Water and Agriculture: Turning a Toxic Relationship into a Beneficial Cycle

Mason Clark[1], Emma Clark[1], Mia Brown[2]

[1] School of Chemistry, University of California, Berkeley, USA

[2] Department of Marine Biology, University of Cape Town, South Africa

Water inequalities and extreme weather events are putting food security and peace at high risk. These tensions, already present, are only going to increase with a changing climate. Water and the access to it, is seen as the main reason for conflicts in the future[1]. As a major consumer of water[1], agriculture is deeply involved in this concern and should therefore be active in the elaboration of solutions regarding water distribution.

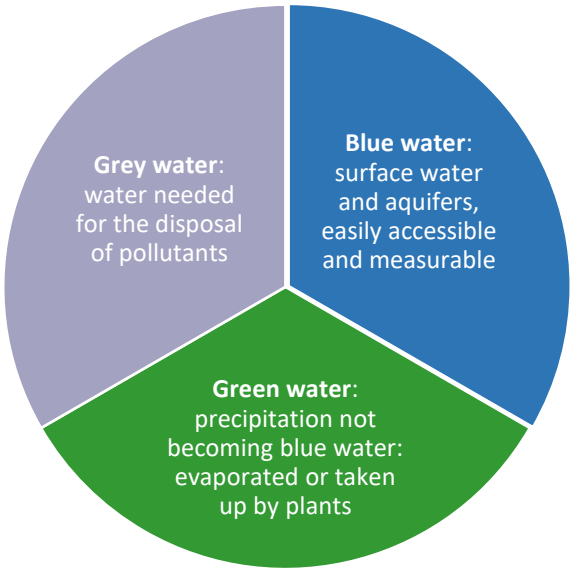

Figure 1: Sum of the virtual water needed for the production of a food: the water taken from aquifers, precipitation and disposal of pollutant. The flow from one to the other is a continuous process.

Water is obviously needed to produce food; whether it means rain or irrigation of fields, water and food for cattle or flooded areas for rice, water is an essential component of agriculture. Therefore, the first thought to save on water would be to use water more responsibly, growing more drought resistant varieties to water them less.

However, it is also important to consider the “invisible” or “virtual” water need, to fully measure the impact and implications of water shortage or water inequalities. So, the definition of blue, green and grey water was proposed (see Fig 1) to quantify the real need of water depending on the whole production chain. With this definition, it becomes clear that agriculture is not only a neutral consumer seen locally but can be part of the problem of increasing local water shortage and pollution or be the part of a solution with regards to water distribution and quality. Indeed, growing plants or cattle in one place can imply growing crops for feed in another place, to export crops means transport green water from one place to another, sometimes far away place. In this optic, to reduce the water footprint of crops, it is important to reduce pollution (less water losses to grey water), use the aquifers in a sustainable way (not exceeding the refill rate, no water waste) and planning the cultivation in a way to reduce green water (less water-hungry crops, reduce evaporation) (see fig 2).

