Guidelines
on
Improved Water Allocation for Agriculture

League of Arab States

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Short glossary of main terms

Crop water productivity	*Measure of the economic, social, or biophysical gain from the use of a unit of water consumed in crop production*
Net/ real water savings	*Amount of water resulting from a reduction in consumption and/or in the non-recoverable fraction of the return flows, and that can be made available for alternative uses (Future Water 2020)*
Water allocation	*Formal and informal system that determines who is able to use water resources, how, when, and where (FAO 2020)*
Water basin	*The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta (European Environmental Agency). In addition there are internal basins that converge in a natural depression with no outlet and groundwater basins that are hydrologically closely interconnected aquifer systems. Within countries, basin management agencies are often administratively defined.*
Water governance	*The political, social, economic, and administrative systems in place that influence water's use and management (SIWI, nd)*
Water reallocation	*Changes to existing system of water allocation with resultant modifications in the way that the who, how, when, and where of the way water is delivered, being more complicated because it starts from an initial state of affairs with entrenched interest and patterns of water use*

Water tenure	*The relationship, whether legally or customarily defined, between people, as individuals or groups, with respect to water resources (OECD 2015)*

Chapter 1 Introduction

1.1 Background

This document presents the Guidelines on Improved Water Allocation for Agriculture. It is commissioned by the High-Level Joint Water-Agriculture Technical Committee (HLJTC) of the League of Arab States (LAS). The preparation of the Guidelines was undertaken by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Economic and Social Commission for Western Asia (ESCWA)[1].

The Guidelines provide systematic guidance to decision makers and water resource planners in the Arab countries on improving water allocation for agriculture. They are prepared for regulators and practioners alike, for water system manager, policy makers and farmer leaders: meant to highlight the importance of implementing optimized water allocations and giving directions on how to make this happen.

The Guidelines contain (1) a systematic assessment of improvements of water allocation for agriculture, (2) a scan of the necessary governance arrangements to support optimized water allocation and (3) guidance on the process to introduce the necessary changes. This is all captured in an Agenda Tool, that complements these Guidelines.

1.2 Water allocation and agriculture

The allocation of water is at the heart of water governance especially in deciding who gets what amount of water, when and under what circumstances (see box 1). Which sector (agriculture, industries, cities, mining, environment etc.) has what access to water? Which system receives which volume of water? How is water allocated in time and quantity? How is water quality served by the way water is allocated? All of these are fundamental questions. This allocation of water sets the pattern for water resource management. It determines how much water goes to agriculture, creates the basis for how water is delivered and supplies are scheduled. It drives the day-to-day distribution of water.

Box 1: Defining water allocation

The OECD (2015)[2] describes water allocation as follows:
"Water resources allocation determines who is able to use water resources, how, when

[1] The Voluntary Guidelines were drafted by Frank van Steenbergen and Nadim Fajaralla. The drafting benefitted from a regular discussions on selected topics with a team consisting of Mohammed Al Hamdi, Pasquale Steduto, Hicham Charieg, Mohammed Abdalla, Hammou Laamrani, Ziad Khayat, Julie Abouarab . Maya Atie and Kamal Mostafa Elsayed. In the preparation of the document a literature review was undertaken, an electronic survey was undertaken, and several regional resource persons were interviewed. The draft document was reviewed by a group of regional and international water experts, upon which modifications were made. The document was finalized after discussion in the High-Level Joint Water-Agriculture Technical Committee in an extensive workshop and after receiving a final round of comment.

[2] OECD (2015), Water Resources Allocation: Sharing Risks and Opportunities, OECD Studies on Water, OECD Publishing, Paris.

and where…. Most allocation regimes today are strongly conditioned by historical preferences and usage patterns, tracing their roots to previous decades or even centuries. They have often evolved in a piecemeal fashion over time and exhibit a high degree of path dependency, which manifests in laws and policies, and even in the design and operational rules of .. water infrastructures. This means that water use is often "locked-in" to uses that are no longer as valuable today as they were decades ago, curtailing the value (ecological, socio-cultural, or economic) that individuals and society obtain from water. In essence, allocation is a means to manage the risk of shortage and to adjudicate between competing uses. Allocation arrangements consist of a combination of policies and practice.

Yet, although water allocation is at the heart of water governance, and one may say close to the core of society and economy at large, it is at the same time often a blind spot. In many cases, formal water allocation is not a topic of discussion and practices are accepted as they are, with no plan to improve. Some countries have placed water allocation on the agenda, but find it hard to make systematic progress. There is so far no center of excellence and no community of practice. The missed opportunity then is that water allocation is out of sight, and with that de facto often a never changing 'given'. On the other hand, as these Guidelines present, there are many opportunities to critically improve current water allocation arrangements, especially for the agriculture sector, and make adjustments that can have huge beneficial impacts on water consumption, food security, job creation, climate resilience and water productivity.

Now that many countries descend below the water stress line, investment opportunities in capturing 'new' water resources are quickly closing and water scarcity becomes more and more of a security issue, it becomes high time to start asking the questions on how water is allocated, how it can be improved to ensure sustainable allocation of water for agriculture and other sectors, what governance arrangements are conducive, what methods of improvement to follow to ensure effective implementations of quotas and restrictions? Water allocation applies to existing systems, to systems that are newly developed, and to water that is saved through water efficiency measures: how is the water best allocated – to whom, at which volumes and in what manner. This applies for surface and groundwater systems alike.

Particularly, in relation to agriculture, water allocation is extremely important. First, water use in agriculture, irrigation in particular, exceeds almost everywhere in the Arab countries all other sectoral water uses In the region agriculture use 80% of all water resources and represents an even larger portion of all consumptive use[3] (Woertz 2017). So, if water productivity can be improved and good quality water can be saved in agriculture, it can be freed up, used to irrigate rainfed areas, to improve production rates or be reallocated for other purposes, such as domestic water supply, industrial use, or environment (see box 2). Second, in irrigation, water allocation assumes an additional dimension as it is **not only dependent on who gets what, but also on how water is delivered and is made available to users**: quantity, timing, duration, and sequence. Ideally this should be flexible and tailored to the requirements of the crop. Also other water needs in the system might become more important, such as for drinking water, the more so in low rainfall years. If water allocation is

[3] Quoting Woertz (2017): "Agriculture's water use is consumptive; following evapotranspiration through the plants that are grown it cannot be recycled like residential water supplies or used twice like the cooling water of power plants. Hence, agriculture's share of *consumptive* water use is even higher, hovering around 92%".

optimized, it could contribute greatly to water use efficiency, water productivity and multifunctionality. Yet, instead of being optimized, water allocation is often not in synchronization with requirements of time and quantity, leading to a wastage of water delivery – constituting an opportunity lost. Typically, all attention in improving water use efficiency goes to field optimization measures or individual incentive systems. Whilst this is important, it is missing the large opportunity of improving water allocation at system level, i.e., regulating water allocations from the top[4].

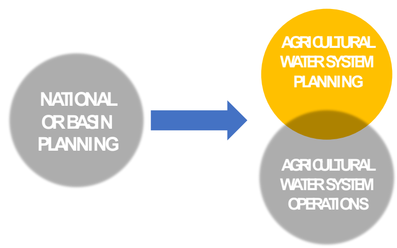

Figure 1: Improving water allocation: three domains

These Voluntary Guidelines discuss water allocation for agriculture: in this there are two levels. First is the intersectoral allocation of water to agriculture, at national level or at basin level: are there mechanisms in place whereby water is systematically allocated to different sectors, agriculture being a prime sector among these. Are these mechanisms implemented effectively? Do they stay within the available quantity"

The second level is the water allocation within the agricultural water systems: deciding the nature, source, quantity, timing of water delivery. Some of these decisions concern the planning and design of agricultural water systems, others concern more the way the systems are operated (see figure 1).

There are many entry points in improving water allocation. In many situations water allocation can be improved at the higher intersectoral level and at the level of the agricultural water system. There is no sequential order – opportunities to do things better exist at each level and one does not necessarily follow from the other.

There are in fact by now several practical examples on how optimizing water allocation for agriculture can lead to large improvements in the social and economic dividends of water and to water use efficiency, equity, and multi-functionality. What is required is that such examples are followed widely and become mainstream practice. At intersectoral level some countries for instance have set in place systems of basin management, whereby water on a regular basis is allocated to different uses in the basin. A priority listing is done to ensure that water goes to the most valued uses with agriculture being set against other water uses. Also

[4] There has been a tendency to promote better water management by influencing the behavior of individual water users, for instance by exploring the pricing of water services. The argument behind this is that this would motivate water users to apply water more prudently. Another example are the efforts to promote more efficient field level water application through precision irrigation or better crop agronomy for instance.

there are many examples of the huge benefits of improved water allocation within agricultural water systems. Curtailing sanctioned surface irrigation water deliveries may for instance encourage the conjunctive use of surface water and groundwater in canal command areas, where such groundwater is available. Such conjunctive practice will avoid water logging, will improve water productivity as water application will be more precise and will also free up surface water for other purposes. Another example is where the 'when' in water allocation such as in the duration of the irrigation cycle is adjusted to be in tune with the demands of the crops grown or overall adjustment of the volumes of water supplied so that there is no overirrigation and conjunctive management of surface and groundwater is promoted. Other examples are more fundamental and concern the transfer of water from upstream to downstream communities to share water for irrigation and domestic use more equitably.

1.3 What is the urgency for member countries of the League of Arab States?

The urgency to revisit water allocation systems is high in all countries in the League of Arab States. Irrigated agriculture in almost each of the Arab countries is important: it is an economic mainstay, a large employer[5] and in many countries closely linked to national security. Population growth throughout the LAS is relatively fast, equating to an increased demand to keep up with food production. In addition, there are the effects of climate change with more erratic weather patterns and higher temperatures, necessitating an overhaul of water management in agricultural systems.

A very pertinent challenge for the Arab countries is the use of groundwater. Groundwater dependency in Arab countries is very high, in Algeria, Bahrain, Jordan, Lebanon, Libya, Oman, Qatar, Saudi Arabia, Tunisia, United Arab Emirates and Yemen – see figure 2. The region is using far more groundwater than what is available on a renewable basis. In most countries, withdrawals exceed sustainable limits. This results in lowered groundwater tables, the ingression or up coning of lower quality water, the loss of moisture in top soils that otherwise can regulate biotic life and micro-climate. Some countries have exhausted their fossil groundwater stocks. Pumping saline groundwater from 600 meters depth and then treating it with reverse osmosis for agricultural use is common in some countries, such as Jordan. For some these are signs that a crisis is near and the time-bomb is about to go off. According to work by FAO preliminary assessment of the global groundwater allocation assumptions implicit in long term food production projections" suggested that any country using groundwater for more than 50% of its irrigation service, was withdrawing water at an unsustainable rate (pers. Comm: P. Riddel). This is a huge issue of sustainability of water use that requires drastic measures among others those offered by changed water allocation, including caps to groundwater use.

[5] Particularly in Mauretania, Sudan, Yemen agricultural labour is more than 40% of the labour force. In Morocco, Algeria, Tunisia, Egypt, and Syria it ranges between 18-35% (Woertz 2017).

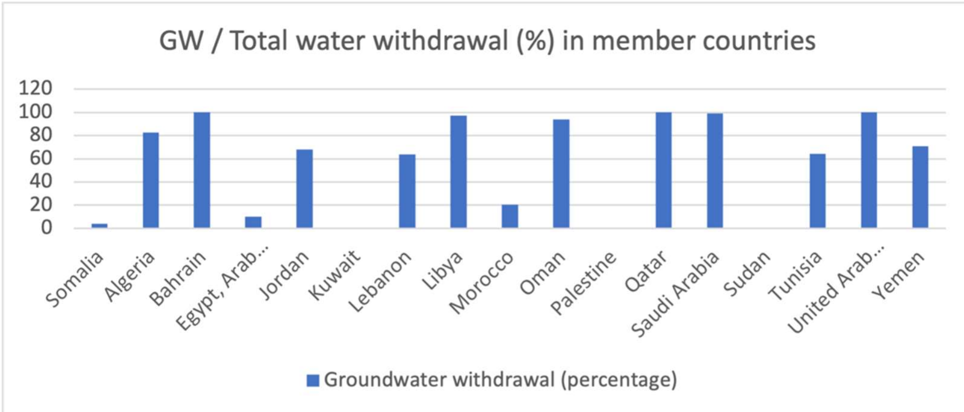

Figure 2: Groundwater withdrawals as proportion of total water use in selected Arab Countries[6] (source: FAO Aquastat, several year)

Against these challenges, the management of the agricultural water systems in general has not improved. Box 2 gives an overview. In the existing irrigated areas, actual water consumption has increased in most countries. Biomass production has kept pace with population growth only in 3 out of 19 countries. Water productivity[7] (measured in biomass per volume water used) has improved only in one third of the countries but stagnated or declined in the other half. Box 2 based on a big data using the twelve-years detailed WAPOR system gives an overview of trends in selected Arab countries. Annex 1 has an extensive key water data set.

With respect to groundwater management in the last ten years, there have been attempts to regulate by groundwater permits (Algeria), replenishment of depleted aquifers (Tunisia), Groundwater By-laws[8] (Jordan), aquifer contracts (Morocco), regulating use (Siwa, Egypt) or community management (Yemen), but by far and large the challenge of managing groundwater is not met. There have been very few cases where groundwater is adequately managed, but more evidence that it is being depleted. In some countries – that could afford so, the Gulf Countries groundwater supply has been replaced by desalination. In a few cases groundwater is replaced by reallocated surface water, such as in Tunisia and Morocco, in Jordan freshwater uses in the Jordan Valley are decreasing and treated wastewater is increasing as a result of the reallocation and water substitution policies over the last 10 years where 125 Million Cubic Meter (MCM) of high quality reclaimed wastewater is in use annually to liberate the fresh water for domestic use, this change is accompanied by a change to irrigation techniques and schemes like drip irrigation and micro sprinklers that resulted in substantial improvement of water use efficiency with tangible results on the production vs water consumption.

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[6] For some member countries data were not available.

