Chapter 3
Rethinking the Agricultural Development Model in Post-COVID-19 Era Based on Scientific Knowledge: The Moroccan Case

Mohamed Taher Sraïri

Abstract The agricultural sector is a strategic economic activity in Morocco, still accounting for around 14% of GDP and employing 40% of the active population. With the emergence of the COVID-19 pandemic, it has been literally shaken up, with growing uncertainties about market opportunities and workers' availability, given the drop in consumers' incomes and the requested social distancing. However, citizens have rapidly acknowledged the importance of agriculture, as it ensured a regular food supply during the lockdown at relatively affordable prices. The pandemic, which has emerged in a particularly dry year in Morocco, has provided an opportunity to revise the constraints facing the agricultural sector, particularly water stress and work remuneration. It has also drawn attention to food sovereignty due to consumers' awareness of the significant share of staple food imported. It is true that these imports represent an amount of virtual water which allow over-passing the domestic water shortage; however, the food trade balance is still in deficit despite the role of agriculture in the export of high value commodities as emphasized by public authorities. In addition, recent studies have shown that agricultural exports rely on growing amounts of groundwater, in areas with an arid to semi-arid climate. This has happened despite the significant state subsidies awarded to farmers to convert old furrow irrigation means to drip irrigation systems. On-farm investigations have demonstrated as well that drip irrigation has mainly resulted in an expansion of the area with irrigated cash crops. This situation has been considered as the opposite of the goal sought by the Moroccan agricultural strategy, which stated that irrigated fruits and vegetables would guarantee higher economic water productivity than rain-fed crops. Altogether, these rapid trends have simply ignored the important added value of rainfall. It seems, therefore, crucial to recognize that the post-COVID-19 agriculture should be different from what it has become. Indeed, there is a need for a paradigm shift where rain-fed agriculture has to get at the top of the political agenda, with significant financial allocation. Moreover, this will have to be coupled with a change in farmers and consumers' awareness about the positive effects of short circuits, to decrease

M. T. Sraïri (✉)
Department of Animal Production and Biotechnology, Head of the School of Agricultural Sciences, Hassan II Agronomy and Veterinary Medicine Institute, Rabat, Morocco
e-mail: mt.srairi@iav.ac.ma

M. Behnassi et al. (eds.), *Food Security and Climate-Smart Food Systems*,
https://doi.org/10.1007/978-3-030-92738-7_3

fossil energy inputs, as well as to promote a low external inputs' agriculture with an insight on the sustainability of diets. In this chapter, we discuss these issues as it appears that it is not only food production which is at stake while talking about post-COVID-19 farming. This has to encompass wide topics, such as environment preservation, rural development, sustainable food systems, etc. This is a compulsory vision based on scientific knowledge, to ensure social inclusiveness and sustainable use of limited resources, to reduce rural exodus, and to guarantee the attractiveness of farming activities to young generations.

Keywords Agriculture · Food sovereignty · Income · Scientific knowledge · Water productivity · Work

1 Introduction

In Morocco, to govern is to rain
Théodore Steeg (1868-1950)

In Morocco, since the Independence (1956), the agricultural sector has always been considered as a key development priority, given the weight of rural affairs in governance and political issues (Leveau 1972). Successive governments have devoted major interest and financial means to enhance the performance of the agricultural sector, particularly through the development of irrigation. In fact, since the colonization era (Préfol 1986) and under the reign of King Hassan II (1961–1999), a national effort of building large-scale dams has been undertaken (Funnel and Binns 1989) within the framework of the so-called 'Million ha irrigation plan'. This was a mandatory orientation, as the arid and semi-arid climate characterizing most areas of the country—more than 80% of its surface, with average annual rainfall levels below 400 mm, and with a very long and hot summer season—implies the use of irrigation to secure the harvest of vital crops, such as fruits, vegetables, sugar beet, maize and lucerne (to feed dairy herds), etc.

By the year 2008, public authorities launched an ambitious agricultural strategy named the 'Green Morocco Plan'(GMP) which aimed to accelerate the rhythm of irrigation adoption, by subsidizing at levels up to 80% and even 100% (in the smallholder farms, with less than 5 ha) of the investments needed to dig wells and boreholes, as well as drip irrigation equipment. This plan also relied on an innovative approach based on the liberal dogma, by allowing private entrepreneurs to get access to state-owned land, through public private partnerships, and thus encouraging large investment projects in farms earlier managed by state-owned enterprises (Mahdi 2014), which often showed poor performance. These measures have ushered a new dynamic of agricultural intensification, through the mobilization of important financial means, estimated to have reached around 20 billion US $, although it did not benefit fairly to all the operators in the sector; women being particularly excluded (Montanari and Bergh 2019). Although it has allowed improving the output of several commodities, such as fruits, vegetables and poultry meat, the GMP has however not

succeeded in securing a steady increase in vital products, particularly cereal grains, dates, milk, etc. For the specific case of the dairy sector, Morocco has witnessed a milk boycott during 2017, which has revealed the setbacks in the chain's governance, hindering all the efforts made to increase its value and milk consumption average levels, in order to improve animal source food intake. Morocco remains, therefore, still importing huge quantities of staple food products: for example, more than 4 million metric tons of soft wheat annually (almost 120 kg *per capita* per year).

With the emergence of the COVID-19 pandemic, some important players in the exports of cereal grains have announced that they could adopt protectionist measures and limit the volumes injected in global markets (Espita et al. 2020). Consequently, local voices in Morocco have tried to inform the public opinion on the risks of these new developments. They have also insisted on the idea that former free trade-oriented policies should be questioned, given the sensitive issues represented by food sovereignty and its consequences on domestic affairs. Moreover, the COVID-19 pandemic has also implied a surge of cases in some agricultural related activities, particularly in berries' handling workshops, mainly export oriented.