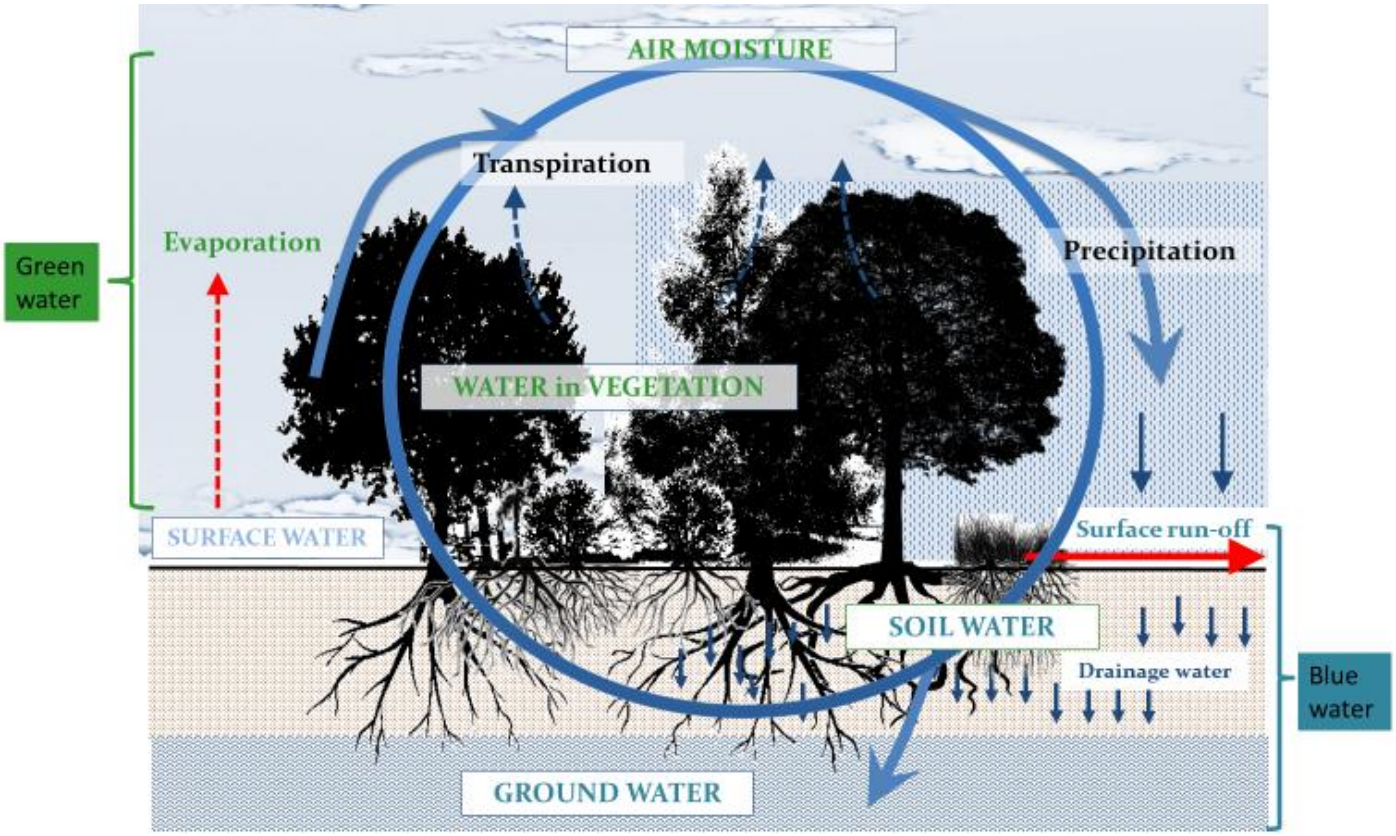

Figure 2: Water cycle around a forest.

What is the field of possibilities?

Much of the efforts to invest in developing the future of agriculture has to mitigate water stress. Not only shall we plan cultivation in a way to reduce green water (less water-hungry crops, reduce evaporation). It is possible to plan even further: plant to increase the flow from green to replenish blue water. Water accumulation in perennial plant parts (tree roots), that function as a water pool, slowing down water drainage and surface flow, have an effect similar to blue water pool replenishment.

Planting trees is essential for many ecological services, it is an unavoidable point to cool down the planet – not only to provide mitigated temperatures during a hot summer[2, 3]. Trees are among the most effective way to store carbon and reduce air CO_2[4]. But one bottleneck of CO_2 uptake is however precisely water. Indeed, CO_2 uptake by plants is largely affected by the water stress, and higher levels of CO_2 without sufficient regular water supply are not used by growing plants. In other words, water stress diminishes the CO_2 uptake; even equivalent wetter years do not manage to make up for this loss[5]. Hence, keeping a sufficient soil moisture is not essential only for life (drinking water) or for cultivation, but also on the bigger scale, to ensure a balanced climate. Trees, on the other hand, in form of forests, have the capacity to influence precipitation patterns, and bring rain far from coastal areas [6]. How can we significantly increase tree coverage and so put in motion the virtuous circle of water and CO_2 capture?

