HOW TO TACKLE ILLEGAL WATER ABSTRACTIONS?

Taking stock of experience and lessons learned

FUNDACIÓN BOTÍN

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Cover photo by WWF/Felipe Fuentelsaz. Construction of an illegal borehole in a forest area. March 2007"

The report is based on a literature review and shared experiences, and is complemented by case studies for the Northern Cape portion of Orange and Vaal basins, South Africa[1]; the Barwon-Darling river system, Australia[2]; and the Doñana and Daimiel areas, Spain[3]. It is based on material obtained from publicly available sources as specified and does not contain any legal advice.

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EXECUTIVE SUMMARY

In the past decade, there has been **increasing attention in research, management and media to unauthorised water use**. However, actions in policy and water management to deal with it are still limited.

Illegal water use has been **reported in many countries**, particularly in areas where water is a scarce resource. It is driven by a variety of **causes**. The net benefits from water use and deficiencies in governance and institutions can be considered as active drivers that foster illegal uses, whilst social norms are underlying factors that make action against illegal water use more difficult to be socially and economically accepted.

Regarding its **effects**, illegal water abstraction can jeopardize the security of access for users having formal water rights, can have negative environmental impacts and often drives other mirror practices, such as the unauthorized transformation of protected or public lands into irrigated land.

The review of the existing literature and three case studies have helped us identify **five strategies to detect illegal water use**:

1. Setting up of an appropriate and enforceable water rights system.
2. Improved and integrated control of water uses on the ground.
3. Development and maintenance of an inventory, register or database of water uses.
4. Improved monitoring of water abstraction via remote sensing.
5. Integrated data management.

In addition, we have identified **seven strategies to tackle illegal water use** within management:

1. Involvement of water users in law enforcement and control.
2. Administrative action, closure of abstraction points and fines.
3. Legal actions and fines.
4. Capacity building of water users to help them comply with abstraction restrictions.
5. Establishment of cross-compliance requirements in agricultural subsidies.
6. Positive incentives.
7. Raising awareness about the consequences of over-abstraction.

These strategies are described in the report with examples of their implementation and the analysis of their strengths and weaknesses. Based on the existing experiences and remaining barriers, it is **hard to provide water managers with 'silver bullets'**. The complexity and local circumstances of illegal water use will require exploring different strategies and pathways, and we hope that the report and associated recommendations will be useful for water practitioners.

1. INTRODUCTION

In the past decade, there has been **increasing attention in research, management and media to unauthorised water use**. Relevant reports and articles have been published[4] as site-specific assessments or wider (European/global) compilations, many of them nurturing this report. Furthermore, the International Water Association (IWA) has developed an urban water service-focused classification of water uses, including "unauthorized consumption"[5]. Media increasingly refer to water thefts and unlawful or illegal water use.

However, changes in policy and water management to deal with unauthorised water use are still an exception, with only a handful of documented case studies around the world. Therefore, this report aims to:

- Provide a **framework for understanding and addressing** problems derived from the illegal use of water resources;
- **Compile and review** information, literature and case studies;
- **Exchange ideas and lessons learned on successful and failed experiences** in different parts of the world; and
- **Formulate recommendations** for water practitioners.

1.1 DEFINITIONS

In general, **water use is regulated through the granting of formal water rights** that determine the conditions of that use. The nature of water rights varies greatly. They can be private or publicly owned; and they are referred to in different jurisdictions as licenses, concessions, permits, access entitlements, or allocations. Despite their diversity, there are some basic attributes of water rights that circumscribe the extent of the access, use and control rights granted to the holder of the water right. These attributes can be grouped into those describing the resource (e.g. quantity and quality of the water), the source and location (e.g. surface or groundwater, desalinized or reused waters), the type of use (e.g. irrigation, domestic), the duration of the entitlement (i.e. temporal vs permanent) and the management and administration of the right (ownership and transfer, security and enforcement)[6].

When we use the term "illegal water use", we refer to **any taking of water in violation of existing regulations**[7]. The terms used in literature and media refer also to "non-authorised", "unauthorised", "unlawful", "theft," "stealing", "smuggling" and "misappropriation", and it covers the whole range from "abstraction" to "consumption". The authorities often are reluctant to acknowledge the existence of illegal abstractions and 'unaccounted water'.

