

The future of water resource availability in France: how is the agricultural sector taken into account in foresight studies?

Whereas water is one of the factors that determine human activities – including agriculture – and ensure ecosystems function properly, its use is already under considerable strain in some French regions. Several projections and foresight studies have therefore tried to take a closer look at what will happen to this essential natural element in the future. This paper compares three recent studies (*Aqua 2030*, *Garonne 2050* and *Explore 2070*) to bring out the main factors that will influence this resource's availability and usage, in particular in the agricultural sector. These exercises invariably conclude that tension will exacerbate going forward, forcing agriculture to adapt, under pressure from climate change as well as other water withdrawals. These studies, however, are also limited when it comes to specifying and quantifying these tensions.

Water is essential to agricultural activities and a deciding factor for both crop production (chemical reactions during synthesis, nutrient transport, thermal regulation) and animal husbandry (food, drinking water and cleaning facilities). Agriculture withdraws this resource from the ground and networks. It also contributes – positively and negatively – to determining and restoring its quality, and to regulating water cycles. However, observations over the past four decades have alerted us to the strain that water is enduring today and on occasion raised questions about whether it will be able to satisfy its multiple uses over the long term. In the future, the imbalances between supply and demand could be exacerbated by global megatrends such as demographic growth, urbanisation, climate change, etc.¹. These prospects are forcing decision-makers to look ahead in order to anticipate the impacts on local areas.

Several projections and foresight studies have tried to shed light on the issues and to inform the debate. This paper focuses on three of the dozen or so available studies², in order to discuss and compare their results and methods.

The first study, which primarily takes a qualitative approach, is titled *Aqua 2030 - Prospective eau milieux aquatiques et territoires durables 2030*. It started in 2010 and was published in 2013. A consortium comprising

Irstea, ACTeon and Futuribles conducted it for the French authority for Sustainable Development (CGDD for *Commissariat général au développement durable*). *Aqua 2030* is geared to spark collective discussions about this resource's quality and quantity in the future, in light of interactions between aquatic environments and territorial dynamics. Its timeline shows that it is interested in the near future, i.e. the one that decision-makers are considering, while looking beyond the short term.

The second study, *Garonne 2050 - Étude prospective sur les besoins et ressources en eau à l'échelle du bassin de la Garonne*, sets its sights on 2050, so it can take into account climate change and the demographic challenge that the Garonne river basin will be facing (1 million additional inhabitants by 2050). This study was commissioned by the Adour-Garonne water agency (Agence de l'eau) in 2010, and entrusted to a consortium comprising CACG, ACTeon and Futuribles. Its goal is to inform the debate between stakeholders in this area with a view to plotting out an adaptation strategy in the local master plan of water management and development (SDAGE) for 2016-2021. This study combines an approach based on qualitative scenarios and model-based quantification.

The third one, *Explore 2070 - Eau et changement climatique : quelles stratégies d'adaptation possibles ?* explores and assesses

strategies to adapt to climate change, and gives modelling a central role. It was commissioned by the French Ecology Ministry's water and biodiversity department (*Direction de l'eau et de la biodiversité*) and conducted from 2010 to 2012. It involved several partner organisations (ONEMA, water agencies, DREAL, DGPR, etc.) and providers (ACTeon, International Office for Water, Énergies Demain, etc.). Its timeline is based on the willingness to find a middle ground where the principal variables can be jointly considered (i.e. economic, demographic and climate-related factors).

Analysing these three studies will bring to mind the main factors deemed decisive to describe this resource's future and usages in general, and the way in which agriculture and its future development are taken into account in particular. After comparing their findings, we will discuss the advantages and limits in their attempts at quantification, which is one of the key issues in these discussions.

1. Giuntoli I. *et al.*, 2013, *Évolutions observées dans les débits des rivières en France*, ONEMA.

2. The list, which is not exhaustive, includes *Aqua 2030*, *Explore 2070*, *Garonne 2050*, *Imagine 2030*, *R2D2 2050*, *Les risques stratégiques de gestion quantitative de l'eau en France et les perspectives d'adaptation à l'horizon 2030*, VULCAIN, REXHySS, Scampeï, VulNaR, ADAPT'EAU, HyMeX and others. Some of these studies are now complete, others are ongoing.