To ensure a global effect, the surface converted must be consequent enough. To get an idea, it can be useful to refer to the historical small glacial period following the colonization of the Americas[7]: If the Great Dying of American native populations led to surfaces of the dimension of 55 million hectares - the size of France - to be taken back from native forests, thus reducing CO_2 of about 5ppm, influencing the climate worldwide, it is unthinkable to cover areas with "native" forest, nowadays, of those – or greater – dimensions. However, considered the surface occupied by agriculture, **if agriculture is conceived, on a large scale, as a forest, the horizon of possibilities suddenly widens up**. In times where agriculture has such a significant impact on the environment and is such a big consumer of water, it is not difficult to imagine that changes in agricultural practices will have an impact on various environmental factors.

Among these practices, intercropping is seen as having a high impact in water-related issues. Natural Water Retention Measures is a project mandated by the Directorate General of the European Commission. A report of this project places intercropping as a significant measure to enhance sustainability, as it triggers the increase of infiltration and/or groundwater recharge by slowing down runoff and increasing soil water retention: it plays also a role for the enhancement of precipitation. Additionally, it is an important part of measures to reduce flood risks and an important element for a better protection for ecosystems, the reduction of erosion and the filtration of pollutants.[8]

The efficiency of "cooperation between species" like intercropping, symbiosis or other partnerships, is particularly visible in arid or semi-arid areas. There are several cases of enhancement of agriculture with the combination of plants and/or microorganisms[9, 10]. Symbiosis in particular with fungi also improves water use, to a point to be used to support cultivation in regions affected by desertification[11]. As water stress and its possible catastrophic effects are primarily occurring in those parts of the world, it is even more important and urgent to act with global, sustainable solutions with those vulnerable regions in mind[12].

Another important point in favor of the development of agroforestry-type cultivation, is the pressure on native forests to keep up with the high demand for fertile land to grow crops for exportation (cocoa, palm oil, soy, biofuels, to name a few), leading not only to deforestation[13] but also to important social and political conflicts[12, 14, 15]. There is a need for a system that allows to grow high demand crops and subsistence crops at the same time, while keeping the soil fertile on a longer term, to relieve pressure on native forests. And if there are chances that this approach also helps – even a little – to empower the producer families and reducing conflicts by putting instruments in the hands of as many people as possible, it is worth more than a step in this direction. Therefore, in the following path of tree planting

calls as the Billion Tree Campaign [16], or the trillion tree campaign [17], it is essential to integrate trees in the very core of agriculture.

