental and climatic impacts to make the right choices in terms of sovereignty. What do we produce at home and what do we import, and conversely, what do we export to finance our imports? At what environmental cost, with what water footprint and overall climate impact (as regards transport, for example), at home and from whom we buy? Innovative methods such as LCA (Life Cycle Assessment) for comparing different scenarios need to be disseminated widely.

Economic development and trade requirements differ from country to country. While climate issues are the same for many countries in both the North and the South, the economic and social contexts are different, implying adapted intensities of change.

The southern countries, where the agricultural strategies of past decades have been strongly influenced by donor policies, particularly in terms of irrigation and the development of the current model, need to increase their agricultural production. The high demographic growth that characterizes these regions makes the challenge of food sovereignty even more important. Limiting the expansion of megacities and the rural exodus that feeds it makes a dynamic rural economy vital. The dependence of their economies and trade balances on agricultural activity makes irrigated agriculture a major stakeholder.

Northern countries, for their part, need to improve their self-sufficiency in certain crops, notably fruits and vegetables, reduce their carbon footprint, and also improve both product quantity and quality. Their societal sensitivity to environmental issues, particularly to water and soil resources, puts heavy and costly restraints on their farmers.

This divergence of interests is compounded by the desire of producing countries to maintain their market shares, leading to fierce price competition. This competition is further intensified by crises and wars and the market disruptions they cause. However, it is in the interests of the northern countries to help develop agriculture in the southern countries out of a concern for global solidarity but also so that their populations can continue to live there and thus contribute to finding solutions to the human and political problems posed by emigration.