1 - The resource's future and uses: the determining factors

Comparing these studies sheds light on the principal factors that will influence water availability and uses tomorrow. Studies often distinguish two aspects: supply (available resources) and demand (expressed needs), and place them side by side to identify possible discrepancies and thus identify future challenges. *Aqua 2030* is an exception to this rule because it does not use this dualistic approach, avoiding quantification of this resource.

Climate change is the main factor influencing available resources

On the "supply" side, the goal is to discern how much water will be available in the future. To do so, the methods involve projection more than foresight. *Garonne 2050* and *Explore 2070*, place a single factor – climate change – at the centre of their analysis.

Global climate models (GCMs) are driven by greenhouse gas emission scenarios³, and used to estimate future trends in the variables that have a significant effect on water resources, namely air temperature, rainfall (changes in spatial and temporal patterns), potential evapotranspiration, droughts, heat-waves, snow cover, etc. These results do not represent local climate characteristics, even though the geographically disparate distribution of water requires regionalised climate data. The "disaggregation" methods in these GCMs sidestep this hurdle⁴. Once these variables have been calculated, models depicting surface hydrology (which is sometimes coupled with subsurface hydrology) can quantify the future climate's impacts on the resource. At this point, studies estimate water balances (rainfall evaporation and runoff), river flows, groundwater levels and groundwater recharge⁴. The box below summarises these findings in *Explore 2070*.

As it centres on a single determining factor – climate change –, the study on the "available supply" of water is based on modelling work focused on resource quantification and spatial information. As *Aqua 2030* uses a different methodology (see 2.2) and a nearer-term timeframe it does not put the spotlight on climate change. It does, however, consi-

der it through components like extreme events or water warming.

Water use: the foresight scenarios and agriculture

The chapter on "demand" takes a more foresight based slant and stems from the need to think collectively about all water uses. Unsurprisingly, they all look at the energy, residential, agricultural and industrial sectors, which respectively account for 59.5%, 18.3%, 12.4% and 9.8% of water withdrawals⁵. However, the studies go into different levels of detail when they describe these uses.

The main factors influencing demand for drinking water are demographic growth, unit consumption (cubic metres per inhabitant per year), water network losses and urban development. The future of the energy sector is mainly based on assumptions regarding future energy mixes.

Integrating "environmental" demand is not as simple. *Explore 2070* and *Garonne 2050* tackle this issue with minimum targets, i.e. baseline flows below which ecosystems are considered not to function well. *Aqua 2030*, once again, takes a different approach: as it does not venture into quantifying, it can describe the "biodiversity" component in a similar way to the other "uses".

Agriculture is addressed much like other consumptions channels: the goal is to characterise possible future trends and thereby derive future withdrawals. *Garonne 2050* looks at the future of the CAP, the global market, farming practices, farm structures, regional production and land use. *Aqua 2030* gathers together the agricultural and energy sectors into a single component, on the grounds that the stakes in both sectors overlap (biofuels, hydropower generation and water storage). This study also highlights water quality and technologies (GMOs, irrigation, etc.) in relation to the agricultural sector. *Explore 2070* assumptions appear to be more clear-cut (see table).

These three studies go into varying levels of detail when they describe agriculture. *Aqua 2030* descriptions are rather general (changes in agricultural "development models" rather than figures to track changes in struc-

tures or output). *Explore 2070* is more specific (converting irrigated areas). *Garonne 2050* provides further details on changes in irrigated agricultural areas, crop rotation and the number of farms, thus giving a clearer and more comprehensive picture of the sector.

Beyond substantially shaping water "supply", climate change is also likely to impact future water "demand" – especially from farms – due to increasing evapotranspiration and altering rainfall patterns⁶. *Explore 2070* and *Garonne 2050* also assume crops will have greater requirements.

The three studies therefore build contrasting descriptions of agriculture (see table), explicitly or not including strategies to adapt to changes in the global context. It is important to point that, even though water governance and public policy are essential – regarding the evolution of the various uses, and how the regulation can shape those trends –, *Aqua 2030* is the only study that addresses these issues explicitly. *Garonne 2050* and *Explore 2070* only imply them. In their chapters discussing "demand", *Explore 2070* and *Garonne 2050* are apparently based on qualitative approaches, but these analyses lead to quantified comparisons with supply.