Given that the COVID-19 pandemic has emerged in a context marked by the end of the GMP and the launch of a new strategy called the 'Green Generation 2020–2030', which aims to consolidate the GMP's spirit and overcome its shortcomings, it seems inevitable that an analysis of the possible developments of Moroccan agriculture has to be undertaken. This has to be achieved by questioning the ability of scientific knowledge to efficiently influencing relevant decision-making processes (Sager et al. 2020), given that significant criticism has been targeting the GMP's methodology (Akesbi 2015) since its implementation. In fact, this plan almost ignored the important existing literature on the risks linked to agricultural intensification under arid and semi-arid conditions as well as the diversity in farms' structures and strategies (Faysse 2015). Altogether, these ideas impose an objective thinking on the future paths that may be followed by the Moroccan agricultural sector. This is the main purpose of this chapter which tries to analyse the potential developments of agriculture sector in a post COVID-19 context based on empirical evidence and assessments of global agriculture and food systems (Dernini and Berry 2015), as well as domestic data sources (Office of Change 2020) to establish baselines for comparison with the case of Morocco.

2 The Importance of the Agricultural Sector in Morocco

During the three-month lockdown, the importance of agriculture has become obvious: food stockpiles rapidly constituted by households have gained a value higher than the one of prestigious societies' shares in stock markets. The population has, therefore, learnt about the crucial roles of agricultural sector, mainly the regular and steady supply of vital food commodities, job creation, territories' maintenance, etc. In fact, with the interruption of the services in large cities, numerous workers of rural origin were forced to go back to their villages, where they tried to recover a modest income,

through farming activities. During this lockdown, the vital contribution of farmers' work, which ensures food supply, has been acknowledged by the public.

Such developments are in total accordance with the thesis of the American anthropologist David Graeber who insists on the emergence in modern societies of hundreds of trivial jobs (or 'bullshit jobs'), whereas the most important activities needed to ensure the well-being (food, education, health, etc.) have become less considered as they do not guarantee decent wages (Graeber 2018). This comes as a key finding which is now well-established; indeed, analysing the remunerations in the agricultural sector demonstrates that even though it employs 40% of the workforce (3.7 million people), it only ensures 13–14% of the GDP (Haut Commissariat au Plan 2015). This means that the wages are limited and not steady, given the seasonality of farming activities, mainly in rain-fed systems. And even in large-scale irrigation schemes, as well as in areas with complementary irrigation (i.e., regions which have turned to the groundwater economy with private wells), a working day will only allow a limited income, generally less than 10 US $ (Sraïri et al. 2013; Sraïri and Ghabiyel 2017). This is often due to the heavy workload induced by livestock rearing (routine daily work needed to feed the animals, milk the dairy stock, etc.) (Cournut et al. 2018), but which sometimes is the only source of income for smallholder farmers who do not own sufficient assets (capital, land, and water) to practice cash crops. Indeed, it is worth mentioning that smallholder farms (i.e., with less than 5 ha of arable land) still represent more than 80% of the total number of farms. Therefore, with such a structural constraint, livestock has to be considered as the 'wealth of the poor' (Duteurtre and Faye 2009). This is not the case for intensive poultry production, which has faced a severe downturn with the outbreak of the COVID-19 pandemic, given that fast food consumption has plummeted, inducing a significant drop in eggs and meat demand as well as a sharp decrease in farm gate prices (Kouame 2020). This has been worsened by the fact that all ceremonies—such as weddings and pilgrimages which traditionally constitute events where poultry products are massively used—have been halted.

Finally, with regard to the work in agricultural sector, most of farmers—who do not enjoy social protection—are less motivated to remain active in farming activity forever. This certainly explains the significant number of persons, particularly farmers' sons who prefer migration to urban centers or abroad, seeking alternative sources of livelihood. This dynamic is also exacerbated by other factors, especially water scarcity.

3 Water Stress and Its Consequences for Water Productivity Evaluation

Water stress and its impacts on agriculture sector in Morocco have become an inevitable issue for debate. This is mainly due to the arid and semi-arid nature of the country, as the average annual rainfall levels do not exceed 400 mm in more than

85% of its total area (Fig. 1). This means an acute water stress, since the renewable annual water volume availability *per capita* has become below 730 m^3 (as it was above 2,500 m^3 in the 1960s), given the population growth (less than 11,6 million in 1960, above 35,9 million in 2020) and the decrease in rainfall levels (Fig. 2).

Since agriculture utilizes more than 85% of the total volumes in Morocco in a context of water shortage, a serious threat to its development is represented by water scarcity. This was already pointed out by previous research, which found that developing agriculture in a country facing also limited land availability could be compared to 'mirages' (Swearingen 1986). Analysing water uses by the agricultural sector under such constraints implies a series of precautions, given that this resource is not uniform, as it has several sources: green water (rainfall); blue water (irrigation, whether from surface sources—dams and springs—as well as groundwater—wells and boreholes—and even unconventional sources such as treated wastewater and desalinated seawater); and finally virtual water (which means the water volumes used in the countries of origin of food imported in another location). In fact, the latter source of water has been recognized as a significant mean to overpass scarcity