This report does not consider the so-called "informal uses", when water use is not regulated by law, and thus not infringing regulation. We do however wish to address situations where the regulatory framework is incomplete, which makes its enforcement challenging.

The types of infraction associated with unauthorized water use are strongly related to the specific water regulation in each country[8] and, even within the same country, the typology of unauthorized water use can be very broad. Infractions can be classified as follows:

- Use without any water right;
- Use with an on-going but not yet finalized water right licensing application;
- Use beyond the established limits of the water right;
- Non-compliant changes to the characteristics of the water right, e.g. timing, purpose, location, trading.

Furthermore, in this report, we wish to **focus on illegal water uses in industrialized countries**. In emerging economies or developing countries, the unauthorized access to water or customary use – for drinking, grazing or cultivating – is often fundamental to livelihoods and the subsistence of water users. In industrialized countries, the regulation of access to water for economic uses can be considered as a constraint to economic activities but does not have the same degree of life-threatening urgency that can be found in less developed economies[9].

1.2 RELEVANCE OF ILLEGAL WATER USE

Illegal water abstractions are a major and still unsolved challenge in many parts of the world. Illegal water abstraction often contributes to overexploitation, unreliability of water-related data and severe gaps in policy implementation. Water managers are still looking for effective and lasting solutions.

Regarding the **magnitude of illegal water use**, it is rather uncommon to find official data or even estimates. However, illegal water use is often mentioned in media and by NGOs. Some figures have been compiled in research articles[10]. For example, it was estimated that **as many as half of the wells** in European Mediterranean countries **may be unregistered or illegal[11]**.

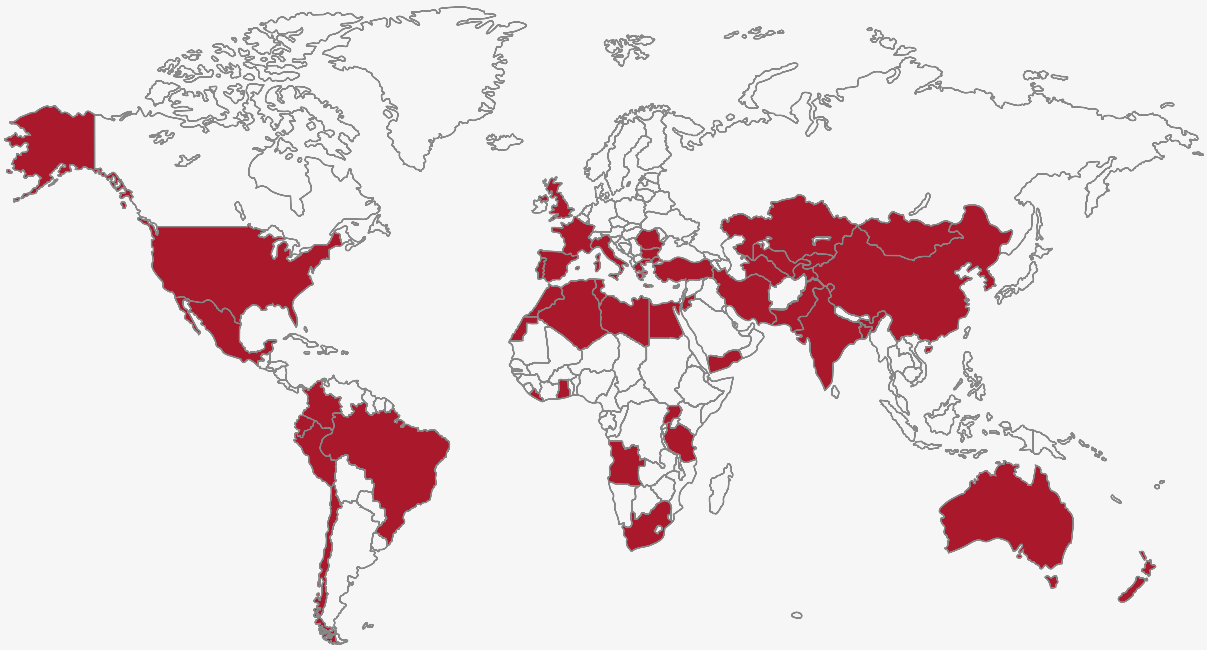

Figure 1: Map of countries where evidence on illegal water use has been found for this study (based on a blank map by 2017 Astroinstitute.Org).