2 - Findings, limits and prospects

The prospects for agriculture

After reviewing the determining factors and visions of agriculture that surface in these studies, the question is what we can learn from their findings. The three studies set out to identify the impacts of global changes on water resources and local areas, but their motivations were not all exactly the same (see introduction). The fact that their objectives and timeframes differ, and that they drew on a large number of variables and assumptions, precludes any attempt at comparing quantified results. Nevertheless, the studies converge on a few general conclusions.

3. *Explore 2070* and *Garonne 2050* use Scenario A1B, drawn up by the Intergovernmental Panel on Climate Change (IPCC). It is an intermediate scenario.

4. Habets F. et al., 2011, *Impact du changement climatique sur les ressources en eau du bassin versant de la Seine. Résultats du projet CLIMATOR*, Seine-Normandie water agency.

5. Agricultural land irrigation accounts for 12.4% of gross withdrawals in France (2007 figures), but 48% of water volume consumption (resources not returned to the environment after use), and as much as 79% in summer (2001 figures). Source: CGDD, 2012, *Le financement de la gestion des ressources en eau en France*, Études & Documents No. 62.

6. The link between the decrease in rainfall and reduction in plant water comfort is not always self-evident and depends on the timeframe. Brisson N., Levraut F., 2012, *Livre vert du projet CLIMATOR. Changement climatique, agriculture et forêt en France : simulations d'impacts sur les principales espèces*, Ademe.

Climate and hydrology in mainland France, according to *Explore 2070*

By 2046-2065, temperature would increase by 1.4°C to 3.0°C and trends in rainfall are uncertain – except for the fact that they would decline by an estimated 16% to 23% in summer compared with the period 1961-1990.

Surface hydrology: average yearly flows would shrink significantly (10% to 40%), especially in the Seine-Normandie and Adour-Garonne basins, where low flows would decline faster than on the annual scale.

Subsurface hydrology: piezometry is expected to drop due to a 10% to 25% decrease in recharge, especially in the Loire watershed (25% to 30%) and Southwest France (30% to 50%). These groundwater level shifts would contribute to dwindling low flows and lengthening the periods during which riverbeds are dry.

Source: *Explore 2070* fact sheets, A1B emissions scenario

Table: the scenarios for agriculture

This table sums up the agricultural landscapes, within each study's timeframe and within each of the scenarios they discuss (S1, S2, S3, etc.).

Aqua 2030	
S1	Trends continue through 2030: 40% of agricultural land used for intensive farming, 60% for extensive farming (low use of inputs).
S2	"A vau-l'eau" : crisis and economy prevails; 20% intensive and 80% extensive.
S3	Techno-garden, anthropisation : economic growth with environmental technologies; integrated and precision agriculture predominate; minimal inputs, without production decrease.
S4	Will regions unite or divide? Regional authorities gain more power; integrated intensive farming (targeting European markets) and multipurpose extensive farming (targeting local requirements) coexist side by side.
S5	Choice of sound technologies : exercises self-restraint to protect the environment; high-performance and environment-friendly farming; CAP rewritten around environmental objectives.
Garonne 2050 ⁷⁻⁸	
S1	Trends continue through 2050, the number of farms decreases by 60%, agricultural land and irrigated areas shrink by 10%, withdrawals stay stable, summer crop rotation shrivel, energy crops stagnate.
S2	Storage : the number of farms remains stable, agricultural land use also; irrigated area increases; soybean, protein-rich-crop, silage corn and irrigated alfalfa plantations spread; energy crops develop.
S3	Moderation : the number of farms drops by 80% to 90%, agricultural land use shrinks by 20% and withdrawals by 50%; irrigation restricted to high-value-added crops; extensification (straw cereals, sunflower and prairies for ranching); seed production; «islands» of sweetcorn appear while irrigated peas, soybean and consumption corn disappear; wood and fibres replace ethanol and biodiesel industries.
Explore 2070	
S1	Trends continue through 2070: constant crop rotation and changes in agricultural land use are dictated by urban development policy (concentration or sprawl); demand for water for agriculture increases due to climate change.
S2	Moderation : 100% of irrigated corn becomes 50% dry cereals, 30% irrigated wheat, 10% irrigated soybean and 10% irrigated cereals.
S3	Intermediate : 50% of irrigated corn becomes 25% irrigated cereals and 25% dry cereals; 20% of dry soft wheat becomes irrigated in the north of the Loire.
S4	Requirements increase : 20% of dry soft wheat becomes irrigated soft wheat north of the Loire; total irrigated area south of the Loire increases (doubles at most).