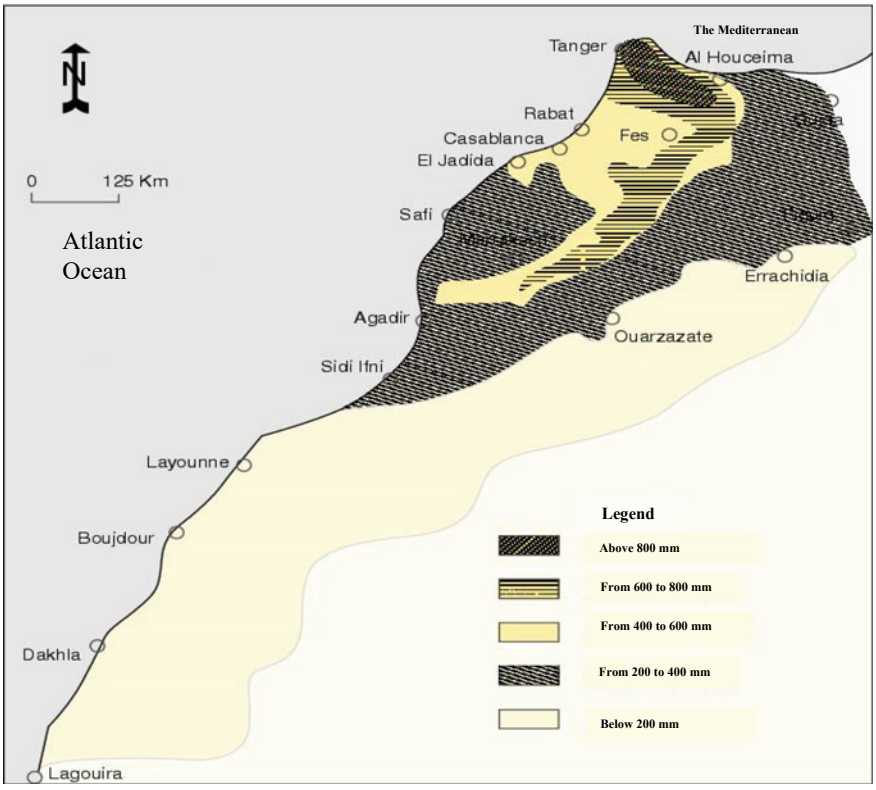

Fig. 1 Regional average rainfall levels in Morocco

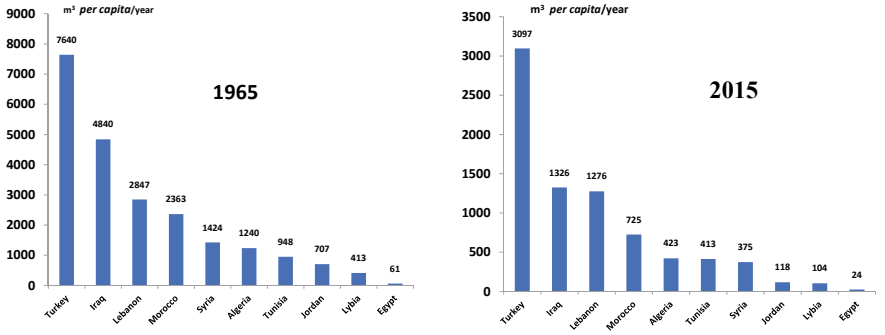

Fig. 2 Renewable water availability *per capita* per year in the Middle East and North Africa (MENA) countries. *Source* The World Bank (2017)

in water-stressed regions like the MENA, where water stress is acute (Antonelli and Tamea 2014).

In addition, climate change scenarios (an increase of 2 °C in average temperatures and less rainfall; −15%, with more frequent extreme climate events like flash floods and long periods of drought) imply that the water stress is going to get amplified, exacerbating social and economic vulnerability of people whose livelihoods are mainly linked to farming activities (Schilling et al. 2020). This might be even more felt in rain-fed systems with no possibilities of irrigation, as these continue to represent more than 80% of the total arable land. This is really worrying for the future of the agricultural sector, given that irrigation has been considered since the colonization era as the unique vector of development; this approach seems reaching its utmost limits. Since the launching of the GMP, its dynamic was to reach a climax and the public authorities have allocated significant budgets to ensure the adoption of irrigation means (from wells and boreholes digging to drip irrigation equipment installation). As a consequence, the area converted from furrow irrigation to drip irrigation has almost reached 500,000 ha (around a third of the total irrigation surface), ensuring, according to the promoters of such a program, significant water savings. However, on-farm follow-ups have revealed that these savings are almost theoretical (Batchelor et al. 2014), whereas in reality, drip irrigation spreading has mainly resulted in an increase of the surface irrigated per farm, and the substitution of traditional rain-fed crops (cereals, leguminous pulses, autumn fodder like oats and barley) by high water-consuming cash crops (orchards, vegetables, maize, etc.). The follow-ups have also revealed the important means of 'bricolage' adopted by farmers and technicians to allow the spreading of such an innovation (Benouniche et al. 2014) in systems where formal training is almost lacking. As a consequence, water uses have soared, mainly from private sources (i.e. wells and boreholes), implying the emergence of the groundwater depletion phenomenon (Molle and Tanouti, 2017).

This situation is particularly obvious in the most arid areas of the country (i.e. its southern and eastern zones). Moreover, such financial rationality applied to the agricultural sector has also induced that the rain-fed crops—which used to be its

actual pillar and a barometer that is still used to assess its annual performance by spring (i.e. the expected output of cereal grains which in fact influences the whole economic growth of the country)—are increasingly considered as elements of the past. At the contrary, irrigated crops (mainly orchards) have reached an emblem of high investment agriculture, enabling farmers who practice them to get social consideration, given the skills they necessitate and their contribution to the country's export potential. This dichotomy between irrigation and rain-fed agriculture has created dangerous drifts, which have become unacceptable. For instance, some ideas began to defend that irrigated crops systematically perform better than rain-fed ones, as they allow higher yields (without taking into consideration the low level of dry matter their products contain…) and better profitability. But these ideas do not consider that the irrigation expansion has amplified water withdrawal from aquifers, generating groundwater depletion (El Moustaine et al. 2014). Moreover, it has also resulted in output surpluses for certain kinds of fruits and vegetables. Therefore, it has not always allowed reaching the goal which was sought, i.e. an increase in water economic productivity (US $ per cubic meter of water).

There are many examples which confirm these findings. For instance, the difficulties to sell citrus fruits, due to important volumes ensured by newly-planted domains, which benefited from public subsidies (irrigation, seeds, etc.) in addition to the limited competitiveness of the Moroccan product on global markets (as some other countries have lower prices), have even definitely pushed certain farmers to pull up trees. This has also been precipitated in some regions, like the Souss Massa (south-west of the country), due to severe water shortages as well as the increase of irrigation water salinity levels, implying that farmers simply abandon their trees. Moreover, water reserves in dams have collapsed due to several successive years of extreme drought meaning that the public authorities have informed farmers they cannot rely anymore on surface water to irrigate their plots; the remaining volumes in dams being reserved to cities' supply. A similar scenario has also been witnessed in the oasis regions, where the expansion in desert borders of irrigation areas from groundwater sources has quite exclusively been devoted to the cultivation of watermelon and date palms, creating a dichotomy between traditional oases and 'modern' expansion areas (Hamamouche et al. 2018). Logically, the same phenomena of output surplus and water resources depletion have occurred, aggravated by the very arid climate of these regions (less than 100 mm per year). Therefore, the steady supply of water to urban centers has become hampered, as the level of the aquifer has deepened. In addition, watermelon profitability is not definitely guaranteed, as it can suffer from a drop in the local demand or an abundant output, which is sometimes not absorbed by the export markets.