[7] As discussed in chapter 3 water productivity can be measured in different ways. Instead of measuring water productivity in biomass produced (which is possible with remote sensing), it can be measured in economic terms as well. This may reflect changes in cropping patterns and acknowledge a shift to higher value production. In this case for instance Jordan did well for instance: In 2005, 1103 m3 of water was used to produce 988 million USD of agricultural products. In 2017, 943 m3 of water was used to produce 4252 million USD of agricultural products, significant jump in economic water productivity (pers. Comm Maysoon Zoubi)

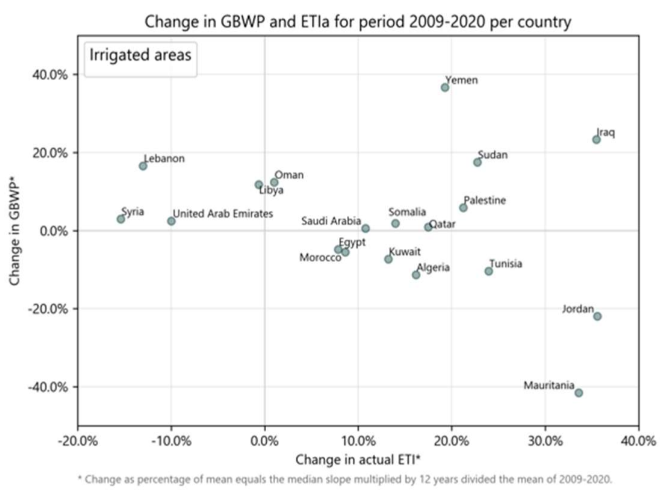
[8] Groundwater By-law No. 85 year 2002 amended in 2015

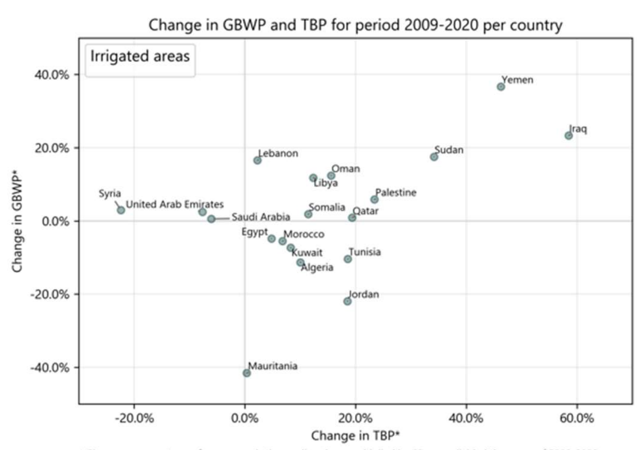
Box 2: League of Arab States: trends in water consumption, agricultural production, water productivity and climate change 2009-2020

A big data analysis for Arab countries was undertaken, using the WAPOR data base over twelve years (2009-2020) The WAPOR data base (https://wapor.apps.fao.org/home/WAPOR_2/1) has data on 250 by 250-meter pixels for 19 out of 22 countries in the League of Arab States. The data is available on ten-day intervals throughout the period and contains, among others data on total biomass production (TBP indicating agricultural productivity), actual evapotranspiration (AETI indicating water consumption) and reference ET (indicating climate-related water demands). This makes it possible to calculate indicators such as gross biomass water productivity (GBWP reflecting efficiency of production). There are inevitable constraints in using satellite data such as cloud cover and pixel classification, yet particularly in analysing trends the large data set is very reliable. Furthermore, to boost data quality, the analyses for these Guidelines were done based on all 'robust' pixels in the irrigated areas for each country, i.e., pixels that unambiguously classified as irrigated over the entire period. This removed the 'noise' of fringe areas for instance.

The analyses indicate the following:

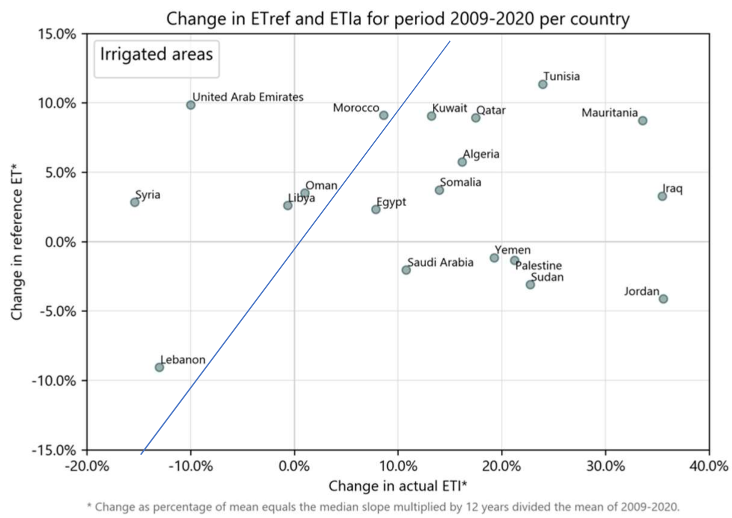
- In 15 out of 19 countries water use in irrigated areas, as indicated by AETI, has increased. In 12 countries it even increased by more than 10%. In only 4 countries water consumption decreased. This included two countries in conflict and crisis. **In summary across the board over the last twelve years more water is being consumed in the existing irrigation systems rather than less**. Given the already prevailing water scarcity and the still ongoing development of additional new irrigation systems in several countries, this is a highly worrying development
- As one would expect with increased water use, in 14 out of 19 countries biomass production in the existing irrigated areas increased. The increase in production was typically around 10% over the decade. However, assuming that population growth in the region over the decade was 22.5% **only in 4 out of 19 countries biomass production kept pace and/or exceeded population growth and hence domestic demand.**





- Overall, changes in water productivity in existing irrigated areas in the past decade have been patchy in the Arab countries. There has been no trend of improvement in the amount of crop that is produced against a certain volume of water. I**n one third of the countries (7) biomass water productivity improved**[9]**; in another third (7) it was static and in five countries biomass water productivity even went down (5).**

We also analysed the impact of climate change over the period in particular the so-called reference evapotranspiration. This measures the 'drying power' of the atmosphere, as it effects plant growth. It is a function of temperature, air humidity and wind speed. In the period 2019-2020 the climate in six countries became less demanding but in 13 countries – as may be expected - reference evapotranspiration increased, hence more atmospheric water demand. The increase was typically between 5 to 10%. Though significant it does not explain entirely the increase water consumption in the existing irrigated areas.



In fact in 13 out of 19 countries actual water consumption in irrigated areas increased (often significantly) higher than the atmospheric water demand would require.

1.4 How to use the Guidelines?

The aim of the Guidelines is to put improved water allocation on the map politically and institutionally. In a situation of the highest water scarcities in the world, of heavily overexploited groundwater resources, of a growing population and the uncertainties that come with climate change, the fall-out of not systematically improving water allocation and missing the opportunities it offers will be high. Inaction is irresponsible and may result in chaotic disengagement of water from agriculture.

These Guidelines discuss four topics:
- Section 2: Improving governance arrangements that support and drive improved water allocation for agriculture
- Section 3: Improve water allocation for agriculture - both the water allocated to agriculture and the water allocated within agriculture
- Section 4: Implementing the process of changing water allocation
- Section 5: Using the water allocation agenda setting tool

[9] A change in biomass can also be caused by a dramatic change in cropping patterns because the biomass produced by different crops varies. Given the large overall trends, there is no indication of this having caused a significant effect.

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The Guidelines are meant to provide guidance and inspiration. For this reason, it includes several infographics and practical cases of improved water allocation in different geographical settings proper to the Arab region. It is hoped that these give the motivation and confidence that change is do-able and the returns from it are high. Every member country of the Arab region for every major agricultural water system, should scan the options and prioritize immediate and medium-term action.

Chapter 2 Effective governance for improved water allocation

Water allocation is part of water governance, but is often not addressed, neither by explicit decisions on how much water to allocate to agriculture nor in the planning and management of existing systems or in the development of new agricultural water systems. Different elements of water governance may facilitate the attention for improved water allocation and support its implementation. Most significant are to have adequate understanding of the water resources available and under use; the recognition of improved water allocations in policy and regulation; institutional leadership; transparent public and private roles; clear and complete water tenure; routine integration of water allocation in operations and systematic coordination of stakeholders and users (figure 3). These are discussed below.

Figure 3: Governance checklist for improved water allocation for agriculture (Source: Authors)

2.1 Adequate metrics

Adequate metrics that describe the water resources available and the current use is at the base of optimizing water allocations. Much is technically possible and within reach (see also section 4.2) but the adequacy of the information used is also a governance issue: the ability to have adequate non-politically manipulated data on the table, the planning on the basis of correct numbers and quantified targets and the presence of a community of experts and researchers who advise water managers and decision making. All these are not givens.

There are for instance examples where unrealistic figures on national water resources are used to build up national water strategy, yet with the numbers camouflaging the real short falls and state of depletion. There are also examples on water allocation rules that divide water that are based on a situation that never occurs. There are water gauging stations that are tampered and SCADA systems that are sabotaged. More in general, it is observed with concerns that the collection of basic water parameters is some countries is receiving less and less financial and institutional support. Yet adequate monitoring and feedback is part of any realistic process that promotes improved water allocation (see chapter 4). Adequate metrics create realism, confidence in the process and common understanding.

2.2 Policy and regulations

The need to manage water resources optimally is reflected in the water policies of most member countries of the LAS. Water use efficiency, water productivity and water resources protection are recognized in national strategies of many countries. The common challenge is to translate these ambitions into reality.

Policy details differ between countries. In some country policies, the need to allocate water to given sectoral priorities is mentioned. In some cases even a ranking is given between sectors[10] such as domestic use, industries, environment, where agriculture is usually not the highest ranked priority. The importance of the sector for strategic food security and job creation may be highlighted, but agriculture is also the bulk user with other higher value uses taking precedence in allocation.

In some countries the need to (re)allocate water and change the existing arrangements is referred to specifically. This creates an explicit policy endorsement to optimize allocation. One of the countries that made much headway in this is Jordan (see box 3), which formulated a Water Reallocation Policy in 2016 as part of the National Water Strategy. The most ideal situation is that the policy singles out the improved allocation of water as a priority specifically and assigns responsibilities and targets, or even specifies the procedures.

The need for improved water allocation – or water management in general – may also be reflected in agricultural policies or drinking water policies, including for instance the substitution of high quality water (suitable for drinking water) with lower water quality.

[10] In some countries during the summer season, the prioritization is also applied inside the agriculture sector , between strategic and non-strategic crops.

Box 3: Water reallocation policy of Jordan

Jordan is among the three most water scarce countries globally – with water availability dropping below 100 cubic meters per capita. Climate change, transboundary water resource development, already existing overextraction and the influx of refugees contribute to huge present and future challenges.

Jordan is one of the few countries that issued a Water Reallocation Policy. The Water Reallocation Policy issued in 2016 alongside seven other specific policies (including a Water Substitution and Reuse Policy) are part of the National Water Strategy 2016-2025.

The Reallocation Policy proposed to cap fresh groundwater allocations to irrigated agriculture in the high lands and eventually to reduce groundwater consumption.

In irrigation systems in the Jordan Valley fresh[11] surface water shall be replaced by treated wastewater. Irrigated agriculture can be expanded only where treated wastewater is available. The capacity to deliver treated wastewater is expanded from the present 135 BCM to 240 BCM. The fresh water that is withdrawn from irrigation is used for domestic water supply.

A general principle at the highest level of water allocation is that each governorate shall retain its available water for its sole needs, unless otherwise necessary. In that case the water will be transferred to the geographically nearest governorate and to the governorate of highest need, with due consideration to sustainability, long term feasibility, availability of infrastructure and cost.

Joint committees of the Ministries of Water and Irrigation, Environment, Agriculture, and other organizations whose activities affect the performance in the water sector will develop short and long-term plans to monitor and control the water consumption, quality, and impacts.

Source: Ministry of Water and Irrigation (2016) Water Reallocation Policy. Water Substitution and Reuse Policy.

2.3 Institutional leadership and responsibility

The assignment of clear leadership including access to implementation capacity is essential, in addition to support at policy level. Preferably such leadership is institutionalized.

Responsibilities for water management differs between countries. In some countries there are basin councils and committees in place that are expected to balance water use between different sectors. In other countries such arrangements do not exist. Also within water system leadership differs. In some countries water management for agriculture is much decentralized, in other areas larger irrigation systems have separate management under centralized control.

[11] Fresh water is water relatively free from salts and other contaminants. A common standard is a conductivity of less than 1500 µS/cm.

The effectiveness of leadership is also related to the legitimacy of the water allocation system. If decisions on water allocation are seen to be unreasonable or influenced by corrupt practice, there will no trust and the water allocation rules as they are issued are likely to be violated by the different users. Leadership in other words must create legitimacy.

It also must be acknowledged that in many countries there is no effective state control over parts of the agricultural water management system and no systematic communication between state and water users. This particularly applies to groundwater use. This is related to the decentralized nature of groundwater resources and the practice of farmers making wells without permits, a phenomenon that is unfortunately common in many of the Arab countries. Unlicensed wells constitute a large portion of all wells in many countries, for example Yemen, Tunisia, Jordan, Syria, or Morocco. This is sometimes stimulated by inconsistent state policies, such as the subsidies on energy costs, that promote groundwater usage even when the resource is in peril. The emergence of solar systems is another risk to sustainable groundwater use and efficient water use. In some countries, such as Algeria, there was relatively strict control in licensing well development and/or drilling companies but this has waned. Due to the decentralized nature of groundwater management, co-management with water users is often the most viable arrangement in a context where a large range of options are utilized: regulated use, water saving, substitution of water resources and improved groundwater recharge. The aim is to come to combined packages where regulation of water use does not necessarily lead to reduced production. Box 4 provides an example from Morocco. The lessons from this case is that co-management arrangements may offer the best hope, but that implementation should be for real and go beyond agreeing on principles and making plans. Co-management needs to be carried by institutional leadership and be binding. In case of groundwater regulation and in controlled well drilling leadership comes not from authoritarian authority but from the amalgamation of public and local community power.

Box 4: Aquifer contracts in Souss, Morocco: experiences in co-management

Starting in 2006, the Moroccan government has used aquifer contracts as an instrument to control groundwater depletion. The aquifer contracts describe specific measures to be implemented for the concerned regions and the contribution of different signatory parties. The first aquifer contract was signed in 2006 for the Souss region. The Souss Massa-Draa region covers 112,000 hectares of cultivated land. Farming is dominated by lucrative agricultural exports. Total water consumption amounted to 551 Mm3 per year in 2003. Of this only 60% is covered by natural recharge. The balance is overuse.

The aquifer contract was a non-binding understanding between stakeholders and the government. It specified measures to be implemented across the Souss Massa-Draa Basin such as the implementation of water saving measures, the replacement with surface water, the closure of wells. Signatories of the aquifer contract included the regional government, the River Basin Authority (RBA); the Chambers of Agriculture; Federation of Water Users Associations; the well driller association and the main electricity and drinking water office and public water utility as well as national research institutions. The contract was casted as a Framework Agreement complemented by specific Partnership Agreements. The River Basin Authority was given the overall responsibility.

There was weakness in enforcement, partly rooted in the voluntary nature of the agreement. Some of the more challenging measures were avoided. The plans to reduce the cultivated area for instance were not implemented. Contrary to provisions, a compromise was reached to legalize unauthorized wells. Rather than the RBA strictly controlling expansion of the command area, the RBA was assigned to only 'monitor' area expansion. Well metering was only partly implemented. As a result, overuse slowed down, but did not disappear. Water levels kept dropping, affecting smaller farmers who were unable to keep up with the cost of deepening wells. Funding for the contract implementation (USD 246 million) was to come mainly from state investments and through water fees but did not entirely mature.

In the final analysis the aquifer contract is a promising approach for a multi-user platform aiming to consolidate specific groundwater management activities on the ground. However, the voluntary nature of the contract, the differences in sense of urgency, the focus on supply side solutions rather than demand management, the lack of institutional capacity (for instance in the understaffing of the RBA) affected the effectiveness. More rigor, broad-based commitment and enforcement capacity would help to make the otherwise promising approach successful.

Source: Closas and Villroth (2016)

2.4 Well-defined and transparent private sector roles

In almost all countries, constitutionally, the national state or the regional state own the water. The legal and regulatory environment must be created for the correct relationship between the public and private sector, given that water is public property

There are several examples where the right to use supposedly underutilized water resources has been allocated to the commercial sector and where an increased engagement of private investors in agricultural water services is endorsed in policy. The reasoning has been that unlike national governments such private parties have access to the finance needed to develop such resources and are supposed to work more efficiently. This idea is associated with the Dublin Principle of 'water as an economic good'[12]. The private sector efficiency argument has not always held true. The connection between private parties paying for water services to come efficient water use has on several occasions been contrary. For instance in the auction of water rights in Chile many private parties snapped up water resources not because they were the best and most efficient user, but because they had access to the capital and could buy the water rights as a speculative investment. The assignment of water to private parties led to underutilization and inefficient use.