Source : author

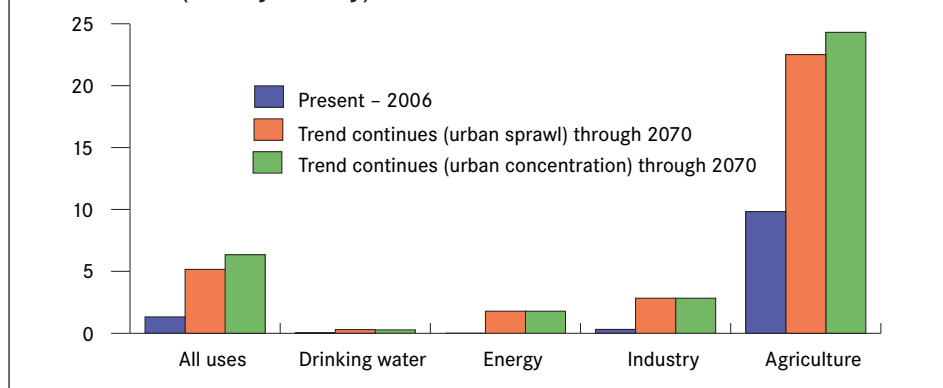
Firstly, each of the studies provides a scenario in which current trends continue, and it seems useful to compare them. In *Garonne 2050* and *Aqua 2030*, the baseline scenario supposes a tension between economic and environmental agendas, and the dynamics already at work in local areas have a considerable impact on natural environments. In *Garonne 2050*, the amount of water routed into agriculture will be stabilised because of shrinking irrigated areas. While in *Aqua 2030*, the water withdrawal increases due to the spread of intensive farming. *Explore 2070* foresees a noticeable shortfall because of inadequacy between agricultural water demand and supply due to climate change (see chart). All these baseline scenarios are presented as

unsustainable regarding all uses. They reflect an exacerbation of the tension already at work, and strategically beckon debate on this resource's future and on the necessary adjustments which need to be made today.

Contrasting with the baseline, these studies also put forward several scenarios involving "moderation". These scenarios describe a more sustainable adequacy between supply and demand. For *Aqua 2030*, this involves meeting water framework directive

objectives. For *Garonne 2050* it is a matter of river flows meeting environmental requirements. This implies decreasing demand from an agricultural sector that is struggling following several episodes of droughts. In *Explore 2070*, "moderation" means agriculture will reduce its withdrawals and the deficit will remain at current levels. In these studies, exercising "moderation" clearly means that agriculture will need to adapt – on occasion radically.

Graphique 1 - Percentage of unsatisfied withdrawals between 2006 and 2070 (1 in 5 years dry)



Source : *Explore 2070* data

7. Two other scenarios – "local" and "liberal" are not summarised here because the assumptions underlying them are similar to the ones underlying the scenarios in the table.

8. The 5 scenarios (3 in the table and 2 others) provided the basis to reach three possible future situations for the Adour-Garonne basin, which were presented to the basin committee in December 2013. Other assumptions have also been used for agriculture, including irrigating predominantly in spring and meeting requirements four years out of five.

In the end, the studies' conclusions and recommendations are very similar and line up with France's national plan to adapt to climate change (PNACC for *Plan National d'Adaptation au Changement Climatique*), which is banking on a balance between increasing supply (optimising existing water, substitution in the form of retention facilities) and limiting demand (seeking efficiency, exercising restraint). Local issues come into play with the need to plot out strategies that accommodate each area's specifics, focusing particularly on the ones that are already dealing with tension, such as the Adour-Garonne, Rhône-Méditerranée and Seine-Normandie basins. These various approaches also match the one in the *Rapport Martin*⁹, which is aimed at leveraging a shared vision – honed closely alongside local areas – for the various uses in light of the area's characteristics.

Even though this is not always stated clearly in conclusion chapters, the conciliation or competition issue transpires in the chosen methods¹⁰. According to a paper by the French general commission for planning and foresight (CGSP for *Commissariat général à la stratégie et à la prospective*), the agricultural sector “could serve as an adjustment variable in some regions, other uses having higher priority such as drinking water”¹¹. This mirrors the water uses hierarchy in *Explore 2070* which ranks agriculture last. The final scenarios in *Garonne 2050*⁸ set the water volume allocated to agriculture. This choice underlines a form of strain between the willingness to keep this economic activity in local areas and the requirement for agriculture to adapt (shrinking irrigated areas, shifting crop rotations) by assigning it less water than it has today.