These facts do not however prevent those who benefited from public subsidies to exploit groundwater to lobby for further support, particularly for solar energy pumping, which will amplify water withdrawals. This can only generate social exclusion, given that those who cannot handle additional investments for digging deeper boreholes have already withdrawn from the groundwater economy (Ameur et al. 2017). The expansion of drip irrigation area has been promoted to the status of a doxa for all operators in agricultural sector, from farmers to technicians and researchers,

implying that all the efforts converge toward more production with additional water, even from unconventional sources (i.e. treated wastewater and desalinated seawater). Very few voices now dare expressing different ideas from this single thought, like for example the improvement of rain-fed crops' yields, particularly cereals which prove adapted to the specific climate of North-African centuries.

In fact, the output of cereal grains did not improve enough with the launching of the GMP, despite some support measures, like the promotion of the cereal seed system (Bishaw et al. 2019). The existing data show that the annual cereal production in Morocco has remained largely determined by rainfall levels and their distribution, implying an important inter-annual variability (Fig. 3). In fact, the GMP almost added nothing to the existing patterns of production, as it only reinforced the substitution of barley by soft wheat as the leading species, in terms of the area sown, given the important demand for that particular cereal in consumption habits. No significant improvement in the average yield could be achieved and their levels remain very far from the average global (3 tons/ha) and even African (2.3 tons/ha) levels. Despite the efforts to generalize the use of fertilizers, at a time where Morocco is one of the leading countries in rock phosphate production (Lyon et al. 2020), low cereal yields also reflect the poor water management in soils. They also reveal the weak extension systems, implying that for this strategic sector, long-term interventions to spread conservation agriculture adoption are urgently needed, as it has been shown in a similar North African context (Tunisia) (Bahri et al. 2019).

The single thought legitimizing the continued depletion of water from arid areas is in fact based on the theory of comparative advantages, where Morocco is assigned to export more and more fruits and vegetables by mobilizing a cheap workforce at a time where he has to import a large share of the staple food used (cereal grains, pulses, vegetal oils, sugar, feedstuffs for livestock, cheese, etc.) (Table 1). Likewise, this single thought neglects all the collateral damages inflicted to the environment,

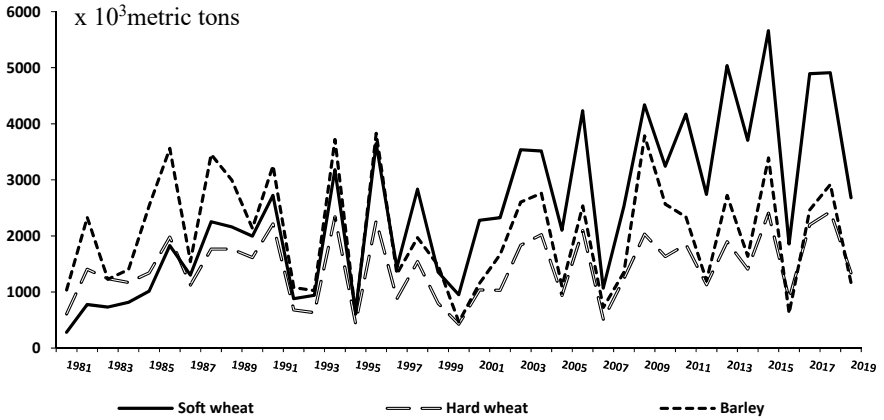

Fig. 3 Inter-annual variability of the output of cereal crops (1981–2019). *Source* Adapted from ONICL (2020)

Table 1 Main imports of food commodities in Morocco, 2018 and 2019 ($\times 10^6$ US $)

Commodity	Imports in 2019	Imports in 2018
Wheat	923,2	912,4
Oil meal	524,1	491,1
Maize	523,5	464,7
Sugar	395,7	350,6
Tea	223,5	206,9
Dates	162,3	114,3
Cheese	95,1	103,0

Source Adapted from theOffice of Change (2020)

such as desertification and degradation of many fragile ecosystems, and promotes an agricultural development model whose limitations have been totally unveiled by the COVID-19 pandemic.

4 Rethinking an Innovative Agricultural Development Model

The sudden outbreak of the COVID-19 pandemic has had an appalling impact on the Moroccan economy, as it has prompted a sharp recession, the first of its kind since 1995 (World Bank 2020). This has meant a drop of about 6% in the GDP due to less production and services as well as a decline in tourism incomes (more than 250,000 jobs lost in this sector alone), which will generate an overall deficit whose value reaches around 8% of GDP. The multiple costs (economic, financial, health, etc.) of the pandemic have called for innovative thoughts related to a more balanced world, where the human well-being should be the top priority rather than profit, underlining the importance of implementing efficient education systems and sustainable consumption patterns as well as solidarity. These ideas have to nurture in order to help conceiving alternative ways of living, allowing future generations to evolve in a still liveable planet, in spite of the numerous challenges linked to climate change and the growing pressure on rare resources because of the demographic growth and rapid urbanization (Acuto 2020).

Therefore, the COVID-19 pandemic constitutes an opportunity to be ceased by the Moroccan agricultural sector. It offers an occasion to realize an objective and in-depth assessment of the GMP and the identification of alternative pathways for a sustainable development. The most urgent decision to be taken should aim at reviewing the previous priorities of intense water withdrawals. Indeed, improving water productivity in the agricultural sector requires considering that "a crop needs more than a drop" (Kuper et al. 2009). It has to be accompanied by a necessary assessment of the sources of the resources used whether 'green water', 'blue water' or 'grey water' (Hoekstra and Mekonnen 2012). As a consequence, public policies

have to be assessed carefully by using the latest scientific knowledge, in order to give the priority to 'green water' (Rockström et al. 2009). This has to be adopted wherever rainfall levels allow profitable farming systems to develop, meaning that rain-fed crops and activities have to be effectively encouraged: cereals, pulses and livestock using rangelands and fodder resources without irrigation.