In the Arab countries there has been private investment from extremely water scarce countries to countries with supposedly un/underutilized sources. Examples of such private investments are the New Valley Development (or 'Toshka') project in Egypt and several projects in Sudan such as Upper Atbara, Abu Hamad and Ad-Hamar (Keulertz 2014).

Such private investment has been often less successful than originally envisaged. They have suffered from: (1) inadequate planning and implementation that comes with mega-investments (2) insensitivity to earlier (informal) land and water rights, including downstream uses (3) lack of attention to societal benefits against the quest for access to private investment capital and (4) political vulnerability that comes with regime change, often exacerbated by

[12] The idea of water as an economic good is not uniformly accepted and the commodification of water has been criticized widely as causing inequity, creating hard to reverse processes and favoring capital-rich parties over less wealthy users that may generate large social benefit though.

non-transparent deals and uncertainty as to who can sign on behalf of the legitimate government. Private investment has also concentrated more on the capture of water rather than its efficient use. Table 1 provides recommendations to be followed in the allocation of water to private parties to ensure a safe landing of the commercial investments.

Table 1: Precautionary practice for private sector investment in agricultural water management

	Action	
1	Engage with local stakeholders	In the preparation of the investments local stakeholders should be consulted so that the plans accommodate local requirements and become win-win rather than seen as imposed
2	Benefit and cost scenarios	A good analysis of the short- and long-term benefits and costs for different groups especially government, local population and commercial parties should be made at an early stage by an accepted competent party to inform the conceptualization of the investment project
3	Recognize pre-existing land use	Pre-existing land uses should be understood and recognized. Clear decisions are required on how to incorporate such earlier land uses
4	Recognize in situ and downstream water use	An assessment of the impact of the commercial investment on local and downstream water use as well as on groundwater availability should be included in the preparation documents and independently verified.
5	Undertake risk analysis	The commercial investment may be dependent on public investments (irrigation headworks, power lines or road connections) or certain special regulations (import permits, export licenses). A risk analysis may map out the sensitivity to such complementary activities.
6	Have clear and univocal arrangements	Benefit sharing arrangements on commercial investment have sometimes been open to interpretation and speculation. Such vagueness should be avoided as much as possible.
7	Include performance standards	Performance standards should be included in the agreements with the private sector operator for instance on jobs created, environmental impact, contribution to food security and proper water use. Preferably they should also be defined jointly to ensure acceptance and commitment to achieve them. There is also a need to jointly design a logical framework to assess level of achievements with clear quantitative and qualitative thresholds.
8	Exclude liability claims	Under Investor-State Dispute Settlement or Investor Court Systems mechanisms commercial foreign investors may raise large claims based on foregone profits, when the state is not able to honor its promises. This poses an enormous risk, particularly because these legal mechanisms are often structured unevenly, to the benefit

		of the foreign investors[13]. Such liability claims should be excluded in the contract.

2.5 Clear water tenure

Water tenure is increasingly recognized as an important factor in water resource management. Water tenure – the definition of entitlement of water users to the water – is also essential in improving water allocation. Water tenure can be defined as '*the relationship, whether legally or customarily defined[14], between people, as individuals or groups, with respect to water resources'* (FAO 2020). If this relation is unclear or highly ambiguous, it is difficult to allocate water at all. It is helpful to think in water tenure in 'bundles of rights[15]' as provided in table 2. The various elements in the bundle of rights, such as the right to exclude other potential users or the right to transfer, shape the water allocation arrangements.

Table 2: Elements of water tenure

Use rights	Right to abstract and use water for specific purposes
Exclusion rights	Right to prevent others to capture or abuse the water resource
Transferability rights	Right to sell, lease, or otherwise transfer water rights
Governance and management rights	Authority to set rules, implement those rules and resolve conflicts related to water, usually within broader regulatory or policy framework. This includes *the rights of water users to engage in decision of water allocation*
Procedural rights	Procedural basis for rights holders to respond effectively and protect their water tenure, including right to access to information, right to participate in decisions regarding tenure, opportunities to appeal to decisions impacting water rights and rights to compensation
Related responsibilities	Responsibilities that are part of the bundle of rights, such as payment of fees, maintenance, cropping practice (bans on certain crops for instance) and water management practices (no tampering, restrictions on drainage releases)

Based on: FAO (2020)

[13] These dispute mechanisms are included in many bilateral trade agreements. Originally intended to protect the interests of foreign investors, there is now ample documentation on how they have been used unfairly to place huge financial claims on states for not being able to honor contractual provisions, even due to unforeseen circumstances. The mechanism are biased in favor of foreign investors: only they can initiate and states cannot appeal. The arbitrators are selected from small groups of corporate lawyers who may have close relations to investors. Most states are not familiar with the ISDS or ICS mechanisms unlike the corporate investors and the legal advisors they use. It has led to claims of billions of dollars, exceeding the original (intended) investments, often awarded in favor of foreign capital. See for instance: https://www.tni.org/en/topic/investment-protection

[14] There can be a tension between legal and customary water rights, as witnessed in some areas. Where this exists it should be resolved, and legal and customary water rights should be aligned. When this happens enforcement of rights is usually secured as local systems and public authority complement.

[15] Water rights here are understood as the legitimized usufruct in a given water system. Note that this differs from water rights as described in the Human Right to Water, which describes a legitimate access of people to reliable drinking water.

In many Arab countries water tenure is relatively limited in scope. In the bundle of rights, the use and exclusion rights may be well understood, but even then such use rights are often not codified or their status may not have been updated, as in Lebanon. The other possible rights in the bundle of rights are often not spelled out, yet governance and procedural rights define individual water user's relation to overall water allocation systems. An overhaul of water tenure either by codification or by a more comprehensive definition of entitlements and duties may contribute to improved water allocation.

2.6 Routine integration in operations

Ideally the optimization of water allocation is part of the routine operations of a basin agency or an agricultural water service provider. In reality this may not be the case. A basin agency may refrain in its regular activities from allocation water to different sectors. Similarly, for irrigation agencies the main responsibilities may be the adequate maintenance of the canal and drainage systems to reduce losses and ensure appropriate activation and the delivery of water according to agreed allocation arrangements. There is often less attention to optimize water allocations on a regular basis and reassess who will get how much water when and where: hence there is no driving force for the improved delivery of water. In particular, in supply-based irrigation systems, which use pre-arranged water supply schedules, having a regular optimization of the allocation schedules as part of the operational mandates will contribute to improved water management.

2.7 Systematic stakeholder and user coordination

To improve water allocation systematic cross sectoral and stakeholder coordination is essential. There are two main situations:

- where there is a strong public operator that needs to align with different users, as is common in surface water systems
- where there is a regulating authority that needs to closely align with the different largely autonomous users, as is typical of groundwater systems. In both cases the coordination with water users is important.

There has been an upsurge in many countries in the formation of water users' associations, representing agricultural water users and in principle contributing to more systematic coordination: bundling the interests of different individual water users and creating an interface between water system operators and farmers. The status of water users' association differs from country to country[16]. The creation of water user associations has in many cases been triggered by a project investment or policy initiative. In some cases it has also been undone by it – as in Sudan in early 2010s. The effectiveness of these water users' associations in water allocation has varied. Some were leaning towards maintenance, in other case they were engaged in local water management. For water users' associations to be effective, they should be part of the entire water governance and be responsible for local

[16] There are important differences between countries as to the standing and composition of water users' associations. In some countries water users associations have a separate legal status; in other countries they have a 'borrowed' status and are registered as cooperative societies for instance or are recognized but without formal legal status. Water user associations may be closely interlinked with the formal governance system or may be isolated and mainly occupied with the management of their own local system. In some countries membership is compulsory for all water users in the system, in other cases it is not.

water resource management, including the water allocation at their level of responsibility. WUAs should report and enforce allocation rules. WUA can have an effective role in policing water distribution and at least in the 'naming and shaming' of violators. Being part of overall water governance WUA membership should be compulsory and not optional. The role of WUAs improved water management can be reinforced by special programs whereby water users associations are triggered to optimize local water management and assess the best ways and times to distribute water among their members. There is also much merit in WUAs of different areas meeting each other, and appreciate upstream and downstream relations and also position themselves as partners and not just as recipients of irrigation services.

In some Arab countries, such as Algeria, basin organizations have been created, to bring together wide range of stakeholders, all related to a specific water basin. The interest may often go beyond agricultural water use but in many basins, this remains the prime water use. The effectiveness of basin organizations is served well when they have clout, in allocating water to different users/ uses and in approving plans and budgets for basin activities for instance. Otherwise, basin organizations risk being primarily consultative bodies with limited impact.

Box 5: Engaging special groups

It may also be worthwhile to engage special groups, in particular young people that form an aspirational force. In Lebanon, Sudan and Egypt youth water parliaments have been established to provide a platform and conduit for the engagement of young people in water management. This can include debates on water allocation.

Chapter 3 Toward improved water allocation for agriculture

The urgent need to manage water better in Arab countries is undeniable. Being the most water stressed part of the world, a better targeted and balanced water allocation for agriculture will make a large contribution to national development and water security. The contention of these Guidelines is that the system of water allocation should as much as possible align with national strategic objectives, as captured in national plans and agricultural and water policies as well as realistic (and not political) assessment of water resource availability.

Improved water allocation for agriculture can contribute to relief many pressures:

- addressing water scarcity and groundwater overuse,
- increasing sustainable food production in the light of food security needs,
- giving space to non-agricultural water uses in the agricultural areas,
- dealing with the likely occurrence of droughts and floods
- anticipating the impact of climate change and making use of different regional initiatives in this regard
- freeing up high quality water for other purposes by allowing the use of lower water quality water for agriculture, that is however still fit for use in farming[17]
- creating more flexibility and demand orientation
- contributing to sustainable water use.

There are hence many objectives that can be served by improving water allocation in agriculture and the choices made and combination chosen should reflect national priorities. They also need to have a degree of flexibility so as to adjustments in a time of crisis The improvements made obviously must fit within the boundaries of water availability, infrastructure, pre-existing tenure, and operational capacities. These boundaries may also change and the allocation of water should be a dynamic rather than static undertaking.

Following figure 1 these chapter discusses improved water allocations at two levels:

- intersectoral water allocation at national or basin level
- improved water allocation within agricultural water system, in both their planning and operation.

3.1 Improved intersectoral water allocation

Intersectoral water allocation system makes it possible to prioritize water uses and to draw a line in the sand when water resources are unavailable or in danger of being exhausted. If implemented effectively it can also be a powerful mechanism to deal with drought and deficits. It should not start from scratch but take into account existing laws, customs and historical practice and consult those directly affected.

As agriculture is in most countries the major consumer of increasingly scarce water, such intersectoral allocations determine the boundaries on the volume of water that can be used in

[17] For drinking water electroconductivity levels above 800 µS/cm are not acceptable. For agriculture the upper norm is set often at 1500-2000 µS/cm, though special arrangements (mixing, salt tolerant crops, magnetic devicces) make cultivation at higher salt levels possible. Similarly other contaminants have higher tolerance levels in agriculture than they have for humans or animals.

agriculture. The intersectoral allocations can be set at national level or at basin level: the important thing is that they are translated into specific targets for different agricultural water use systems. The water allocation also need to be placed in a larger context of how much agricultural production and hence agricultural water use is desirable in the country or the basin. Deficits can be accommodated by increased import of agricultural commodities, though it makes a country more vulnerable to international trade and possible shortages or sanctions.

There is a clear difference in water allocation at national or basin level intersectoral allocation of water in surface and groundwater and this section discusses the different guidelines for both situations.

3.1.1 Surface water allocation to agriculture

If surface water resources are well quantified (see section 2.1), they can be allocated in broad categories in a country – between sectors and between geographies. This makes it possible to connect water resources availability to the overall development of the country.

Such intersectoral allocation of water resources work best if they follow a number of criteria:

- Reliable assessment describe the surface water resources available, preferably in nearly near time so to allocation can respond to imminent water shortages for instance
- The intersectoral allocation to agriculture is connected to operational hydraulic units, such as irrigation systems, reservoirs, or basins
- This intersectoral allocation to agriculture is translated into operational numbers such as maximum irrigation quota or volumes of water delivered. These can be complemented by restrictions such as bans on certain crops or restrictions in expanding the irrigated command area
- The allocation is done on a seasonal or annual basis, but considers the multi-annual storage and demand of water
- Different uses are ranked on a priority basis, including water allocation to different uses during times of deficit
- It is necessary to determine the quota for ordinary and emergency situations.
- A consultative mechanisms is built into the intersectoral and regional water allocation to understand specific needs and create broad acceptance
- Enforceable rules exist to act in case the allocation is violated.

An example of a well-established national water allocation system is from Tunisia and is described in box 6.

Box 6: The National Water Allocation System in Tunisia

The surface water system in Tunisia consists of a large number of interconnected dams. This has made it possible to allocate surface water at national level, based on the water operations of all interconnected reservoirs. The platform where water is allocated is the Ministry of Agriculture, Hydraulic Resources and Fisheries in consultation with the agricultural representatives of the governorates of the country. Charters on the water allocation exists with all the governorates.

In the intersectoral water allocation drinking water takes precedence, following the country's 'blue book'. The volume of water going to drinking water as well as for instance industrial water is relatively small however, because consumed volumes are small and because these users often have developed other complementary supply sources.

Annually the total volume of water likely to be available is assessed. This forms the basis of a water allocation among the different governorates based on the charters that were signed. It comes down to the distribution of the deficit to agriculture the country. The main battleground is how water is distributed within agriculture within each governorate, a challenge managed by the governorate's agricultural bureau. In the allocation at this level the preference is given to the survival of tree crops over the planting of annual crops. Regional water councils are promoted in each governorate.

As there have been several years of droughts and climate change the current arrangements are under pressure. Some of the water rich governorates in the South of Tunisia are requesting that more water is retained to allow more development in their areas. In the coastal Northern areas more surface water would have to be replaced by treated water or desalinization. There is also scope to improve the performance of the integrated water system among other by better maintenance that now often suffers from underfunding, caused by politically motivated low water service charges. The Ministry of Agriculture, Hydraulic Resources and Fisheries is also replacing the system of water allocation on annual basis to a multi-year management to distribute the surpluses of rainy years on dry years, thus ensuring constant allocations, regardless of the quality of rainfall in the current year.

3.1.2 Ground water allocation to agriculture

As described earlier ground water is in critical state in many of the members of the League of Arab States. This is a problem that is still largely ignored and not addressed. To the contrary: in several countries public incentives persist that stimulate groundwater extraction, in particular subsidies on energy costs or pumping equipment. The opposite however is required: ground water use in most areas needs to be curbed. According to Yada et al (2010), groundwater depletion globally amounts to 39% of the groundwater abstracted, a figure that is also indicative of the situation in the member countries of the League of Arab Nations. If no action is taken agriculture and other water-dependent activities may be abandoned in certain places, strategic reserves will be depleted for the generations to come and in some areas they entire landscape ecology may change. Urgent action is required.

The allocation of national ground water resources is very different from that of surface water. There are two main differences. First is that groundwater in most countries is extracted by many individual abstractors: small farmers, large farmers, and municipal and industrial consumers. Unless the groundwater use is centralized as happened in some systems in China, Spain, and Bangladesh (see box 12), the allocation will take the shape of regulating a large number of individual users. The second difference is that groundwater storage extends over many years, even decades and centuries. Furthermore, some groundwater is fossil and is not renewed. Hence groundwater allocation is not only intersectoral but also intergenerational: how much groundwater to use now and how much to leave for future generations?