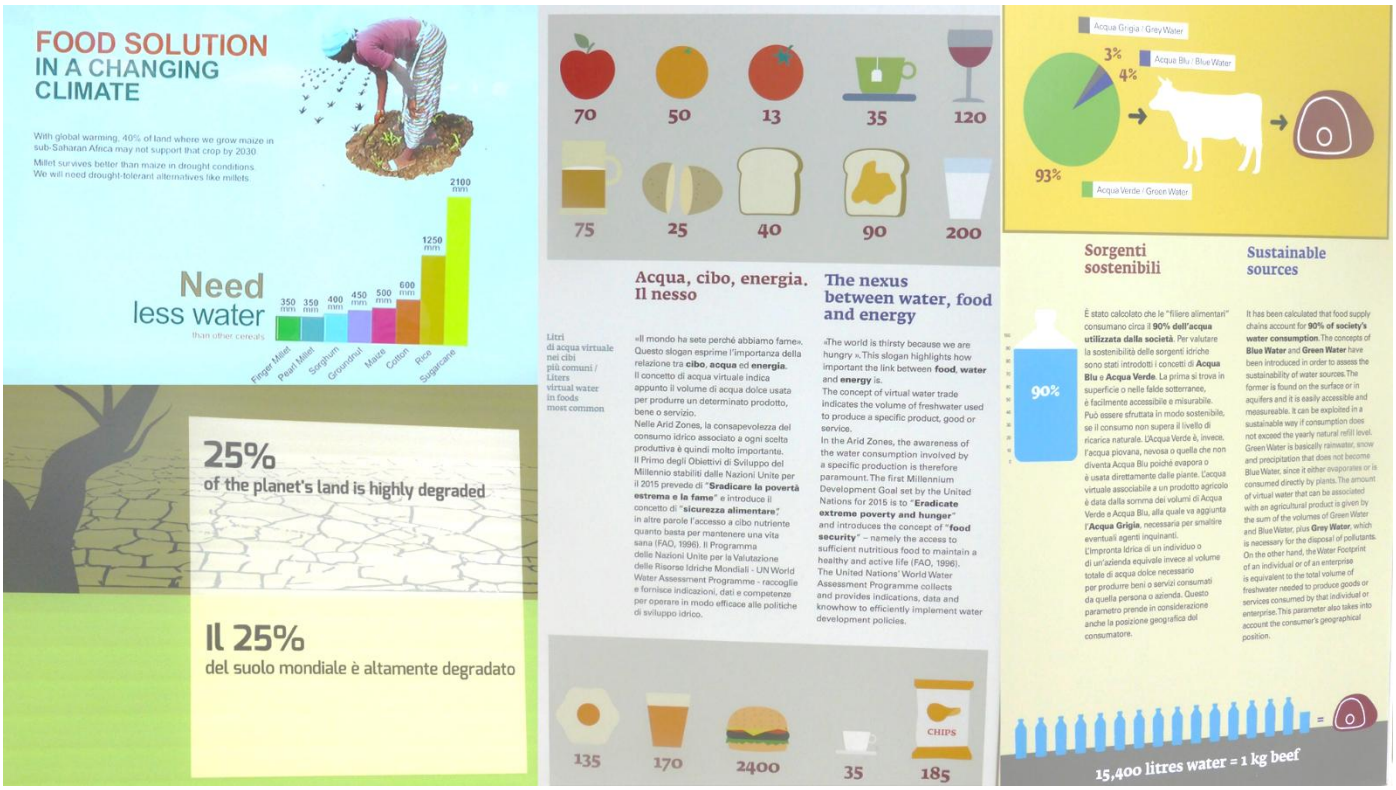

Fig. 3: Posters from EXPO, the world fair about food, Milano, Italy, EXPO2015. The world needs to change the way to approach food consumption, production and the calculation about the real costs of it.

Of course, food choices and the very conception of animal husbandry have a deep impact on the water cycle, too[18]. Not only is meat consumption a very high consumer of this "virtual" green water to feed those animals (see figure 3), but it also consumes a large amount of either grey water in case of intensive animal keeping, or large surfaces often taken from forests in case of extensive animal keeping. Reports by EAT[19] show that an adjustment of the consumption of animal products is linked with health on global scale, and that following either approaches – health and environmental sustainability – will lead to a common beneficial change. Our range of action is thus extended beyond food production and producers all the way along the food consumption and consumer, especially those who have the most choice – industrialized countries.

The future – where to?

Our human society has influenced in many ways, in different directions, climate and environment on a large scale, since centuries, in particular through agricultural activity. As a consequence, we ought to take our capability to do so with responsibility and wisdom and to extend our knowledge and action

accordingly. The future of agriculture cannot only focus on producing more drought resistant crops. For one, even if some places on the planet are more likely to suffer permanent water deprivation, extreme weather events mean sudden changes in weather patterns that drought resistant plants alone are not meant to cope with. Also, planting crops in a "business as usual" way will not contribute to lessen the adverse effects that are already occurring. Furthermore, the increasing water stress goes beyond local events, it is a global issue where the causes are often delocalized from their effects, so the solutions have to follow a similar logic, going beyond a local change of one crop type. Similarly, consuming food with a very high content of "virtual" water as a part of a concept of standard, desirable life standard must be questioned.