In the same line, Sraïri et al. (2009a) have demonstrated in the Tadla irrigation scheme that dual purpose herds (both milk and meat at the same time) require important volumes of water: respectively 1.7 and 9.1 m^3 of water per kg of milk and live weight. The same authors also found in the Saïss plain (i.e. a rain-fed area with cereals and pulses, but which turned recently to the groundwater economy, by planting orchards), that the dairy stock within smallholder farms uses rainfall as the main source of water to get milk and live weight. In addition, livestock also uses significant amounts of virtual water, like imported grains and even bread leftovers. These findings mean that the livestock chains do not cause any harm to the groundwater table in areas with more than 500 mm of annual rainfall levels (Sraïri et al. 2016). At the contrary, onions and orchards, which have developed significantly in the area because of the public incentives levied by GMP, contribute to the groundwater depletion phenomenon. In fact, rain-fed crops, particularly cereals and legume pulses, not only ensure food supply for humans, but they also produce various by-products such as straws and stubble, which are strategic to rear livestock (Magnan et al. 2012). In addition, livestock plays a crucial role in farming systems' resilience as it allows diversifying the sources of incomes, and it represents an insurance to face climate crises as well as economic disturbances (Ryschawy et al. 2013). It often represents the unique source of revenues in smallholder farms, where the existing assets (land, capital and even water) are not sufficient to ensure livelihoods. Livestock will however mobilize important volumes of routine work, with limited remunerations (Sraïri et al. 2018).

Moreover, the governance of supply chains implying thousands of smallholder farms impose a bottom-up organization, where stakeholders (farmers, processors, retailers, consumers' organizations, etc.) have negotiating space to discuss urgent hot topics related to the chain: quality assessment and remuneration, technical support for farmers, value chain distribution, etc. (Sraïri et al. 2009b; Sraïri et al. 2011; Ourabah et al. 2017). Unfortunately, that was not respected in GMP's goals regarding dairy chain. The efforts converged towards encouraging mega dairy farms which benefitted from a consequent share of subsidies (heifers' imports, milking devices, drip irrigation, etc.), but without taking into account the evolution of smallholder systems, whose constraints (especially limited farm gate milk price, several setbacks linked to insufficient feed availability, and unbalanced dietary rations) remained quite unchanged (Sraïri et al. 2015). Altogether, these findings have finally resulted in the emergence of the phenomenon of the 'dairy boycott' which was witnessed during spring 2017 for a period of six months. Even if it targeted only one dairy processor (the leading one in the market which used to collect around 50% of the volumes, i.e. 'Centrale Danone'), it soon affected all the chain, as milk collection circuits were all severely disrupted, given the significant drop of consumption levels. As a consequence, farmers could not easily market their daily output. It is estimated,

according to FAOSTAT (2020), that Morocco has lost around 25% of its annual milk production from 2017 to 2018, and this means that all efforts undertaken within the framework of GMP for this chain, particularly huge amounts of public money, have been simply wasted (Fig. 4).

The difficulties of implementing a sustainable dairy chain remind everyone of the constraints which have to be taken into consideration when it comes to resources management (Sraïri et al. 2019). Hence, the importance to promote a sound governance of the whole agricultural sector is obvious, by designing policies through inclusive approaches. As the water constraint is surely the most biting, it has to be acknowledged that adding value to rainfall must be the top priority in the future agenda. As a consequence, improving cereals' average yield has to be sought by all means, not by additional irrigation or by sowing more surfaces devoted to these crops in irrigation schemes. At the opposite, improving the cereal output has to be achieved in the rain-fed areas, mainly in favourable years with enough and regular rainfall levels. This has to be entailed by support efforts as well as research programs which should allow the reinforcement of synergies between rain-fed crops and livestock, in order to lay the foundations of a sustainable agricultural development on the long run (Szymczak et al. 2020). This also has to be done in low external input agricultural systems with a minimum use of irrigation water, fossil energy, fertilizers and pesticides, through the integral recycling of biomass residues as well as manure, in what is currently known as the 'circular economy', where livestock plays an essential role (Peyraud et al. 2019). This concept is far from the pillars sustaining the recent development of poultry products' chains, either chicken meat or laying hens, which have allowed Morocco to reach by 2020 average annual consumption levels of 22 kg of poultry meat and 185 eggs *per capita* (FISA 2020). In fact, such an output from poultry facilities is almost entirely based on imported inputs, particularly maize grain (2.2 million metric tons per year) and soya meal, implying a significant carbon footprint for these products (Sraïri 2011).

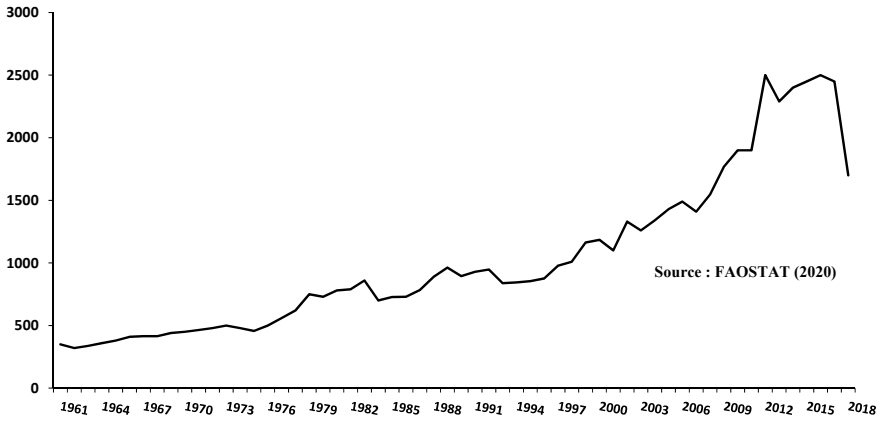

Fig. 4 Evolution of the annual raw milk output in Morocco (1961–2019). *Source* FAOSTAT (2020)