Therefore, though it is possible to undertake an intersectoral allocation of groundwater, including determining the share of groundwater going to agriculture, it is more useful to calculate the amount of a groundwater than can sustainably be used in agriculture and to set targets on how to achieve this cap. In many cases a drastic reduction in groundwater use for agriculture is necessary.

The definition of sustainable groundwater yields may be taken from the Sustainable Government Management Act of the State of California: the "management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results, The undesirable results can be defined as chronic lowering of groundwater levels resulting in a significant and unreasonable depletion of supply, significant and unreasonable reduction of groundwater storage, significant and unreasonable seawater intrusion, significant and unreasonable degraded water quality, significant and unreasonable land subsidence and depletion of interconnected surface waters that have significant and unreasonable adverse impact. All these negative impacts are either impossible to correct with compensating measures or have very high cost implications, largely exceeding the cost and effort of trying to prevent them.

A special case are non-renewable or fossil groundwater stocks. Here a clear and well-reasoned decision is required on how to use these. In countries such as Egypt, Libya and Saudi Arabia fossil groundwater has been used in agriculture, often with wasteful practice. In some countries a policy narrative has been used that fossil groundwater would be used to transition rural areas to new more wealthy and less water dependent levels. In reality, this has not happened and the spin-off to society of fossil groundwater use even in the short term has been limited (see box 7). In general based on such prior experience it is recommended not to use fossil groundwater in agriculture, unless there is a strong transformative plan for its use. As a norm we may say that in one generation we will not use more than 5% of remaining fossil groundwater stocks.

In all calculations of groundwater reserves there are major margins of error. As groundwater is a strategic asset for generations to come, it is important to err on the cautious side and set the cap considerably lower.

On the basis of this cap, action can be taken to control groundwater use and bring it to the level of the cap, i.e. the sustainable yield of non-fossil aquifers and the agreed use of non-fossil aquifers.

Part of this reduction will happen spontaneously as irrigation wells go out of production, because they fall dry or are no longer economical. Yet a calculated plan is required to come to a balance in groundwater use and reach this goal, combining several measures. This in line with the recommendation of the Vision on Groundwater Governance, prepared based on global consultation under the direction of FAO, GEF, IAH, UNESCO and World Bank: 'to prepare groundwater management plans for priority aquifers'. The contents of such groundwater management plans is given in box 7.

Box 7: Elements of groundwater management plans for priority aquifers

- A defined groundwater cap and time horizon by which to achieve sustainable groundwater use

- a technically and economically sound array of demand-side and supply-side (incl recharge) management measures to achieve re-balancing of groundwater withdrawals in line with the defined cap
- Prioritization of water uses on the basis of social and economic priorities
- additional governance provisions and management strategies where essentially non-renewable groundwater resources are to be drawn down
- definition of stakeholder roles and institutions and specification of how those roles will be factored in to planning and management, and how stakeholder institutions will be supported, including community local groundwatr management
- planning for conjunctive management measures in situations of groundwater over-abundance and consequent soil water-logging and land drainage problems
- pollution abatement or control measures in the aquifer recharge zone such that the risk of groundwater quality deterioration is managed
- regulatory measures, economic incentives and policy changes to address groundwater management needs within the given legal and institutional framework — here the priority will be to achieve a practical balance between top-down administration and bottom-up stakeholder engagement participation
- working on the essential linkages to other sectors, be it land use planning, energy provision, trade or other policies.

Source: Based on FAO (2016), Global Framework for Action to achieve the Vision on Groundwater Governance

3.2 Improved water allocation within agriculture water systems

The main objectives for improving water allocations within agricultural water systems are given in figure 4. They concern objectives that are of particular importance at planning level in agricultural water systems and objectives that play out in the operation of agricultural water systems, i.e. during water scheduling and distribution. The different objectives also at different levels are often interlocked. They concern the following issues:

Water allocation objectives at system planning level

1. Improve water allocation to improve different types of water productivity
2. Improve climate change preparedness to deal with floods and droughts
3. Improve reuse of drainage water while ensuring acceptable water quality
4. Create an optimum conjunctive water management balance between the use of surface water and shallow groundwater to avoid water logging or overuse
5. Substitute agricultural water supplies with reclaimed water and free up high quality water for priority uses.

Water allocation objectives at system operations level

6. Optimize irrigation supplies and schedules and align with agricultural cropping patterns and related crop water requirements
7. Improve demand orientation and flexibilities in the water delivery

8. Improve the multifunctional use of water in agricultural water systems and safeguard water availability for domestic use, industries, wetlands, or environmental flows
9. Take special measures to create more equity in access to water – giving downstream users and small farmers fair share of water and avoid that they are burdened with excess water

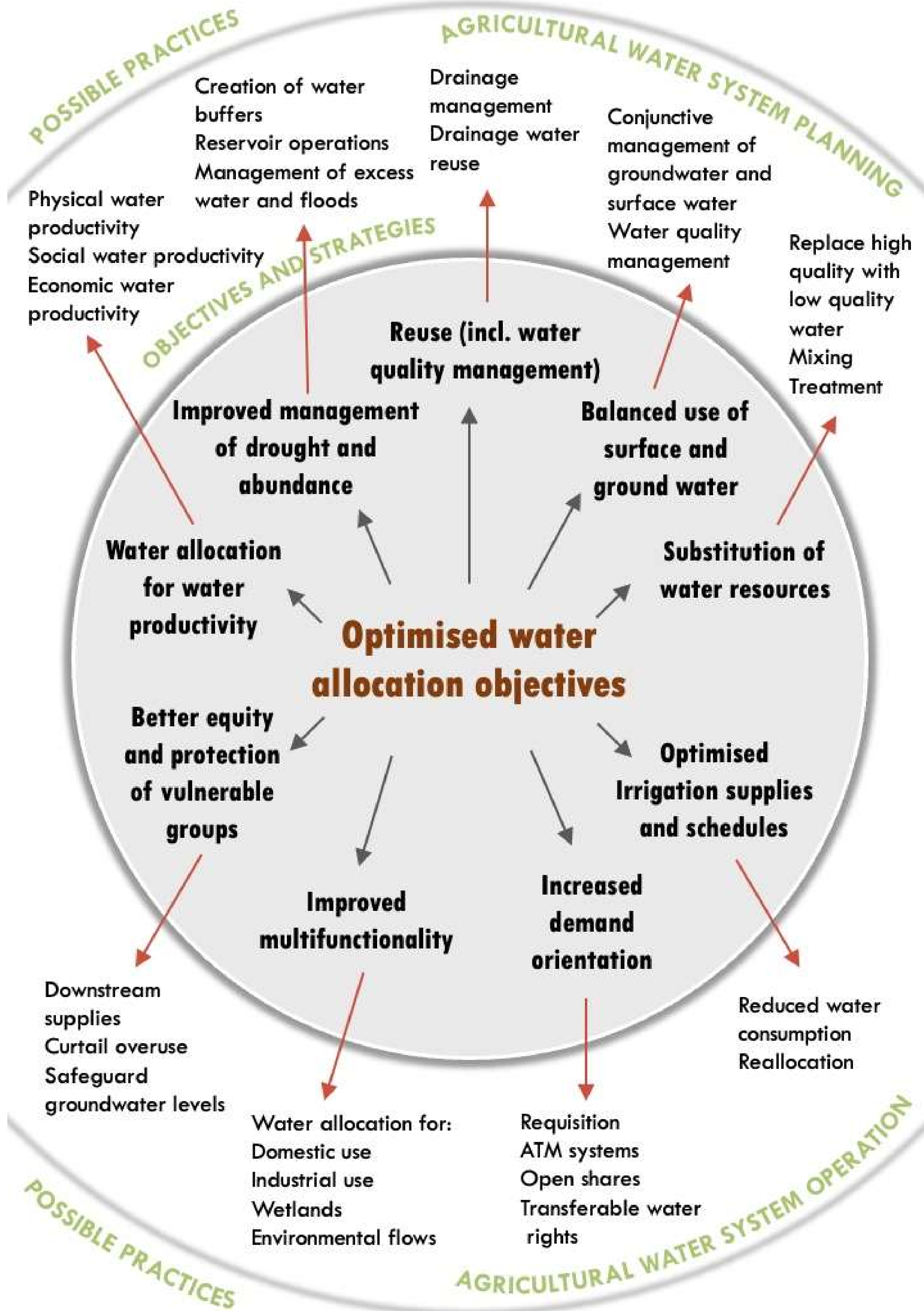

Figure 4: Objectives, strategies, and practices in optimizing water allocation in agricultural water systems (Source: Authors)

3.2.1 Water allocation for improved water productivity

Water allocation can serve systematically to improve biophysical water productivity, for instance when water is allocated to higher value uses or areas with more conducive growing conditions in terms of soils or climate for instance. Furthermore water allocation, by defining who gets water, when and how, can influence how irrigation schedules are organized. When this is aligned with preferred cropping patterns[18], it will improve – next to many other measures - biophysical water productivity.

There is however more to such biophysical or 'crop per drop' water productivity. There are other considerations too: economic water productivity: how much economic value is created with the new production as well as social water productivity: who benefits from the water?

It makes sense to analyze the societal benefits of water allocation and to answer the question who benefits from the water? This is particularly relevant in newly developed systems because there are important choices to be made. Box 8 describes the issue of groundwater overexploitation, raising important questions as to the social water productivity.

Box 8: The social water productivity in groundwater overuse in Tunisia

Despite the regulatory measures in place, the overexploitation of groundwater aquifers in Tunisia remains a challenging issue. A study indicates that 71 out of 273 groundwater reservoirs are overexploited, with a rate of 146% (Frija et al. 2014). For example, in the Sisseb basin, located in north of Kairouan in central Tunisia, groundwater use began in the 1960s to become a source of irrigation for 15,000 hectares of agricultural land, in addition to supplying tourism activities, and coastal cities. The density of wells reached a high 20 wells/km^2 in the Sisseb region (Kacem et al. 2008).

This overuse has caused the need for continuous deepening of wells (at a rate of 30 cm to one meter per year), the drying of 500 shallow wells, the abandonment of large areas of irrigated agricultural land, and an increase in water salinity. The rate of drilling wells increased after the 2011 revolution in the Nadhour region. Some regional commissions for agricultural development (governmental institutions in charge of agricultural activities at local level) stopped providing water to farmers outside their designated official borders in order to reduce the irrigated area allowed for each farmer and reduce pressure on the water systems (Faysse et al. 2011).

To continue pumping groundwater, farmers had to deepen their wells periodically (every 2-3 years). This situation was more favorable to investors rather than small farmers who do not have enough capital to deepen their wells. The competition over groundwater resources has led to tensions between small farmers and investors in the region, as small farmers perceive that they have priority access to water given that agricultural activity is their main and sometimes only source of income. On the other hand, investors justify their priority access to groundwater to their investment in modern irrigation systems to irrigate fruit trees, which contributes to rationalize water consumption compared to other crops. (Dugué et al. 2014).

It may be useful to undertake a Social Water Productivity Analysis and look at the contribution of the agricultural water allocation in terms of employment creation, income of

[18] This is where the alignment between agricultural decisions on choice of crops and that of irrigation administration becomes crucial. Ambiguity in these roles compromises a country's food security

farmers, contribution to local economy or food security. Below (figure 5) is a framework[19] to undertake such an analysis, reviewing the proportion of crop value going to different factors, who is behind those and how much this means for the local economy. By understanding where the added value in the agricultural water system is created, who benefits from it and how it strengthens the economy in the area, better choices can be made on where to allocate water to.

Analytical framework for assessing social water productivity

	How much is spent on the component (proportion of price of the retail farm price)	Who benefits describe the economic operators (small scale, large scale, local, external)	Contribution to local economy – spin off: is this revenue earned by this category of users likely to be spent in the local economy
Farm labour			
Farmland and water operator			
Farm input services			
Agri-business (traders)			
Retailers			

Figure 5: Analytical framework for assessing social water productivity

3.2.2 Climate variability preparedness: dealing with low and high flows of water

The water allocation arrangements for agricultural systems can be better prepared for variations in climate. Whilst this is useful under any circumstances, more frequent peaks and lows in water availability are expected with climate change, making the creation of more buffering capacity within the irrigation systems more expedient.

Another effect of climate change is the increased 'atmospheric' water demand due to higher temperatures and drier air and the higher presence of CO2 in the air, affecting different crops differently. C3 crops, in particular wheat and cotton under irrigation (i.e. non-limited water conditions) can benefit from such elevated atmospheric CO_2 level. Excellent water management then becomes imperative as an adaptation measure: to save water and exploiting the potential in C3 crops to convert the higher CO_2 concentration into higher yields.

The Regional Initiative for the Assessment of Climate Change Impacts on Water Resources and Socio-Economic Vulnerability in the Arab Region (RICCAR) , launched in 2009 under the auspices of the Arab Ministerial Water Council, assesses climate change implications on water and water-dependent sectors in the region. It uses regional climate modelling, hydrological modelling and an integrated vulnerability assessment to enhance priority-setting, policy making and project preparation on regional and transboundary issues. Accordingly,

[19] Based on the work of Jeroen Vos and Wageningen University.

Arab region projections for midcentury (2046-2065) and end century were generated for representative concentration pathways RCP 4.5 and RCP 8.5.

The areas with highest vulnerability are the Nile Valley (especially the northern parts: this is in addition to the impact of seawater-level rise that may affect a third of the land surface in the Nile Delta), the Tigris–Euphrates basin (further stressed due to increased irrigation development, the south-western Arabian Peninsula, and the western parts of North Africa on the Atlas Mountains. Evapotranspiration will increase and runoff will decline, resulting in increased intensity of water scarcity. Irrigated areas are more prone to climate change: 85%–90% of these are located is in the highest vulnerability classes (United Nations Economic and Social Commission for Western Asia (ESCWA) et al. 2017). The most important crops in the region, particularly wheat and sorghum, are all highly vulnerable to climate change as the majority of their areas are located within the highest vulnerability classes.

AquaCrop simulation program, and the climate-variables projections of RICCAR that correspond to scenarios RCP 4.5 and RCP 8.5 were used to assess the impact of projected climate change on selected crops and locations[20]. The effect of elevated CO2 on crop yield, two sets of projected CO2 concentration changes, for each of the RCP scenarios, were also simulated. The assessment results were further translated into country specific policy alternatives to enhance resilience of agriculture sector to climate change[21]. This is central to shaping agricultural strategies that are adaptable to future changes.

Bolstering the water allocation system to prepare for climate change must be done in several ways:

1. First is to create more surface water storage. Depending on the agricultural water systems this can be at the head of the system, decentralized within the system or out of the system. An example of the latter is when flood escapes are constructed on main canal and drains to lead water during excess time (flood season or low water demand periods) to external storages. In creating new surface storage all relevant social and environmental safeguards are observed.
2. Second is to make better use of freshwater aquifers underneath the agricultural systems by recharging it by routing excess flows.
3. In general, to improve water management, the more so for C3 crops. This may be supported by improved water allocations for such high potential crops.

3.2.3 Reuse of drainage water while ensuring acceptable water quality

In several agricultural water systems drainage water is produced – either permanently due to high irrigation duties or periodically during times of high flows and/or low demand. The challenge is not to let this water go to waste but to reuse this drainage water and make it part of the overall water allocation in the agricultural systems. This can be done by connecting drains to canal system or by pumping water from drains.