Despite the different timeframes, these studies all suggest exacerbated stress on water resources, in a large portion of the country, in the future. These challenges will have varying repercussions on agriculture, depen-

ding on where this activity stands in relation to the other usages on the ranking.

Quantification, why it matters and its limits

Besides the insufficiently explicit rules on use conciliation, these studies have other limits. Here, we will mainly discuss those pertaining to quantification, which is arguably essential in discussions about this issue.

Quantifying future resources is justified for several reasons. Firstly figures are required to comply with regulation which prescribes calculations involving withdrawable volumes¹², crisis flows and low-flow objectives¹³. Quantifying is also essential for the stakeholders who need to size heavy investments (irrigation, hillside retention facilities, etc.). Building “measurable” objectives seems inherent to studying the future of water resources.

The *Aqua 2030* foresight exercise, however, decides against quantifying and thereby sidesteps all the related difficulties. It broaches impacts on water resource quality and quantity but does not put a figure on the latter. It considers the consequences of disruptions (in technologies for instance), which are not always simple to build into models¹⁴ despite the nearer-term timeframe. This study is thus hampered by the limits inherent to the lack of quantitative findings, in particular as regards scenario consistency and representations of the level of tension.

The quantification in the other studies begs a question about elaborating various “measurable” objectives. Indeed, “measurable” effects generally depend on the situation in which they are formulated. They often reflect existing conflicts and interactions between the various stakeholders influencing the foresight studies, even though these aspects are rarely explicit¹⁴. The relevance of these objectives may therefore be under debate once the framework evolves due to changes on a global scale and research findings.

Even though quantification contributes to consistency, there may also be a significant amount of inaccuracy. On the supply side, they stem from scientific uncertainty over modelling, but ongoing progress in research is nevertheless narrowing those grey areas. On the demand side, conversely, the lack of a robust, shared method to derive quantitative estimates puts into question the capacity to provide quantitative findings. The – sometimes brief – descriptions of agricultural demand and the essentially qualitative appraisals of the quantitative results are two examples of this.

Lastly, other problems revolving around quantitative management of water are often eluded or addressed on the fringe of the exercise. As a result, studies could underestimate the tensions at play. Examples include pollution, needless to say, but also soil and biodiversity erosion, watercourse morphology and other essential factors, which impact and are

impacted by the volumes of water available for the various uses. We can also mention questions involving geographic scales, and the possible differences between the watershed and the supplying basin¹⁴. These issues provide a number of angles for research to better understand these various aspects, starting with studies combining the quantitative and qualitative dimensions of the resource, and economic assessments geared to estimating the costs of the different scenarios.

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Beyond the figures and their limits, these recent projections and foresight studies all underscore the significant tensions that will surround water resources in the future. The fact that these conclusions converge will require the agricultural sector to adapt, due to changes in the climate down the road as well as other global developments, which will impact this resource directly or via other uses. This prospect therefore increases the need for adaptation strategies accommodating each local area's specifics on the supply side (optimising storage, retention facilities, etc.) and demand side (choice of species and varieties, evolving practices, irrigation efficiency). Beyond shedding light on the efforts that each sector now needs to make, these studies also raise an important question about the methods for arbitrating and reconciling the different uses, and hence access to water.

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9. Martin P., 2013, *La gestion quantitative de l'eau en agriculture : une nouvelle vision, pour un meilleur partage*, report for the French Prime Minister.

10. In this regard, Article L.211-1 of the French Environmental Code provides the main principles for sharing water today.

11. Godot C., avril 2013, *Les risques stratégiques de la gestion quantitative de l'eau en France et les perspectives d'adaptation à l'horizon 2030*, CGSP, Analysis No. 328.

12. *Circulaire du 30/06/08* on absorbing quantitative deficits in water withdrawal and the collective management of irrigation withdrawals (MEEDDAT official journal No. 2008/15 of 15 August 2008).

13. *Decree of 17 March 2006* on the content of water management and development master plans, article 6.II as amended by the decree of 27 January 2009.

14. Fernandez S. et al., *Prospectives et tensions sur l'eau. Des crises de l'eau en 2050 ?*, summarising the 30 and 31 May 2013 symposium organised by SHF, AFEID and Académie de l'eau.

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