In addition to farming systems design in favour of integrated crop-livestock activities, adding value to the irrigation water is also mandatory, as it remains limited in many chains (Schyns and Hoekstra 2014). This might also need to be accompanied by the promotion of priority proximity markets. All these concepts represent opposite directions to the philosophy of GMP which has mainly promoted the model of very large specialized farms, with the domination of monoculture with a decoupling between livestock and crops: either orchards or dairy herds fed with maize silage irrigated from groundwater. Such models are nowadays criticized because of their environmental and even economic vulnerabilities (Garrett et al. 2020). In fact, in Morocco, it has appeared that large farms specialized in one species (citrus, olives, etc.), which benefitted from important public incentives to plant trees and to dig boreholes as well as to equip themselves with drip irrigation means, were particularly vulnerable to any hazard related to heath (the emergence of a new pathogen), economy (the decrease in prices because of a surplus output or because consumers lost their incomes) or even climate change (extreme events like drought, flood, hails or freezing).

Given all these rapid developments and taking into account the increased food prices volatility in global markets, it has to be acknowledged that the key concept of 'food sovereignty' has to be considered again, as Morocco imports around 200 kg *per capita* per year of cereal grains (mainly soft and hard wheat, but also maize for poultry and ruminants). Recognizing the specificities of food and agriculture means a massive investment in local production systems while avoiding an overdependence on global markets. Moreover, it also ensures thinking about the sustainability of future's food systems in Morocco, a country which used to adhere strongly to the precepts of the Mediterranean diet, but, because of the shifting dietary patterns, it is starting to suffer from significant outbreaks of overweight and obesity: respectively 46.8 and 16.4% of the total population according to the World Health Organization (WHO 2011). In fact, adding value to rainfall for food production not only will decrease fossil fuel used for pumping irrigation water as important volumes of subsidized butane are consumed for that purpose (Doukkali and Lejars 2015), but it will also ensure preserving diets with an important contribution of locally grown staple food of vegetal origin, one of the pillars of sustainable food systems (Willett et al. 2019). Finally, promoting the local production and short circuits will also allow decreasing the important amounts of fossil fuel needed to export and import hundreds of thousands of tons of raw food commodities, thus participating to global mitigation efforts.

5 Conclusion

One of the major teachings of the COVID-19 pandemic for Morocco has certainly been the increased interest devoted to agriculture and food systems by the public opinion. Citizens have been forced to acknowledge the vital role of agriculture and farmers' labour. The continuity of agricultural activities during the three-month lockdown, despite health risks and economic uncertainties, has allowed securing a steady

food supply. However, the average consumer has discovered during this period the huge amount of imported staple food (cereal grains, pulses, feed for animals, etc.), a fact which can only persuade him of the current situation of food dependency towards global markets. These imports currently represent around 130 US $ per capita and per year, and have to be considered as imports of virtual water, certainly allowing to find a solution to the structural water stress felt all over the country. These imports have also contributed to supply food to numerous households, given their relatively affordable prices, particularly in the case of families having lost their sources of income and becoming totally dependent on public furlough funding. However, what would have happened if the prices have significantly increased in global markets?

The pandemic having triggered in a very dry year, its effects on the domestic economy will be exacerbated and felt on the long term. This should not constitute an excuse to get back to past reflexes where the expansion of irrigation and the extreme mobilization of water resources (even unconventional such as desalinated seawater and treated sewage water) was the norm. On the contrary, it is urgent to engage a responsible debate on water uses in the agricultural sector at all scales, even if it requires the revision of the ambitions, while accepting that the scientific knowledge has to be associated to policy making, as it was the case during the COVID-19 pandemic management and efforts to avoid its spread. This is particularly of concern since numerous voices have alerted on the risks of a growing water stress which would disturb the supply of this vital resource to important urban centres.

Altogether, these ideas imply a paradigm shift towards the valorisation of rainfall water, by building the capacity of operators in the agricultural sector, particularly through the promotion of good management practices: the choice of seeds, crop fertilization and protection, sufficient and balanced dietary rations for animals, management of manure and liquid wastes, etc. These represent numerous challenges which imply reconsidering the roles of agricultural training, in its various levels (from farmers to technicians and conception engineers). In order to achieve the ambitions of the 'Green Generation' 2020–2030 strategy and allow an inclusive growth, which entails decent wages for the majority of workers in the sector, while ensuring a sustainable use of the needed resources (capital, land and water), a bottom-up approach with inclusive goals has to be implemented. Finally, the ongoing COVID-19 pandemic and the acute economic recession it is inducing should be considered as an opportunity to get rid of past counterproductive ideas and practices. It is more than urgent to see realities as they are and admit that given the numerous structural constraints and hazards impacting the agricultural sector in Morocco (water stress, prices' volatility, emerging diseases, etc.), it is totally illusive to continue to promote it as the locomotive of the economy; investments in effective education systems being by far at the top of the priorities for a new development model.

Acknowledgements The author wishes to thank many crop-livestock farmers who allowed him to pursue long-term farms' follow up, making possible to understand the complexities of issues related to resources' sustainable and profitable use, particularly water and work. Last but not least, the author also thanks his students who assisted in the realization of research works in various areas of Morocco (the irrigation schemes, the oases, the rain-fed plains, etc.), ensuring the collection of reliable data about crop-livestock integration and the challenges it will have to face in the near future.