Drainage water is of lower quality than canal supplies. Drainage water typically has high concentration of leeched agrochemicals or salts. A further complication may be the discharge of effluents of local industries and cities in the open drainage system. In reusing drainage

[20] A technical country team was established and trained by ESCWA, FAO and the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD)

[21] ESCWA, (2020). Climate Resilient Agriculture: Translating Data to Policy Actions. https://www.unescwa.org/publications/climate-resilient-agriculture-translating-data-policy-actions

water and in mixing it with existing canal supplies, the preservation of water quality is important, the more so if the agricultural canal system is also the source of drinking water, as is common in several large irrigation system – see the example of Egypt (Box 9). Similarly the deterioration of soil quality due to accumulation of salts (TDS) in the soil needs to avoided. This requires careful mixing strategies as part of the improved water allocation system. Dedicated drains may remove water that is highly contaminated and unfit for reuse. There is also a case for decentralized mixing strategies whereby reuse is undertaken from smaller secondary drains and not from the larger main drains that may spread contaminants widely. Drainage water reuse needs to be complemented by efforts to reduce the contamination loads and improve the overall quality of drainage water.

Box 9: Managing drainage water use and safeguarding water quality in Egypt

Drinking water intake from canal system in Egypt

For more than four decades reuse of drainage water has been part of Egypt's water management strategy. Targets have been set for drainage water to become part of the overall water allocation for agriculture and acceptable salinity levels for the drainage water. In addition to the drainage water added officially to the system by the development of mixing stations, there is substantial informal reuse of drainage water by farmers especially in the Northern delta, using mobile pumps in field drains and manholes of the subsurface system. With reuse, however, pollutants were diffused throughout the entire water network: cadmium, coliform bacteria, salts, and agri-chemicals. As the canal system is also the intake for drinking water supplies, this prompted the closure of several drainage mixing stations, equivalent at one stage to one-third of the installed reuse capacity. To improve on this several initiatives were launched: the better control of especially point pollution, the exploration of decentralized reuse to isolate areas of good quality reuse water from highly contaminated areas, the development of good mixing strategies and plans to reallocate the fresh water saved due to substation with reused drainage water.

Source: van Steenbergen and Abdel Dayem (2007).

Case studies on drainage water reuse (DWR) while safeguarding water quality in Egypt

Much research has been performed in the Nile region on drainage water reuse (DWR) projects looking at both quantity and quality profiles.

Various strategies for using agricultural drainage water for irrigation were assessed using a water management simulation model in the North-West Delta of Egypt. Optimum results were observed under deficit irrigation strategies combined with controlled drainage, cyclic use of agricultural drainage water with fresh water (2 years drainage/2years fresh), and the inter-seasonal cycling of drainage and fresh water (Wahba, 2016). A study on the relation between the amount of drainage water reuse in the Nile Delta and challenges faced (predictors) found that fresh water released to irrigation is the best predictor of drainage water reuse followed by irrigation improvement project areas and rice cultivation area. Reducing fresh water released to the irrigation system by 30% was shown to reduce drainage water

reuse by 50%, while reducing rice cultivation area by 30% was shown to reduce drainage water reuse by around 14.8 % (Ghaffar and Shaban, 2013).
Another study addressed the variability in the drainage water reuse patterns in terms of discharges and their corresponding salinities in the Nile Delta. The study also simulated expected future discharge patterns while considering future reuse expansion projects. The analysis showed an increasing trend for drainage water reuse and salinity series except the salinity measured in the Western Nile Delta region that had an insignificant decreasing trend. This indicated that a potential for increasing the mean discharges for the Eastern, Middle and Western Delta regions is possible and is accompanied by salinity increases (Shaban, 2020). Further, three different drainage water reuse projects in El-Behira Governorate, Egypt, were assessed based on experimental records and water quality index approach. Results confirmed the "Poor" and "Marginal" water quality status of drainage water in relevance to the Egyptian standards. As such, it was recommended to have treatment systems for drainage water and to accompany drainage water reuse projects with water quality assessments (Ashour and Zeidan, 2021). Another study provided a framework of statistical tools for checking compliance with water quality standards and allocating waste loads from different sources as well as classifying water quality status using the Hadus Drain in Egypt as a case study.

In general drainage water reuse in Egypt are found to be a great opportunity for water allocation for agriculture as long as proper strategies are used for maintaining the adequate quality and quantity of drainage water.

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3.2.4 Balanced conjunctive management of surface water and groundwater

In many agricultural water systems, the canal network in underlain by a shallow (phreatic) aquifer. When there is excess irrigation (due to high water allocations in particular), the seepage water from the surface irrigation system recharges the shallow groundwater resource. This shallow groundwater can then be (re)used to complement the surface supplies. This creates more flexibility in the agricultural water system, as the shallow groundwater can be used on demand. In large irrigation systems the contribution of the recycled groundwater can be as much as 40 to 50% (Shah 2009). In this way moreover total water losses are low, as seepage is reused.[22]

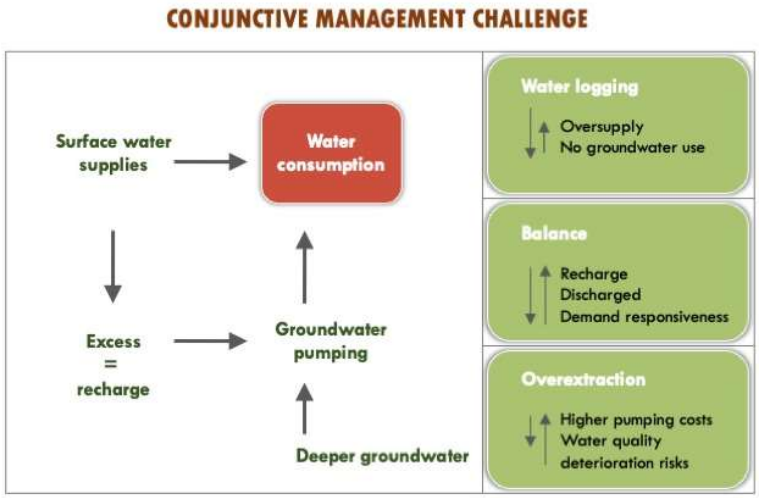

Figure 6: Optimizing the conjunctive water management challenge

Water allocations for agriculture can be used to create systems with optimum conjunctive balance: enough surface water allocations to recharge the shallow aquifer, but not too much so as not to encourage shallow groundwater pumping. This is the conjunctive management challenge. If the surface water allocations are too generous, there is little incentive to pump and excessive recharge, causing water tables to rise, resulting in waterlogging and salinity (see figure 6). If there is little recharge from surface water supplies, the reliance on groundwater may be too much, causing a negative balance (see the case of Tadla, Box 10). The facilitation of balanced conjunctive management of surface and groundwater depends on the quality of the shallow aquifer. Figure 6 shows the causal mechanism of surface water supplies leading to excess seepage, that recharges groundwater that can be reused and the three likely scenarios. In some areas the aquifer is saline by nature: in such instances conjunctive management is problematic.

Box 10: Tadla, Morocco: an example of conjunctive management

The Tadla irrigation system, developed in the 1940s is one of Morocco's largest irrigation systems. It covers an area of slightly over 100,000 ha, served by two storage dams. For a long time, surface water allocation to the Tadla perimeter was generous: 840 mm^3in 1979 for instance. Yet this was not a blessing and resulted in overirrigation. Soil salinity and water logging was common. A drainage system was considered to remove the excess seepage. All

[22] In discussing water savings it is important to consider the total spectrum. Some technologies – such as drip irrigation – save water by reducing seepage losses. This seepage however in many systems, especially when there is fresh groundwater underneath, is not a real water loss, as it can be reused as groundwater under conjunctive management. What matters is the 'gross water saving', i.e. the water saving at systems level. The same argument applies to canal lining. Such is much justified when a canal passes through very leaky soils or on sloping land where there is a risk of scour. In terms of water saving, canal lining can compromise groundwater recharge however and foregoes the opportunities of conjunctive use. In fact in general canal lining is only recommended when there is saline groundwater. In such situations seepage will not be reusable.

this changed in during the drought of 1981-1984, when farmers responded by developing large diameter shallow wells. After drought the water allocation to Tadla was more than halved – standing close to 340 Mm3 – and Tadla developed into a conjunctive water management system. The prevailing flooding system ensured large seepage losses – these were however picked up as recharge, feeding the phreatic aquifer underneath the irrigation system. For a time, this created a balance but after 1992 the groundwater level dropped and the quality of the phreatic groundwater deteriorated. The reduced water supplies were more and more covered by water from the deeper Eocene aquifer – with wells developed over 100 meters deep and more. It is estimated that at least 25% of the irrigation supplies now come from this deeper aquifer (Kselik et al, 2014).

It is argued that the surface water allocation in large irrigation systems is best based on a conjunctive water balance rather than being based on crop water requirements. Neither water logging groundwater decline should occur. The current shortfall maybe compensated by better rainfall storage, routing for instance excessive rivers flows through the canals or by increasing surface water supplies from other non-conventional sources.

3.2.5 Substitution of high-water quality water with lower-quality water

Agricultural water systems often use freshwater of high quality. In some cases, these high quality supplies are better utilized for uses such as domestic water. There may be possibilities to substitute high quality water now used in agriculture with treated wastewater. This is for instance a central element in the Water Reallocation Policy of Jordan of 2016, whereby irrigation supplies in the King Abdulla canal in Jordan Valley are increasingly sourced from treated wastewater and the capacity to produce wastewater of usable quality is increased (box 3). This will free up fresh water for domestic supplies. Another example is the Korba coastal plain in Tunisia, where the depleted groundwater reserves were partly replaced through the injection of treated wastewater. There may be more opportunities for such systematic reallocations (see Box 11).

The quality of the waste water is an important consideration. The risks of wastewater reuse in agriculture range from changes to physicochemical/ microbiological properties of the soil media to human health impacts. Considerable research has been done. FAO (1992), WHO (2006) and EPA/ USAID (2012) contain guidelines on the safe use of waste water in agriculture that should be observed whilst making reused waste water part of the water allocation system. One further frontier for development is the quantitative evaluation of microbiological risk, in particular the concentration of helminths (Jaramillo et al 2017).

Box 11: Substitution with treated wastewater: the Korba coastal plain in Tunisia

The Korba coastal plain is in the east of the Cap Bon peninsula in north-eastern Tunisia. It is an area of around 40 km by 10 km, bounded by the Mediterranean Sea along the eastern border. The geology of the region mainly consists of sandstones, conglomerates, and clay. From the 1960 onwards groundwater use increased rapidly, leaving the aquifer dry.

To restore the aquifer, third stage treated wastewater from urban users and industries was injected in the aquifer. The planned capacity of the wastewater treatment facility was 7500 cubic meter a day but in reality, 20% of this was available. This nevertheless helped to restore groundwater levels over a 3-5 year period with 2.7 meter and improve the quality of water that had been affected by sea water ingression. The beneficial impact did not cover the entire Korba plain was concentrated close to the infiltration plants and the Southeastern section of the plain and did not cover in the entire depleted area.

Source: https://thewaterchannel.tv/thewaterblog/substitution-preserving-coastal-aquifers-in-korba-tunisia/

3.2.6 Optimize irrigation supplies and schedules and align with agricultural cropping patterns

Water allocations should harmonize with the actual or preferred cropping pattern. Whilst in groundwater system this is usually not an issue because water is supplied on demand, in surface irrigation on the other hand water delivery is more rigid and there is often scope for improvement by improving water allocations. It is not uncommon that the water allocated to certain areas for instance is far more than what is required for crop cultivation, leading to water logging (see also box 7). In other cases the allocation over time is not correct, making it difficult to grow certain crops.

In principle there are four elements along which agricultural water allocation, as subsequently captured in irrigation schedules, may be optimized (see figure 7: the length of irrigation cycle, the volume of delivery, the duration of water turn, and the order of irrigation turns.

1. The length of the irrigation cycle should support the preferred cropping pattern. Short-, rooted crops like vegetables require frequent watering and hence short duration irrigation cycles are required. Other crops – cereals or tree crops – do well in longer irrigation cycles.
2. The volume of water delivery should be adequate. If the volume of water is too small, a relatively large portion may be lost in reaching agricultural field boundaries. If the volume is too large, the flow may be unmanageable and standing crops may be damaged.

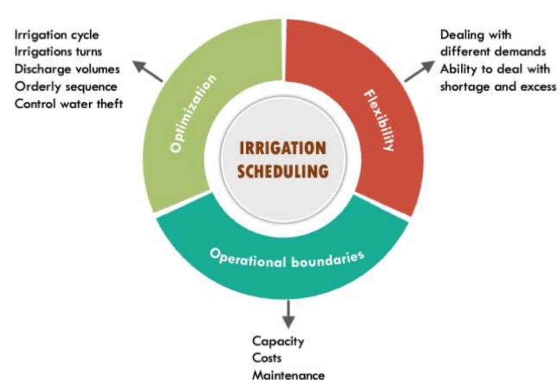

Figure 7: Optimizing water delivery

3. Combined with the duration of the irrigation turn and the return period of the irrigation cycle, the irrigation turns determine the amount of water supplied. This needs to be harmonized with crop water requirements under the prevailing climate and leaching requirement, losses in the canal system and in the field. Particularly if there is also a habit of farmers diverting water illegally, the amounts supplied maybe too much, which not only constitutes water wastage but is also detrimental for crop production. Note that water theft is estimated globally to amount to 30-50% of all water used (Loch et al, 2020) constituting a major disruptor in regulated water use.
4. Finally, the order of the irrigation turns is important. This may be orderly – from head to tail, or tail to head. The advantage of an orderly sequence, in unlined water channels, is that little water is lost in wetting the perimeter of the canal. Particularly in smaller channels, however, a chaotic patterns of water deliveries may result in the frequent wetting and drying of the canals – which can constitute a significant water loss.

In summary the harmonization of water allocations and water delivery schedules with the cropping patterns – in addition to other measures - can improve production and reduce the amount of water used. In addition, some flexibility can be built into the irrigation schedules that makes systems more demand responsive (see 3.2.7). This must take place within the operational boundaries of the irrigation system – see figure 7, such as the physical capacity of the canal and drainage system, the sensitivity to maintenance and the cost of operation, for instance of water lifting.

Where water is saved – through harmonized water allocations or through other water saving measures (such as changed cropping patterns, drought resistant varieties, better field water management, the use of precision irrigation techniques and more) , it is important to have a plan on where to use the water that is salvaged. Such reallocation plans should be part of investments in water use efficiency. It should be clear what will be done with the water that is saved.

3.2.7 Introduce increased demand responsiveness

In surface gravity irrigation system, water allocations may be very rigid and water delivery schedules inflexible. This very rigidity may cause water wastage and forego opportunities to reach high water productivity, as water is not available in the time and quantity that is required. It is therefore useful when possible, to build in demand orientation in the water allocation systems for agriculture.

This may be done in several ways as part of the water allocation system. First is to build in a water requisition system where water is made available on demand. The water user places the demand for water delivery. Such arrangements are possible when there is decentralized storage within the agricultural water system. The second opportunity is to create within the water allocation system special unallocated water shares within the irrigation cycle. These shares may be obtained by the highest bidder[23] and the sales of such shares can help raise funds for operation and maintenance. A third option is to facilitate the exchange of water

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[23] In some smaller agricultural water systems such unallocated shares have also been used to provide water to more vulnerable water users. The allocation of special shares also overcome the problems of a pure market approach, as the trade only concerns a limited part of the water resource on a temporary basis, attracting a realistic resource price in a well regulated market (pers. Comm. Phil Riddell).

shares between different water users. This was also discussed as part of water tenure: the right to transferability.

A special case of demand orientation in groundwater usage is the use of ‘ATM’ systems. These are not yet – to our knowledge – applied in Arab countries, but they are in place in some countries, such as the People’s Republic of China (see the case in box 12) and Spain, but also in country with less strict control by the state, notably in the Barind Tract in Bangladesh.