Agriculture, as a major and essential part of our human part of human activity, must be more that producing food on the short term. Its technical and conceptual development can be and has been both essential to human life and cause for health issues or conflicts through history: it is important to continuously re-consider its practice with the current challenges and future, long term, prospective.

Agriculture, and the consumption of its products, can be - and must be! - an active part of the solution.

References

1. Galland F. La sécurité hydrique, un enjeu majeur pour la sécurité alimentaire. *Diplomatie*. 2019;49:93-95.
2. Pugh TAM, MacKenzie AR, Whyatt JD and Hewitt CN. Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons. *Environ Sci Technol*. 2012;46:7692–7699.
3. Dimoudi A and Nikolopoulou M. Vegetation in the urban environment: microclimatic analysis and benefits. *Energy and Buildings*. 2003;35:69-76.
4. Münnich Vass M. Renewable energies cannot compete with forest carbon sequestration to cost-efficiently meet the EU carbon target for 2050. *Renewable Energy*. 2017;107:164-180.
5. Green JK, Seneviratne SI, Berg AM, Findell KL, Hagemann S, Lawrence DM and Gentine P. Large influence of soil moisture on long-term terrestrial carbon uptake. *Nature*. 2019;565:476-479.
6. Sheil D and Murdiyarso D. How Forests Attract Rain: An Examination of a New Hypothesis. *BioScience*. 2009;59:341–347.
7. Koch A, Brierley C, Maslin MM and Lewis SL. Earth system impacts of the European arrival and Great Dying in the Americas after 1492. *Quaternary Science Reviews*. 2019;207:13-36.
8. NWRMproject. Intercropping. *Individual Natural Water Retention Measures*. 2015.
9. Salah AMA, Prasse R and Marschner B. Intercropping with native perennial plants protects soil of arable fields in semi-arid lands. *Journal of Arid Environments*. 2016;130:1-13.
10. Bright MBH, Diedhiou I, Bayala R, Assigbetse K, Chapuis-Lardy L, Ndour Y and Dick RP. Long-term Piliostigma reticulatum intercropping in the Sahel: Crop productivity, carbon sequestration, nutrient cycling, and soil quality. *Agriculture, Ecosystems & Environment*. 2017;242:9-22.
11. DUPONNOIS R, HAFIDI M, NDOYE I, RAMANANKIERANA H and M.BÂ A. *DES CHAMPIGNONS SYMBIOTIQUES CONTRE LA DESERTIFICATION*. Marseille: INSTITUT DE RECHERCHE POUR LE DEVELOPPEMENT; 2013.
12. Blanfort V and Demenois J. Changement climatiques et agriculture: quels enjeux, quels impacts aujourd'hui et demain? *Diplomatie*. 2019;Les grands dossiers n49:85-89.

13. DeFries RS, Rudel T, Uriarte M and Hansen M. Deforestation driven by urban population growth and agricultural trade in the twenty-first century. *Nature Geoscience Letters*. 2010.
14. Les Agrocarburants Industriels Provoquent la Faim et la Pauvreté. *Cahiers de La Via Campesina*. 2009;1.
15. Conférence Paysanne Internationale: Stop Aux Accaparements de Terres. *Les cahiers de La Via Campesina*. 2012.
16. "Commit to Action – Join the Billion Tree Campaign!".
17. https://www.trilliontreecampaign.org/.
18. Springmann M, Clark M, Mason-D'Croz D, Wiebe K, Bodirsky BL, Lassaletta L, de Vries W, Vermeulen SJ, Herrero M, Carlson KM, Jonell M, Troell M, DeClerck F, Gordon LJ, Zurayk R, Scarborough P, Rayner M, Loken B, Fanzo J, Godfray HCJ, Tilman D, Rockström J and Willett W. Options for keeping the food system within environmental limits. *Nature*. 2018;562:519-525.
19. Healthy Diets from Sustainable Food Systems. 2019.