References

Acuto M (2020) COVID-19: Lessons for an urban(izing) world. One Earth 2:317–319. https://doi.org/10.1016/j.oneear.2020.04.004

Akesbi N (2015) Qui fait la politique agricole au Maroc ? Ou quand l'expert se substitue au chercheur. Annales de l'INRA Tunisie 88:104–126

Ameur F, Kuper M, Lejars C, Dugué P (2017) Prosper, survive or exit: contrasted fortunes of farmers in the groundwater economy in the Saiss plain (Morocco). Agric Water Manag 191:207–2017

Antonelli M, Tamea S (2014) Food-water security and virtual water trade in the Middle East and North Africa. Int J Water Resour Dev 31:326–342. https://doi.org/10.1080/07900627.2015.1030496

Bahri H, Annabi M, M'hamed HC, Frija A (2019) Assessing the long-term impact of conservation agriculture on wheat-based systems in Tunisia using APSIM simulations under a climate change context. Sci Total Environ 692:1223–1233

Batchelor C, Reddy VR, Linstead C, Dhar M, Roy S, May R (2014) Do water-saving technologies improve environmental flows? J Hydrol 518:140–149

Benouniche M, Zwarteveen M, Kuper M (2014) *Bricolage* as an innovation: opening the black box of drip irrigation systems. Irrig Drain 63:651–658. https://doi.org/10.1002/ird.1854

Bishaw Z, Yigezu YA, Niane A, Telleria RJ, Najjar D (eds) (2019) Political economy of the wheat sector in Morocco: seed systems, varietal adoption, and impacts. International Center for Agricultural Research in the Dry Areas, Beirut, Lebanon, p 300

Cournut S, Chauvat S, Correa P, Dos Santos Filho JC, Dieguez F, Hostiou N, Khahn Pham D, Servière G, Sraïri MT, Turlot A, Dedieu B (2018) Analyzing work organization by the work assessment method: a meta-analysis. Agron Sustain Dev 38:58. https://doi.org/10.1007/s13593-018-0534-2

Dernini S, Berry EM (2015) Mediterranean diet: from a healthy diet to a sustainable dietary pattern. Frontiers Nutr https://doi.org/10.3389/fnut.2015.00015

Duteurtre G, Faye B (2009) L'élevage, richesse des pauvres. Versailles, France, EditionsQuæ

Doukkali MR, Lejars C (2015) Energy cost of irrigation policy in Morocco: a social accounting matrix assessment. Int J Water Resour 31:422–435. https://doi.org/10.1080/07900627.2015.103696

El Moustaine R, Chahlaoui A, Bengoumi D, Rour E-H (2014) Effects of anthropogenic factors on groundwater ecosystem in Meknes area (Morocco). J Mater Environ Sci 5:2086–2091

Espita A, Rocha N, Ruta M (2020) COVID-19 and food protectionism: the Impact of the pandemic and export restrictions on world food markets. World Bank Policy Research Working Paper No. 9253, p 30. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3605887

FAOSTAT (2020) Cattle milk annual output in Morocco (1961–2018). Available from: http://www.fao.org/faostat/fr/#data/QL

Faysse N (2015) The rationale of the Green Morocco Plan: missing links between goals and implementation. J North Afr Stud 20:622–634. https://doi.org/10.1080/13629387.2015.1053112

FISA (Fédération Interprofessionnelle du Secteur Avicole) (2020) Statistiques du secteur avicole. Available at: https://www.fisamaroc.org.ma/index.php?option=com_content&view=article&id17&Itemid=53

Funnel DC, Binns JA (1989) Irrigation and rural development in Morocco. Land Use Policy 6:43–52

Garrett RD, Ryschawy J, Bell LW, Cortner O, Ferreira J, Garik AVN, Gil JDB, Klerkx L, Moraine M, Peterson CA, dos Reis JC, Valentim JF (2020) Drivers of decoupling and recoupling of crop and livestock systems at farm and territorial scales. Ecol Soc 25:24. https://doi.org/10.5751/ES-11412-250124

Graeber D (2018) Bullshit Jobs. Editions Les Liens qui Libèrent, Paris, p 416

Hamamouche MF, Kuper M, Amichi H, Lejars C, Ghodbani T (2018) New reading of Saharan agricultural transformation: continuities of ancient oases and their extension. World Dev 107:210–223

Haut Commissariat au Plan (2015) The national survey on household consumption and expenditure in Morocco (in French). http://www.hcp.ma/Introduction-de-Monsieur-Ahmed-LAHLIMI-ALAMI-Haut-Commissaire-au-Plan-a-la-presentation-des-resultats-de-L-enquete_a1819.html

Hoekstra AY, Mekonnen MM (2012) The water footprint of humanity. Proc Natl Acad Sci (PNAS). 109:3232–3237. https://doi.org/10.1073/pnas.1109936109

Kouame JM (2020) Aviculture : la filière perd des plumes. L'Économiste, édition n°5 830. 27 Août 2020. www.leconomiste.com/article/1066363-aviculture-la-filiere-perd-des-plumes

Kuper M, Bouarfa S, Errahj M, Faysse N, Hammani A, Hartani S (2009) A crop needs more than a drop: towards a new praxis in irrigation management in North Africa. Irrig Drain 58:S231–S239

Leveau R (1972) Le fellah marocain, défenseur du trône. Éditions la Découverte, Paris, p 275

Lyon C, Cordell D, Jacobs B, Martin-Ortega J, Marshall R, Camargo-Valero MA, Sherry E (2020) Five pillars for stakeholder analyses in sustainability transformations: the global case of phosphorus. Environ Sci Policy 107:80–89

Magnan N, Larson DM, Taylor JE (2012) Stuck on stubble? The non-market value of agricultural by-products for diversified farmers in Morocco. Am J Agr Econ 94:1055–1069

Mahdi M (2014) Devenir du foncier agricole au Maroc : un cas d'accaparement des terres. New Medit. 13(4):2–10

Molle F, Tanouti O (2017) Squaring the circle: Agriculture intensification versus water conservation in Morocco. Agric Water Manag 192:170–179. https://doi.org/10.1016/j.agwat.2017.07.009

Montanari B, Bergh SI (2019) A gendered analysis of the income generating activities under the Green Morocco Plan: who profits? Hum Ecol 47:409–417. https://doi.org/10.1007/s10745-019-00086-8

Office of Change (2020) Results of foreign exchanges until December 2019 [In French]. Available at: www.oc.gov.ma/fr/actualites/communique-resultats-des-echanges-exterieurs-a-fin-decembre-2019

Ourabah Haddad N, Ton G, Sraïri MT, Bijman J (2017) Organisational challenges of Moroccan dairy cooperatives and the institutional environment. Int J Food Syst Dyn 8:236–249. http://centmapress.ilb.uni-bonn.de/ojs/index.php/fsd/article/view/835/720