Box 12: ATM systems for groundwater use: example from People Republic of China

In the Qinxu Groundwater System all 1473 wells in the county with an automatic operating system that farmers operate with individual swipe cards. The amount of water that can be used is based on a quota that is allocated annually based on land owned and number of family members. If water is used within the quota, a basic unit price is charged. If the water-use exceeds the quota, a premium price applies. There is an upper limit to the quota (twice the basic amount), however – which cannot be exceeded. There are several such systems in operation in water-stressed North China.

Quota can also be traded – between villages and between farmers. The swipe card transactions are transmitted through internet to the Digital Water Resource Information Centre in the Water Resources Bureau of the county. This center meticulously record the number of units consumed by each farmer based on his swipe card transactions.

The results are remarkable. As the swipe cards are pre-paid, the cost collection is 100%. What is even more significant is the effect on the groundwater. Some water demanding crops were phased out and water efficiency measures became common place. Whereas prior to this system (at a cost of Euro 251 per hectare) groundwater levels were in heavy decline, the situation has been turned around with water tables increasing by 1.6 to 4.8 meters a year. The volume of groundwater consumed was lowered steadily: a drop of 40% was achieved within a period of five years. The crux was that the quota were set at the appropriate level.

Source: ADB (2016)

3.2.8 Improve multifunctional use of water in agricultural water systems

In agricultural water systems often, several other functions are served: water for domestic use, water for industries, wetlands, or environmental flows. These multiple functions, where they occur should be recognized and should be part of the water allocation system with the water shares for these other functions clearly described and respected. This is not always the case. Water allocation for domestic and industrial use is not always registered. Similarly, water shares for wetlands and for environmental flows may be recognized but are then sometimes sacrificed due to perceived water scarcity.

This may apply to surface systems and groundwater systems alike. In agricultural groundwater systems, storage tanks and additional pipelines may serve domestic drinking water needs. In canal system drinking water may be sourced directly from drains and canals, or in case the underlying aquifer is saline from small water lenses that occur along the canals that need to be preserved.

Wadi Qarada, Yemen: irrigation deep well also used for village drinking water supply (see the separate connections)

3.2.9 Special measures to enhance equity

Water allocations can also be modified to contribute to larger equity in the agricultural water systems. The example of Wadi Zabid in box 13 provides an example, where water allocations were modified to create more secure supplies for downstream water users, serving to improve the recharge of drinking water wells too.

Several other improvements in water allocation can benefit the more vulnerable water users, such as:

- Having special supply channels to downstream areas so to prevent the large risk of water theft that occurs in a lengthy irrigation canal
- Allocating water to vulnerable indigenous communities for instance in pastoralist areas, as a contribution to equity and peace
- Build in special unallocated water shares that are given to vulnerable community members
- Controlling groundwater overuse as declining water tables tend to squeeze out small farmers more than large landowners (see also box 5)

Box 13: Changing water allocations towards more equity: Wadi Zabid in Yemen

An inspiring recent example of changing water allocation comes from the Tihama in Yemen. The main water systems are spate irrigation systems, that carry short duration floods following rainfall in the upper catchment. These floods used to be diverted by earthen bunds in the dry riverbeds to irrigate adjacent farmland. One of the main systems is Wadi Zabid covering 15000 ha of farmland. Rules on using these diversion bunds were made in the fifteenth century and consisted of period slots in which different areas (head, middle, tail) were irrigated. The rules favored the upstream areas as they were entitled to the base flow of the river as well as could divert flood water in the favorable rainy season when most floods arrive. The period slot of the lower command area on the other hand was very much in the dry season, when few floods would arrive. In effect, water deliveries in the lower command area depended a lot on run-away floods caused by the unplanned breaking of the earthen bunds in the upper command areas during high floods in the rainy season. Such out-of-turn water deliveries were highly beneficial for the downstream area: they would not only water the land, but also recharge the drinking water wells.

All this changed from 1970 to 1979, when permanent weirs were constructed replacing the traditional soil structures. This had two effects. First the permanent structures eliminated the possibility of runaway floods in the main season. Secondly the impermeable structures blocked the subsurface flow in the wadi – further accelerating the drying up of the drinking water wells in the downstream area. As a result, the downstream area gradually started to desertify.

Then in 2019 – in the middle of period of conflicts and war in Yemen - something remarkable happened. The system of water allocation changed to give way to an arrangement that ensured much more equity. Rather than the six-hundred-year-old rules on time slots, a new water allocation system was agreed upon. In the new allocation, land that was irrigated with a flood once could not be irrigated again in a next flood. Instead, the next flood had to go to the next area and so on and so forth. Also, the depth of water put on the land was limited to 40 centimeter and the command area were tightly defined. This new rule favored the downstream areas and water was passed on to the entire command area including the tail. It spread farm production over a larger area and helped to restore the water levels in the wells. The main driver for this change was the high level leadership that took the lead in discussing the new arrangement. In Wadi Zabid extensive discussion were held with local leaders. A turning point was when downstream people were invited to visit the upstream areas and witness the way water was used there and discuss how this affected them. In discussion with the leaders the old rules were changed to a far more egalitarian arrangement that resulted both in 2019 and 2020 the entire command area to be irrigated, for the first time in thirty years.

Source: https://thewaterchannel.tv/thewaterblog/a-new-world-more-equity-changing-water-allocation-in-wadi-zabid-yemen/

Chapter 4 Implementing the process to improve water allocation

Whilst Chapter 2 discussed the governance arrangements that are conducive to an improved water allocation regime and Chapter 3 discussed actual improved water allocation arrangements, this section discusses how to implement the improvement water allocation and how to get an effective process for change. The change may be at two levels:

- at the level of governance – to get the system in place in which optimizing water allocation is secured or at least facilitated (as discussed in section 2);
- at the level of the actual water allocation – to get improved water allocation in actual agricultural water systems (as discussed in chapter 3).

In the change process ideally four elements come together: the change leadership and agenda from the top; an adequate and shared factual understanding of the current situation and the options for improvement; the engagement of large group of stakeholders that matter and give the critical mass for change; and the ownership of the actual users in all their diversity for ground truthing and safe landing.

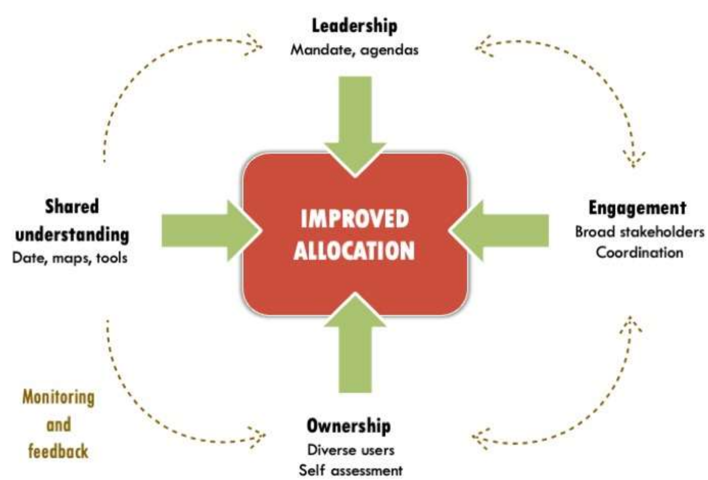


Figure 8: Four elements driving the process of changing water allocation

What ideally ties this together is a process of assessing implementation and monitoring results, so that the feedback thus generated creates a process of refinement and improvement of the water allocation system. Once a proper system of water allocation is in place with clear leadership, roles, and procedures, modifying allocations will be easier. The need for such regular updates may become ever larger because of increased scarcity and the pressures of climate change.

4.1 Create an agenda for improved water allocation

In many instances water allocation and water management in general are not addressed. It is quite common to have conferences and studies on integrated water resource management or water security, but on the ground not much change takes place. The organizations responsible for delivering water services do their routines, but the systematic review and improved water allocation is generally not part of the agenda – neither to optimize delivery, to optimize impact, to create fairness, to accommodate for multifunctional use, or others. The way by which water is supplied is 'by default and history' not by conscious decision. Optimizing water allocation does not happen but falls 'in the cracks.

Chapter 2 discussed that there needs to be institutional responsibility for improved and updated water allocation, either by adding this to the remit of existing institutions or making it part of the work of special committees. This should be done at both levels: in the allocation of water to agriculture, as against other uses and in the better allocation of water within agricultural systems – both in their design and operations. Important improvements can be made at all levels. What is important to get the process moving is to have leadership that is close to operational responsibility. Where water management is decentralized as is the case in several of the Arab countries the leadership should come from the local regions, not from national level for instance. It is important to have champions – persons with an extra drive that see the improvement of water allocation as a personal life mission. Such leadership should be given the space and the encouragement and recognition of the special efforts. It requires such change leaders to (1) bring different stakeholders together (2) invest in developing the shared evidence-based understanding (3) give space to the diverse group of users (4) connect to higher level leadership and follow up processes and (5) give all the confidence that the process is under control. Preferably improved water allocation is recognized by political leadership – by encouragement and endorsement, this setting the norm. There is also the important effect of 'success having many fathers: in this case through publicity not only inform a larger audience but also to make many generously shine in the positive developments. Once the transition to improved arrangements are made, responsibility also at high level and operational level needs to be institutionalized (see Chapter 2).

Leadership in water allocation can also be facilitated by advocacy: raising awareness of the need for change at different levels: changing the narrative within the bureaucracy, among the community of water users and other stakeholders. This creates more space within which difficult measures can be taken by the political leadership.

4.2 Have a strong shared data base

A strong shared database can be catalytic. There is often no systematic overview of the water resources available, the flows and different uses. A prerequisite for optimized water allocation however is a clear understanding of the basin hydrological processes, the different water flows, and water stocks as well as the interaction with land use or the scale and effect of water depletion. Accurate metrics create the basis for a realistic discussion on water allocation.

The accounting of water resources is best done under a commonly agreed framework. The Water Accounting Plus (WA+) Framework (https://www.wateraccounting.org) has been developed by several leading organizations in the water sector such as FAO, IWMI, IHE. It comes with a standard methodology including (i) a resource base sheet, (ii) an evapotranspiration sheet, (iii) a productivity sheet, and (iv) a withdrawal sheet with each sheet containing indicators sets that summarize the overall water resources situation. Data inputs are diverse: hydrological models, water allocation models as well as satellite images.

In addition, a map with current situation and improved options can fast forward joint decision making. It can reveal the situation on the ground with respect to current water allocation in an orderly and undisputed manner, can help create awareness and bring different stakeholders to the table. Water flow recorders – powered by telemetry systems – are equally powerful, especially when the data are placed in the public domain. The data bases should preferably be open – accessible for scrutiny by all – and at least shared and agreed between the main stakeholders so that there is a level playing field.

What is important is that datasets do not mystify but empower. It is important to avoid those models and analyses used that are ambiguous, complicated, and not clear for most people.

The following type of information is useful as input to joint discussions:

- Official water allocations when they exist
- Planned and actual deliveries
- Actual water consumption
- Actual production (in biomass)
- Soil moisture and water stress
- Water productivity
- Weather effects
- Trends over time in the above
- Impact in terms of social water productivity

The use of remote sensing is a powerful tool here because it allows the geographical analysis of the current situation. Remote sensing is also powerful as it can create historical data sets, allowing one to see trends and anomalies. It can create map images and analyze different parameters – soil moisture, climate effects, and combined indicators such as crop water productivity or crop water stress. The limitation of remote sensing must be understood as well: change in crop, crop classification, cloud cover, difficulty in classifying mixed cropping patterns, imperfections in measurement instruments. This limitation must be understood but they do not take away the large contribution that remote sensing can have.

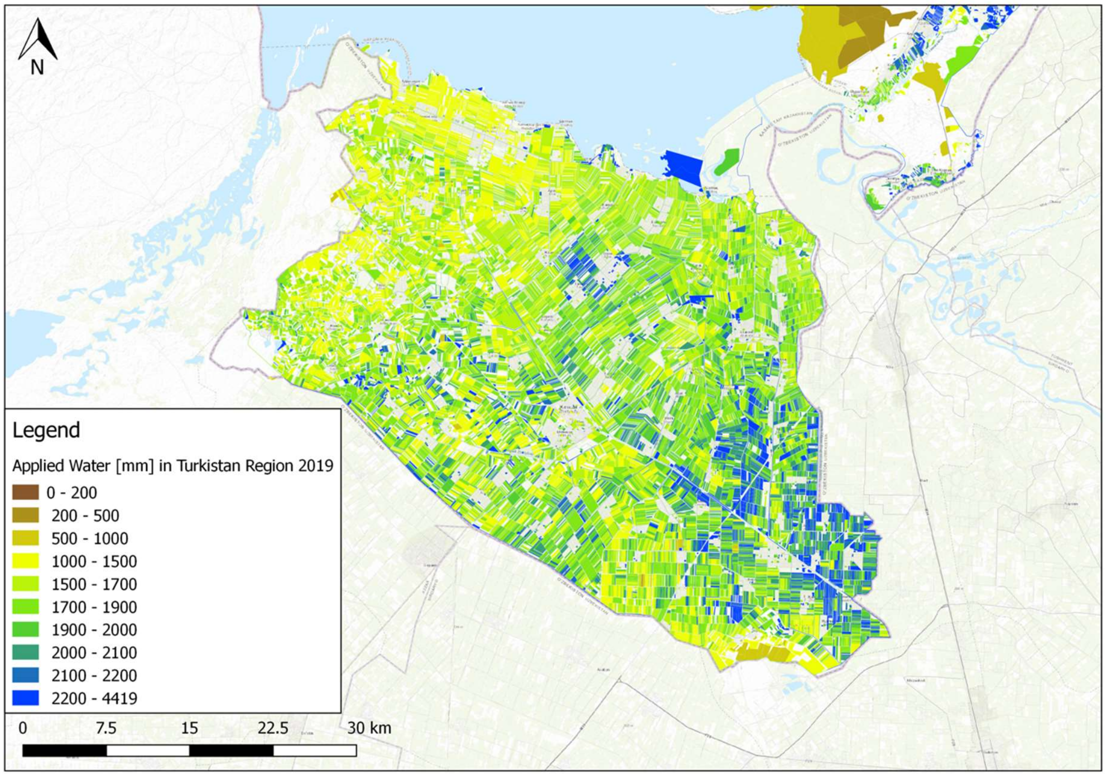
To complement remote sensing and other data, field data collection is extremely useful. It serves to see the situation on the ground but also for instance downstream water users to understand upstream water use and vice versa (see box 14) and start a real dialogue.

Water systems may benefit moreover by employing modern SCADA (Supervisory Control and Data Acquisition) systems. SCADA systems collect and store data from important control points and their immediate environments. The data are displayed on a central control system or website, accessible to technicians and managers, but also to a wider audience of water users or general public.

Box 14: Using maps, building from remote sensing

Remote sensing offers unparalleled opportunities to analyze, visualize and discuss actual water allocation. As historical data are available, time series can be created that make it possible to see how things changed. By now commercial suppliers, such as IrriWatch, offer many indicators at the scale even of individual plots, such as net irrigated area, vegetation cover, precipitation, irrigation water requirements, evapotranspiration, transpiration, soil moisture root zone, applied water, ET from applied water, runoff from applied water, percolation from the root zone to the underground and dry matter production. The costs for sourcing this information sets are low, especially compared with field data collection.

Below is an example from the irrigation system in Turkistan Oblast (Kazakhstan). The main canal runs from east to west. The inequity in applied water is highly visible – with head reaches and some selected middle reaches receiving twice the amount of water (2200 mm) than the lower and outlying reaches (below 1000mm). No flow measurement would be able to show these patterns. The advantage of using a lower resolution is that main areas can be identified, making it easy to discuss and create common understanding among stakeholders.



Source: AgriTechHub & IrriWatch regional scale irrigation analysis 2020

\4.3 Stakeholder engagement

It is important to engage the stakeholders. What is important is to engage a large range of stakeholders in the development of the area – not just the people that make use of the water resource. It is important for instance to involve possibly local government, police, traditional leadership, agricultural field workers, irrigation staff and representation of special groups – youth and women or business councils. It is important that no one is excluded, and that local leadership is recognized – see also the example of box 13. This will create the critical mass for the process of change and mobilize support to overcome obstacles.

- Different stakeholders to get to know each other and appreciate different positions (direct use, follow up activities, resource management, general area development and stability)
- Reflect on different interests and positions and agree on need for improvement and optimizations
- Create common perception preferably by maps and data – allow these to be verified in field visits
- Create structured process with delegated subgroups doing more detailed work – to be presented to the larger group

- Make use of local activists – often there are local ‘change makers’ that have the ability and drive to make extra efforts for the good cause; if acceptable to all, such voluntary activists should be given a place in the follow up processes
- Make communication plans to share the planned changes broadly.

Particularly as new water allocation has many dimensions, see also chapter 3, and involves a large group of stakeholders it is argued that the stakeholder discussion may concentrate on making a water allocation plan for the agricultural water system or for distinct parts there off. This plan is then an intermediate step in coming to action – under the overall change leadership with the different stakeholders engaged, where relevant, in implementation as well.

4.4 Create the ownership of diverse users

Water users are a special category of stakeholders. The changed water allocation will affect them directly – preferably by delivering a better service. In agricultural water systems there are apart from agricultural users often a diverse range of water users and users of water services. This can range from drinking water to towns and cities and to rural settlements, industries, fisheries, recreational users, pastoralists but also houseowners affected by water logging or land subsidence or having waterfront property. It is important to engage all these diverse user groups.

There has been encouraging experience in getting water users to self-assess the water situation, for instance by measuring soil moisture and the need to irrigate themselves. This has helped to improve farm management but also to bundle farmers interest in improved water allocation and irrigation schedules – see box 15. A wide range of soil moisture sensors is now available – many of which are easy to use by agricultural water users. In Annex 3 an overview list is given.

Box 15 : Using soil moisture sensors to modify water allocation

In a two-year field program 54 water users, water user group leaders and irrigation managers the medium size Koga Irrigation Scheme (7000 ha) in Ethiopia were familiarized with the use of soil moisture sensors. This allowed them to “look beyond the soil” and assess whether the land should be irrigated or had been irrigated too much. Two tools in particular were introduced the Wetting Front Detector (WFD) and Chameleon Soil Water Sensor. The WFD is simpler – an ingenious plastic tube that tells the farmer where sufficient water has accumulated in the root zone by pushing up a flag. By installing them at different depths the farmers could evaluate till which depth the soil has been “sufficiently” wetted. The Chameleon Reader connects via wires to a soil moisture sensor installed at different depths. It translates the ease with

which a plant can take up water into a simple color: the colors blue, green or red corresponds to very wet, moist, and dry.

Farmers in the 54 water user groups were introduced to these instruments and taught how to use them. As the project targeted improved on-farm water management and collective action within the water user groups, not every farmer was given an instrument. Special data collectors were deployed to help share the information between farmers.

The results were spectacular. Within one or two seasons of becoming comfortable with the tools farmers improved their field water management. They realized they were overirrigating and that this excessive use of water reduced rather than increased yields. The water users reduced the amounts of water applied. They also agreed with the Koga Irrigation System Authority for a change in the water allocation arrangements. Depending on the area it was agreed to extended the irrigation cycle to the local storage reservoirs from 8 to 11 days, or 9 to 13 days – effectively a water use reduction of 35%. With reduced water applications the wheat crop yield went up: by 10 to 20% according to farmers' estimate. The gain in terms of water productivity or 'crop per drop' was a spectacular 35-40%. The saved water was used to extend the area under cultivation within the blocks, but also to reduce water deliveries from main scheme operations to night storages.

Source: https://thewaterchannel.tv/thewaterblog/more-crop-per-drop-farmer-learning-and-the-promise-of-improved-water-use-in-agriculture/

Chapter 5 Setting Agendas: Using the Water Allocation Improvement Agenda Tool

In this section the different improvements in water allocations are brought together in an assessment tool, the so-called Water Allocation Improvement Agenda Tool.
The purpose of the Water Allocation Improvement Agenda Tool is to assess current water allocation arrangements in specific agricultural water systems. The aim is to identify the most promising improvements in terms of impact and practicality and to hence create an agenda of action. The tool is based on the Guidelines for Improved Water Allocation for Agriculture, as discussed in the preceding chapters.

The assessment concerns the actual water allocation arrangements as they are in place and the concerned governance arrangements that affect the (suboptimal) water allocation. The assessment of the governance arrangements will help identify supporting forces for change as well as again improvements. The assessment of the actual water allocation arrangement will identify priority improvements in the short and medium term. Priorities may be defined by the possible impact and the ease of introduction. Not all improvements can be made at the same time. It is strongly suggested to work step wise and improve the water allocation system over a period, hopefully getting stronger stakeholder ownership over time. It is strongly suggested to get the process to work in selected pilot agricultural water systems in each country, selected on the scope for possible improvements to be made and the interests of the water system managers concerned. In the experience of the contributors to these Guidelines significant improvements are possible in every agricultural water system.

The assessment tool can be applied in several ways. It is suggested that it is first used with a smaller preparatory group, that identify the main areas of improvement in water allocation and governance. This may be based on expert judgement, but it is strongly recommended that field visits, remote sensing analysis and interviews with key persons (water system operators, farmer leaders, other water users) is made use of too. The preparatory work may help identify the areas of most promising improvement. When this is done, the assessment of the current water allocation can be done with a much larger group of stakeholders, focus on selected areas of intervention and agree on who will take the lead in moving it forward. Also, before the Agenda Tool is used, it is recommended to have a briefing with key decision makers, so that political and higher institutional ownership for the change process is secured.

The tool is presented in the shape of two checklists[24].

- The first checklist (A) concerns the governance arrangements in support of better water allocation. It identifies the areas of support of the change process and the priority improvements in the concerned governance arrangements. This checklist can be used at national level and at the level of an individual water system,
- The second checklist (B) scans the current water allocation systems and identifies the most promising improvements, in terms of impact and feasibility. This is most appropriately used at the level of an individual agricultural water systems as it makes it possible to identify very specific improvements.

[24] Ideally improvements are made on both fronts. However it is not necessary and the Agenda Tool can identify the most pressing and promising importance in the water allocation regime (list A) and water allocation arrangements (list B).

The full version of the Agenda Tool with the detailed assessment questions is given in annex 2. A snapshot overview is given in figure 9 below.

Checklist A: Assessing Governance in support of Improved Water Allocations

	Assessment	Action/ area of engagement	Short-term priority	Mid-term priority
Adequate metrics				
Policy and regulations				
Institutional leadership				
Transparent private sector roles				
Clear water tenure				
Routine integration in operations				
Systematic coordination of users and stakeholders				

Checklist B: Assessing Current Water Allocations and Identifying Improvements

		Assessment	Action/ area of improvement	Short-term priority	Mid-term priority
National or basin planning	**Intersectoral allocation of surface water**				
	Intersectoral allocation of ground water				
Water allocation in agri-cultural water system planning	**Water allocation for improved crop water productivity**				
	Climate resilience: improved management of drought and abundance				

	Drainage reuse and water quality management				
	Balanced management of surface water and groundwater				
	Substitution of water resources				
Water allocation in agri-cultural water system operation	**Optimizing irrigation schedules and supplies**				
	Improved demand orientation				
	Improved multifunctionality				
	Measures for improved equity				

Figure 9: Summary of Water Allocation Improvement Agenda Tool.

Annex 1: Key country water data

Water Policy Pillars	1. Effective Water Resources management																		
Indicator	annual total renewable water resources		annual per capita total renewable water resources		water stress		gw/sw withdrawal						water dependency ratio		agricultural/total water withdrawal		actual evapotranspiration and interception of irrigated cropland (AETI)		
Source	FAO AQUASTAT Online Database		FAO AQUASTAT Online Database		Aqueduct 3.0 Country Rankings data sets		FAO AQUASTAT Online Database						FAO AQUASTAT Online Database		FAO AQUASTAT Online Database		WaPOR Database		
Definition	total annual actual renewable water resources		total annual actual renewable water resources per inhabitant		water stress measures total annual water withdrawals (municipal, industrial, and agricultural) expressed as a percentage of the total annual available blue water. Higher values indicate more competition among users. [0-1)Low (<10%) [1-2)Low to medium (10-20%) [2-3)Medium to high (20-40%) [3-4)High (40-80%) [4-5]Extremely high (>80%)		proportion fresh groundwater withdrawal/total freshwater withdrawal and fresh surface water withdrawal/total freshwater withdrawal						indicator expressing the percent of total renewable water resources originating outside the country. This indicator may theoretically vary between 0% and 100%. A country with a dependency ratio equal to 0% does not receive any water from neighbouring countries. A country with a dependency ratio equal to 100% receives all its renewable water from upstream countries, without producing any of its own. This indicator does not consider the possible allocation of water to downstream countries.		agricultural/total water withdrawal				
(Colour) coding	red = low, green = high		red = low, green = high		green = low, red = high		red = low, green = high	red = low, green = high	red = low, green = high	red = low, green = high	red = low, green = high		green = low, red = high		red = low, green = high		green = low, red = high		
Unit	10^9m3/yr		m3/capita/yr		0-5 scale		ratio						percentage (%)		percentage (%)		mm/yr		
Member Country (MC)		**Year**		**Year**		**Year**	**SW withdrawal (10^9 m3/year)**	**GW withdrawal (10^9 m3/year)**	**Tot withdrawal (10^9 m3/year)**	**SW/total withdrawal**	**GW/total withdrawal**	**Year**		**Year**		**Year**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**
Algeria	11.67	2017	282.4	2017	3.69	2010	1.699	8.103	9.802	17.33	82.67	2017	3.60	2017	63.78	2017	843	897	6
Bahrain	0.116	2017	77.7	2017	4.13	2010	0	0.1533	0.1533	0.00	100.00	2017	96.55	2017	33.31	2016	531	527	-1
Comoros	1.2	2017	1474	2017									0.00	2017					
Djibouti			313.5	2017	3.37	2010							0.00	2017					
Egypt, Arab Rep.*	56.8	2017	589.4	2017	3.07	2010	55.5	6.5	64.4	86.18	10.09	2017	98.26	2017	79.16	2017	1309	1413	8
Iraq	89.86	2017	2348	2017	3.13	2010							60.83	2017	91.49	2016	758	835	10
Jordan	0.937	2017	96.58	2017	4.56	2010	0.2888	0.6147	0.9035	31.96	68.04	2016	27.21	2017			464	496	7
Kuwait	0.02	2017	4.834	2017	4.43	2010							100.00	2017			680	812	19
Lebanon	4.503	2017	740.4	2017	4.82	2010	0.396	0.7	1.096	36.13	63.87	2005	0.79	2017	59.54	2005	967	900	-7
Libya	0.7	2017	109.8	2017	4.55	2010	0.17	5.59	5.76	2.95	97.05	2012	0.00	2017	83.19	2012	527	502	-5
Mauritania	11.4	2017	2579	2017	2.14	2010							96.49	2017	90.59	2005	711	876	23
Morocco	29	2017	811.4	2017	3.89	2010	8.251	2.099	10.35	79.72	20.28	2010	0.00	2017	87.79	2010	776	782	1
Oman	1.4	2017	302	2017	4.04	2010	0.102	1.532	1.634	6.24	93.76	2013	0.00	2017	85.84	2013	610	615	1
Palestine	0.837	2017	170.1	2017	2.92	2010							2.99	2017	43.18	2017	507	575	13
Qatar	0.058	2017	21.98	2017	4.97	2010	0	0.2508	0.2508	0.00	100.00	2016	3.45	2017	31.96	2016	693	849	23
Saudi Arabia	2.4	2017	72.86	2017	4.35	2010	0.19	21.01	21.2	0.90	99.10	2017	0.00	2017	82.23	2017	862	1014	18
Somalia	14.7	2017	997.1	2017	1.01	2010	3.167	0.131	3.298	96.03	3.97	2003	59.18	2017			830	942	13
Sudan	37.8	2017	932.6	2017	2.92	2010							96.13	2017	96.21	2011	989	1070	8
Syrian Arab Republic	16.8	2017	919.5	2017	3.64	2010							72.36	2017	87.53	2005	743	587	-21
Tunisia	4.615	2017	400.2	2017	3.67	2010	1.151	2.066	3.217	35.78	64.22	2011	9.10	2017	77.39	2017	691	816	18
United Arab Emirates	0.15	2017	15.96	2017	4.26	2010	0	2.562	2.562	0.00	100.00	2017	0.00	2017	82.84	2005	619	587	-5
Yemen, Rep.	2.1	2017	74.34	2017	3.97	2010	0.987	2.397	3.384	29.17	70.83	2000	0.00	2017	90.74	2005	759	746	-2

* values for total annual renewable water resources and for the surface water withdrawal are provided by the ministry of water resources and irrigation

2. Resilient Water Systems

average annual population affected by floods		water vulnerability to climate change		food vulnerability to climate change		climate change vulnerability and readiness		reference evapotranspiration of rainfed cropland (ET0)			reference evapotranspiration of rainfed cropland (ET0)		
Aqueduct Global Flood Risk Country Ranking		UN-GAIN		UN-GAIN		UN-GAIN		WaPOR Database			WaPOR Database		
a country-wide average flood protection level for each country was assigned based on its income level (World Bank). 1) For low-income countries, it was assumed 10-year flood protection; 2) for lower-middle income countries, it was assumed 25-year flood protection; 3) for upper-middle income countries, it was assumed 50-year flood protection; 4) for high-income countries, it was assumed 100-year flood protection		vulnerbaility measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. This indicator measures overall vulnerability considering the water sector		vulnerbaility measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. This indicator measures overall vulnerability considering the food sector		the ND-GAIN Country Index is composed of two key dimensions of adaptation: vulnerability and readiness. Vulnerbaility measures a country's exposure, sensitivity and capacity to adapt to the negative effects of climate change. ND-GAIN measures overall vulnerability by considering six life-supporting sectors – food, water, health, ecosystem service, human habitat, and infrastructure. Readiness measures a country's ability to leverage investments and convert them to adaptation actions. ND-GAIN measures overall readiness by considering three components – economic readiness, governance readiness and social readiness.							
green = low, red = high		green = low, red is high		red = low, green = high		red = low, green = high		green = low, red = high			green = low, red = high		
number of people		0-1 scale (lower is better)		0-1 scale (higher is better)		0-100 scale (higher is better)		mm/yr			mm/yr		
	Year		**Year**		**Year**		**Year**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**
30773	2010	0.355	2017	0.562	2017	45.230	2017	1722	1774	3	1459	1541	5
		0.494	2017	0.420	2017	48.686	2017	2190	2185	0			
		0.115	2017	0.709	2017	39.231	2017						
49	2010	0.042	2017	0.635	2017	38.925	2017						
464825	2010	0.424	2017	0.592	2017	46.140	2017	2375	2452	3			
192341	2010	0.333	2017	0.606	2017	39.833	2017	2495	2513	1	1530	1453	-5
589	2010	0.395	2017	0.522	2017	49.640	2017	1955	1950	0	1868	1950	-2
361	2010	0.402	2017	0.524	2017	50.322	2017	2736	2861	5			
384	2010	0.269	2017	0.483	2017	45.172	2017	1481	1442	-3	1500	1461	-3
4231	2010	0.391	2017	0.445	2017	40.803	2017	2331	2352	1	1758	1867	6
11003	2010	0.437	2017	0.721	2017	36.035	2017	2843	2989	5	2811	2939	4
65186	2010	0.260	2017	0.537	2017	50.808	2017	1650	1719	4	1608	1769	9
390	2010	0.346	2017	0.626	2017	54.725	2017	2341	2405	3			
								1737	1744	0	1729	1739	1
		0.207	2017	0.423	2017	53.024	2017	2380	2581	8			
10372	2010	0.338	2017	0.589	2017	54.286	2017	2665	2604	-2			
102866	2010	0.542	2017	0.724	2017	20.267	2017	2447	2512	3	2470	2385	-4
157916	2010	0.692	2017	0.747	2017	30.421	2017	3126	3016	-4	2770	2644	-5
46246	2010	0.499	2017	0.570	2017	38.970	2017	1845	1848	0	1630	1651	1
8762	2010	0.366	2017	0.514	2017	49.666	2017	1637	1747	7	1418	1546	8
905	2010	0.334	2017	0.532	2017	58.892	2017	2349	2522	7			
16128	2010	0.426	2017	0.733	2017	33.471	2017	2184	2106	-4	2194	2206	1