ONICL (Interprofessional Office Of Cereals and Pulses) (2020) The output of the main cereal grains' crops (soft and wheat, barley and maize) (In French). Available from: www.onicl.org.ma

Peyraud J-L, Aubin J, Barbier M, Baumont R, Berri C, Bidanel J-P, Citti C, Cotinot C, Ducrot C, Dupraz P, Faverdin P, Friggens N, Houot S, Nozières-Petit M-O, Rogel-Gaillard C, Santé-Lhoutellier V (2019) Science for tomorrow's livestock farming: a forward thinking conducted at INRA. INRA Prod Anim 32 :323–338. https://doi.org/10.20870/productions-animales.2019.32.2.2591

Préfol P (1986) Prodige de l'irrigation au Maroc. Le développement exemplaire du Tadla. 1936–1985. Les Nouvelles Editions Latines. Paris, p 266

Rockström J, Falkenmark M, Karlberg L, Hoff H, Rost S, Gerten D (2009) Future water availability for global food production: the potential of green water for increasing resilience to global change. Water Resour Res 45:W00A12

Ryschawy J, Choisis N, Choisis JP, Gibon A (2013) Paths to last in mixed crop-livestock farming: lessons from an assessment of farm trajectories of change. Animal 7:673–681

Sager F, Mavrot C, Hinterleitner M, Kaufmann D, Grosjean M, Stocker TF (2020) A six-point checklist for utilization-focused scientific policy advice. Climate Policy. In press https://doi.org/10.1080/14693062.2020.1757399

Schilling J, Hertig E, Tramblay Y, Scheffran J (2020) Climate change vulnerability, water resources and social implication in North Africa. Reg Environ Change 20:15. https://doi.org/10.1007/s10113-020-01597-7

Schyns JF, Hoekstra AY (2014) The added value of water footprint assessment for national water policy: a case study for Morocco. PLoS ONE. https://doi.org/10.1371/journal.pone.0099705

Sraïri MT (2011) Le développement de l'élevage au Maroc : succès relatifs, dépendance alimentaire. Le Courrier de l'Environnement de l'INRA. 60 :91–101. http://www7.inra.fr/dpenv/pdf/C60TaherSrairi.pdf

Sraïri MT, Ghabiyel Y (2017) Coping with the work constraints in crop-livestock farming systems. Ann Agric Sci 62:23–32. http://www.sciencedirect.com/science/article/pii/S0570178317300015

Sraïri MT, Chatellier V, Corniaux C, Faye B, Aubron C, Hostiou N, Safa A, Bouhallab S, Lortal S (2019) Durabilité du développement laitier : réflexions autour de quelques cas dans différentes parties du monde. INRA Prod Anim 32:339–358. https://doi.org/10.20870/productions-animales.2019.32.3.2561

Sraïri MT, Bahri S, Ghabiyel Y (2018) Work management as a means to adapt to constraints in farming systems: a case study from two regions in Morocco. Cahiers Agricultures. http://www.cahiersagricultures.fr/articles/cagri/pdf/2017/01/cagri160177.pdf

Sraïri MT, Benjelloun R, Karrou M, Ates S, Kuper M (2016) Biophysical and economic water productivity of dual purpose cattle farming. Animal 10 :283–291. http://journals.cambridge.org/action/displayAbstract?fromPage=online&aid=10082209&fulltextType=RA&fileId=S1751731115002360

Sraïri MT, Sannito Y, Tourrand J-F (2015) Investigating the setbacks in conventional dairy farms by the follow-up of their potential and effective milk yields. Iran J Appl Anim Sci 5:255–264

Sraïri MT, Bahri S, Kuper M (2013) Le travail et sa contribution aux stratégies d'adaptation de petites exploitations agricoles familiales mixtes d'élevage bovin/polyculture au Maroc. Biotechnologies, Agronomie, Société et Environnement 17 :463–474. http://www.pressesagro.be/base/text/v17n3/463.pdf

Sraïri MT, El Jaouhari M, Saydi A, Kuper M, Le Gal P-Y (2011) Supporting small scale dairy farmers increasing their milk production: evidence from Morocco. Trop Anim Health Prod 43:4–49

Sraïri MT, Rjafallah M, Kuper M, Le Gal P-Y (2009) Water productivity of dual purpose herds (milk and meat) production in a Moroccan large-scale irrigated scheme. Irrig Drain 58:S334–S345

Sraïri MT, Benhouda H, Kuper M, Le Gal PY (2009b) Effect of cattle management practices on raw milk quality on farms in a two stage dairy chain. Trop Anim Health Prod 41:259–272. https://doi.org/10.1007/s11250-008-9183-9. http://link.springer.com/article/

Swearingen WD (1986) Moroccan mirages: agrarian dreams and deceptions 1912–1986. Editions I.B. Tauris, London, p 254

Szymczak LS, Carvalho PCDF, Lurette A, Moreas AD, Nunes PADA, Martins AP, Moulin CH (2020) System diversification and grazing management as resilience-enhancing agricultural practices: the case of crop-livestock integration. Agric Syst 184

World Bank (2020) Morocco Economic Monitor, p 44. Available at: https://documents.worldbank.org/en/publication/documents-reports/documentdetail

World Bank (2017) Beyond scarcity: water security in the Middle East and North Africa. MENA Development Report. The World Bank Group. Washington. Available at: https://www.worldbank.org/en/topic/water/publication/beyond-scarcity-water-security-in-the-middle-east-and-north-africa

World Health Organization (WHO) (2011) Non communicable diseases country profiles 2011. Global report. Available from: http://www.who.int/nmh/publications/ncd-profiles2011/en/index.html

Willett W, Rockström J, Loken B, Springmann M, Lang T, Vermeulen S, Ganett T, Tilman D et al (2019) Food in the anthropocene: the *EAT*-Lancet commission on healthy diets from sustainable food systems. Lancet 393:447–492. https://doi.org/10.1016/S0140-6736(18)31788-4