3. Water Use Efficiency

water use efficiency		gross biomass water productivity of irrigated cropland (GBWP)			total biomass production of irrigated cropland (TBP)			gross biomass water productivity of rainfed cropland (GBWP)			total biomass production of rainfed cropland (TBP)		
FAOSTAT		WaPOR Database			WaPOR Database			WaPOR Database			WaPOR Database		
value added in US dollars per volume of water withdrawn in cubic metres, by all major sectors (based on ISIC categories): agriculture, industry and the service sector. The indicator allows countries to assess to what extent their economic growth depends on the use of their water resources. If the value added of a sector or the whole economy grows more than the relevant water use, the indicator value increases, indicating that water is not a limiting factor for economic growth (i.e., economic growth is decoupled from water use). As such, the water-use efficiency concept differs from the related concept of water productivity, which instead considers the productivity of water used in a given activity as an input to a production.													
red = low, green = high		red = low, green = high			red = low, green = high			red = low, green = high			red = low, green = high		
USD/m3		kg/m^3/yr			ton/ha/yr			kg/m^3/yr			ton/ha/yr		
	Year	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**	**Average 2009-2011**	**Average 2017-2019**	**Differnce (%)**
14,1	2015	1,63	1,54	-6	13,8	13,8	0	2,19	2,08	-5	8,1	8,8	9
73,3	2015	0,94	1,18	25	5,0	6,2	24						
20,4	2000												
4,6	2015	1,35	1,26	-6	17,6	17,8	1						
5,2	2015	0,82	0,97	18	6,2	8,2	32	1,63	1,58	-3	5,3	5,6	5
31,7	2015	1,60	1,33	-17	7,3	6,6	-10	1,38	1,53	11	5,4	6,1	12
70,7	2000	0,86	0,91	5	5,8	7,3	26						
23,3	2015	1,70	1,80	6	16,4	16,2	-1	1,61	1,69	5	11,2	10,6	-6
18,5	2010	1,76	1,76	0	9,2	8,8	-5	1,75	1,91	9	5,3	6,6	24
2	2005	0,66	0,49	-25	4,7	4,3	-8	0,59	0,41	-30	2,1	1,9	-12
7,2	2010	2,06	2,06	0	16,0	16,0	0	2,38	2,35	-1	9,2	9,0	-2
32,3	2000	0,86	0,92	7	5,2	5,7	8						
15,7	2005	1,50	1,43	-4	7,6	8,2	9	1,45	1,46	0	7,1	7,6	8
233,9	2005	0,76	0,83	9	5,3	7,1	33						
27,5	2015	0,88	0,89	1	7,6	9,0	18						
0,1	2000	1,14	1,09	-4	9,4	10,3	10	0,98	1,06	9	3,7	4,3	18
1,6	2010	0,50	0,55	10	4,9	5,8	19	0,57	0,71	25	3,1	4,8	52
2,8	2005	1,31	1,40	7	9,7	8,3	-15	2,02	1,90	-6	7,8	7,7	-1
9	2015	1,79	1,65	-7	12,3	13,5	9	2,14	1,96	-9	9,9	10,6	7
70,1	2005	0,90	0,95	5	5,6	5,6	0						
6,9	2000	0,67	0,90	34	5,1	6,7	32	0,36	0,36	0	0,9	1,2	44

Annex 2: Water allocation improvement agenda tool

The purpose of the Water Allocation Improvement Agenda Tool is to assess current water allocation arrangements in specific agricultural water systems. The aim is to identify the most promising improvements in terms of impact and practicality and to hence create an agenda of action. The tool is based on the Guidelines for Improved Water Allocation for Agriculture. the change process is secured.

The tool is presented in the shape of two checklists. :

- The first checklist (A) concerns the governance arrangements in support of better water allocation.
- The second checklist (B) helps scan the current water allocation systems and identify tangible improvements.

Checklist A: Assessing Governance in support of Improved Water Allocations

		Assessment	Action/ area of engagement	Short-term priority	Mid-term priority
1	**Adequate metric**				
	Are there reliable and generally accepted data on main water paraneters, such as water resource availability, water usage, groundwater resources,				
	Is there a community of experts is engaged in water accounting that are cloopw?				
2	**Policy and regulations**				
	Which are the main policy documents, regulations or laws refer to (optimizing) water allocation and can these be used in the process of revising the current water allocation for agriculture?				
	Are there policy and regulatory process where improved water allocation for agriculture can be added?				
3	**Institutional leadership**				
	Is there formal institutional leadership for improved water allocation? Either by organizations or committees/ commissions? Where this political responsibility located? Can this be engaged and activated?				
	Is there need and scope to improve formal institutional leadership for improved water allocation?				
4	**Transparent private sector role**				

	Is water allocated/ being allocated to private commercial investors? If so, has the process included engagement of local stakeholders, recognition of prior land and water use and assessment on overall water balance? Is there scope to improve this?				
	Is water allocated/ being allocated to private commercial investors? If so, has the contract included mutual risk assessment, clear benefit sharing arrangement, performance standards and waiver of liability claims? Is there need and scope to improve this?				
5	**Clear water tenure**				
	Is entitlement to water for agricultural users registered and recognized/codified? Is there scope to improve this?				
	Are entitlement to water for non-agricultural users registered and recognized/ codified?				
	Do the water rights include? - Right to use - Right to exclude - Right to governance - Right to procedures - Right to transfer - Related obligations? Is there need and scope to improve this?				
6	**Routine integration in operations**				
	Which organizations have operational responsibility for water allocation and distribution? Is the regular optimization and				

	adjustment of water allocation part of their mandate?				
	Can their role in updating and optimizing water allocations be strengthened?				
7	**Systematic coordination of users and stakeholders**				
	Is there well-structured coordination between water system operators and water users (and other water stakeholders)? Is (improved) water allocation part of the agenda?				
	Are water users organized in a formal way? How effective are these organizations? Do these organizations have a responsibility in (improving) water allocation? Can this be strengthened?				
	Are stakeholders organized in (basin/catchment) council or committees? How effective are these organizations? Do these organizations have a responsibility in (improving) water allocation? Can this be strengthened?				
	Who has the general leadership of the agricultural water system? Can its engagement in improved water allocation be strengthened? How?				

Checklist B: Assessing Current Water Allocations Performances and Identifying Improvements

1	**Water allocation for improved productivity**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority
	Are there ways to increase the biophysical water productivity. i.e., to get more 'crop per drop', either on 'more crop' side or on the 'less drop' side?				
	What would be the economic benefits of increased water productivity – in terms of total returns, jobs created, food security? Which systems optimizes economic water productivity?				
	What would be the social benefits of increased water productivity? Who benefits how much – producers, laborers, suppliers, traders, processors? Which systems optimizes social water productivity?				
2	**Improved management of drought and abundance?**	Assessment	Action/ area of improvement		
	Is there storage in the water allocation system? For instance, in upstream reservoir, local storages, in canal storage, systematic use of groundwater? What is the capacity of these storages in terms of time?				
	How is water managed during times of shortage and drought? Can the water allocation during times of shortage be improved?				

	How are abundance/ flood situations managed within the water allocation system? Where does excess water (either during periods of low demand, high supply, or heavy rainfall) end up? Can such excess water be better used?				
	Is there scope to increase/ create new storage in the water allocation system?				
	Are the sequence of water turns over the different users systematic – from upstream to downstream for instance or from downstream to upstream? Would adjustments be desirable?				
	Are there other ways to reduce water supplies for irrigation?				
3	**Drainage water reuse and water quality management**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority
	Is drainage water being reused? In what way? Is it part/ can it be part of the overall water allocation?				
	Is there drainage water that is not being reused? What is the reason? Is there scope to reuse?				
	Are there water quality issues which effect the current or future reuse of drainage water? Can they be mitigated for instance by reducing point or non-point pollution or by isolating highly contaminated water?				
4	**Balanced management of surface water and groundwater**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority

	Are there areas that suffer from water logging? When and where does it occur? How is it related to the water allocation system, for instance in case of high supplies? Is there scope to make corrections/ reduction in the water allocation system?				
	Is shallow groundwater being used? How are the patterns of groundwater use influenced by the water allocation system? Is there scope to better adjust surface and groundwater use?				
	Are the irrigation duties relatively high or low? Have they ever been adjusted? Is there scope to readjust them?				
	Is overuse also caused by unauthorized water diversions? Are there ways to control these?				
5	**Substitution of water resources**	Assessment			
	Are there alternative sources of water (such as treated wastewater, industrial process water) that can substitute the current surface and groundwater? Would this be useful?				
	Are there options to safely mix lower quality (saline, moderately polluted) water with higher quality water to improve water supply?		Action/ area of improvement	Short term priority	Mid-term priority
6	**Optimizing irrigation schedules and supplies**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority

	Are current irrigation cycles (=duration of irrigation turns) harmonized with the main or the preferred crops? If not, what would be the way to better harmonize with preferred irrigation interval (shorter or longer cycles)?				
	Is the volume of water per water turn adequate – not too much and not too little? Would adjustments be desirable?				
	Is the duration of the normal irrigation turn adequate – not too short and not too long? Would adjustments be desirable?			Short term priority	Mid-term priority
	Are the sequence of water turns over the different users systematic – from upstream to downstream for instance or from downstream to upstream? Would adjustments be desirable?				
	Are there other ways to reduce water supplies for irrigation?				
	If the water is saved, where would it be used?				
7	**Improved demand orientation?**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority
	Is there flexibility in the water allocation system? Is there a scope to use more/extra or less water if one so requires?				
	Can water rights be transferred temporarily or permanently between water users? Would this be desirable?				

	Is there scope to have ‘open’ shares in the water allocation system that can be used by the persons most needy?				
8	**Improved multifunctionality**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority
	Is the water in the agricultural system used for other purposes: drinking water, industrial water, effluent disposal, wetlands, environmental flows, navigation, etc? Are these uses regulated?				
	Can the supply of water services for these other uses be improved?				
9	**Equity measures and protection of vulnerable people**	Assessment	Action/ area of improvement	Short term priority	Mid-term priority
	Is there large inequity in the system? Is this inequity part of the existing water allocation or is caused by mismanagement? Can this be corrected by adjustments in the water allocation or the way the system is managed?				
	Are there special groups of vulnerable users that require more protection? Can this be given special attention in the water allocation?				

Annex 3: Soil moisture sensors to be used for improving water allocation

Soil Moisture Sensor		Description	User Friendliness	Drawback
Wetting Front Detector (WFD)		It is an ingenious plastic tube that tells the farmer where sufficient water has accumulated in the root zone by pushing up a flag. By installing them at different depths the farmer can evaluate till which depth the soil has been "sufficiently" wetted.	Low risk Water saving Labour saving Compatible to use	The WFD does not tell an irrigator when to start irrigating
Chameleon Soil Water Sensor		The Chameleon Reader connects via wires to a soil moisture sensor installed at different depths. To measure the soil water status, the wires are placed into the slots in the card reader. The LED on the card will turn blue (wet), green (moist) or red (dry) to show the soil water status at each location.	Reduced water use Increased crop yield Improved water management led to reduced conflicts Reduced soil nutrient loss	
Water potential sensor	Tensiometer	A tensiometers measures suction pressure at its porous tip, replicating how hard a root must work to extract water from the soil	Tensiometers are simple, rapid, inexpensive, and easy to use. Different types of liquid like ethylene glycol solution can be used to obtain data during freezing and thawing condition. A tensiometer is ideal for sandy loam or light textured soils	Periodic maintenance is required as air bubbles accumulate under normal use. It is prone to damage due to freezing temperatures. Measure soil water potential only in the vicinity of the tensiometer

			The tensiometer can be used in any horticulture crop under irrigation,	The usable range is only between 0-85 centibars of tension above which the gauge will malfunction.
	Granular Matrix Sensors	The GMS is used for assessing soil moisture in crops like cotton, onion, potato, urbanized landscapes, corn, drip irrigated vegetable crop. The GMS has good accuracy in medium to fine soils because the soil particle size will be similar to that of the transmission material which has a consistency close to that of fine sand that is wrapped in porous membrane of the GMS.	GMS is cheaper and requires less maintenance compared to tensiometer Automation of irrigation in fields can be achieved. Negligible change in sensor performance with variation in soil temperature	It shows different response to different soil types Sometimes, poor contact between the soil and the sensor occurs which could cause high readings which is most likely to occur in heavy soils. It is less responsive to small rains. It is low accurate in sandy soils because of their large particle size
Capacitance sensors		Capacitance sensors typically measure soil moisture at several depths and at 10cm or 20cm intervals, tracking how water is moving through the soil profile and the relative soil moisture at each interval.	Capacitance sensors reduce the amount of applied irrigation	Readings aren't entirely representative. The kit can also be affected by salts in the soil.
Time Domain Reflectometry (TDR)		Consist of two or three metal prongs between 5cm and 30cm long. These are installed by digging a hole and pushing the prongs into the undisturbed soil	It measures moisture quite accurately (± 2%) in any type of soil. Soil moisture from multiple depths can	They need to be carefully calibrated Expensive than other measuring methods

			be obtained from a single probe.	TDR read soil moisture only in the vicinity of the sensor
Frequency Domain Reflectometry (FDR)		SMT50 and the VH400, which are both low-cost soil moisture sensors which are widely used in consumer applications such as irrigation control. The electrical sensor capacitance is a direct measure of soil volumetric content. Its principle is like TDR sensor	It is very accurate (± 1%) if calibrated properly Unlike TDR, it can be used with soil having high salinity. With FDR, measurements can be made at several depths at the same location.	It is expensive as compared to TDR. It can sense moisture content only in the vicinity of the sensor.
Neutron Moderation	Neutron moisture meter	A reliable tool for determining soil water content		Its use of a radioactive source, the maintenance requirement and the cost have restricted its application
	Gamma Ray attenuation	Proximal gamma-ray spectroscopy supported by adequate calibration and correction for growing biomass is an effective field scale technique	Potentially employed as a decision support tool for automatic irrigation scheduling	