References to the existence of water theft, unlawful or illegal water use has been found for a large number of countries, many of them in water-scarce areas:

- Primarily on agricultural water use in the US (California[12]), Mexico (Guanajuato)[13], Peru[14], Chile[15], Portugal and France[16], Spain[17] (e.g. Guadiana[18], Guadalquivir[19], Murcia[20]), Italy (Abruzzo, Molise, Puglia, Campania, Basilicata, Calabria, Sicily and Sardinia regions[21]), Malta[22], Greece (Korenia)[23], Cyprus[24], Romania (e.g. Banat area)[25], Morocco (Saiss basin)[26], Algeria[27], Tunisia[28], Libya (Jefara region)[29], Egypt[30], Israel[31], Jordan[32], Yemen[33], Turkey[34], Iran[35], Kazakhstan[36], Uzbekistan, Turkmenistan, Tajikistan and Kyrgyzstan[37], Pakistan (Hub dam[38], Punjab[39]), India[40], Sri Lanka[41], Mongolia[42], and China[43];
- Primarily on urban water use in the US (Atlanta[44]), Ecuador[45], Colombia (Medellín[46]), Jamaica[47], Brazil[48], Liberia (Monrovia[49]), Ghana[50], South Africa (Western Cape[51], Durban[52]), Angola[53], Tanzania (Dar es Salaam[54]), Uganda (Kampala[55]), Bulgaria[56], Iran[57], Pakistan (Karachi[58]), India[59], Bangladesh[60], Mongolia (Ulaanbaatar)[61], and New Zealand[62].

The above map and list are not comprehensive, but they illustrate that illegal water use is present in many regions across the world.

1.3. OBJECTIVE

Whilst the causes and the theory of what could be done to reduce illegal abstractions have been explored, there is **little information shared on what is happening on the ground**. Therefore, we invited concerned water practitioners and scientists to share information and ideas on successful and failed experiences in different parts of the world and to formulate recommendations for peers. We aim to:

- **Encourage** politicians, regulators, water managers, water users and citizens **to take (more) action against illegal water use**, including its drivers;
- **Increase and improve response** against illegal water use, hopefully, based on the lessons learned and recommendations of this report and its case studies; and subsequently
- **Contribute to reducing the illegally abstracted amount of water** and provide more certainty to water statistics and management planning processes and documents.

The list of case studies and experiences considered in this report is still limited. Thus, it does not claim to be comprehensive but only to provide a first overview of how illegal water use is dealt with in different sectors and parts of the world.

2. DRIVERS OF ILLEGAL WATER USE

Illegal water use can be driven by a variety of causes. We identified three main drivers. First, illegal use is usually driven by the net economic benefits produced using water. Second, infringements may be fostered by the existence of gaps in governance and institutions regulating water use. Finally, social norms are underlying factors that make it difficult for the authorities to act against illegal water uses.

The following figure lists the main drivers:

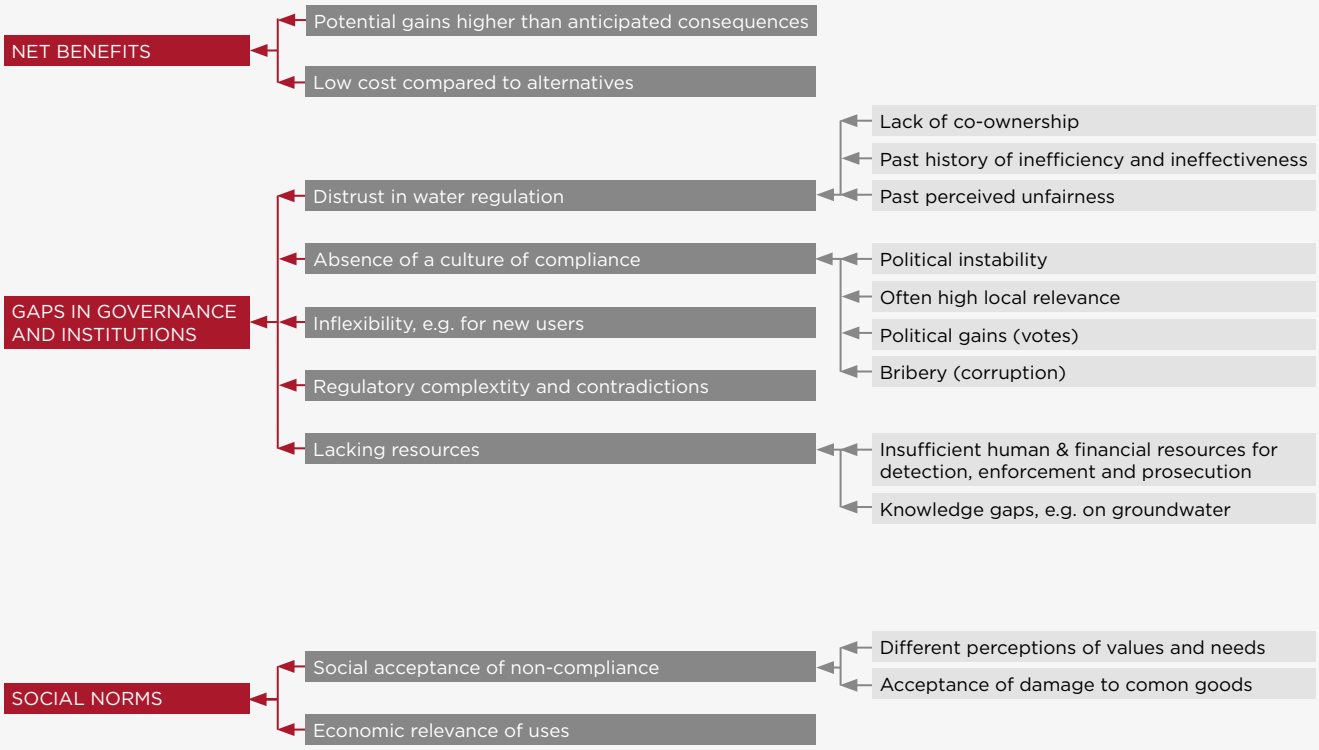

Figure 2: Drivers of illegal water use.

2.1. NET BENEFITS

For individual users, the net benefits from unauthorized uses often outweigh their negative consequences. That is, the **value of potential gains is perceived to be higher than the anticipated consequences** in terms of a drop in water levels, increased salinity, higher energy costs, potential sanctions and risks[63]. Impacts are often unaccounted for or may even be unidentified; there is often a loss of ecological services and water quality degradation, but there may be a time lag between abstraction and impact, and/or it may go unnoticed.

The actions of an individual, however, are unlikely to be determined only by the balance between benefits and losses. Actions are also strongly influenced by social expectations, cultural norms and actors' social identities[64], e.g. when illegal water users compete with legal water users.

2.2. GAPS IN GOVERNANCE AND INSTITUTIONS

Sometimes, illegal water use may simply arise from **regulatory complexities**. As reported from South Africa[65], some related procedures (e.g. the issuing of a mining permit, the environmental impact assessment) can contribute to create the perception that water use has been authorized. Also, at times the

procedure for authorization is fragmented among a number of governmental departments, and is made of complex applications, unrelated long timeframes and changing requirements.

Illegal water use can arise from not considering pre-existing water use. When establishing a new licensing regime, significant work is needed to identify and register existing water users. Moreover, when licensing controls on water use gets stricter over time, efforts are needed to adjust existing permits to the new licensing requirements. Although illegal use remains a key feature of groundwater economies that undermines management, it is often treated as an inconvenient truth or side-effect deemed to be gradually and naturally eliminated through the simple application and expected enforcement of groundwater management rules.[66]

Similarly, enforcement is often hindered by a real **lack of technical and human means** to effectively detect and pursue law-breaching activities, especially considering the spatially scattered nature of groundwater intakes – or also in-stream water, e.g. in England - to be controlled. Additionally, there can be lack of political will to enforce the law, which ultimately translates into lax enforcement. Indeed, strict enforcement of water usage can be politically sensitive and difficult due to the economic, social and political importance of unauthorized water uses[67].

In Australia[68], a lack of investment in water compliance and enforcement by the state government of New South Wales appears to have been a contributing factor in the unlawful use of water in the Barwon-Darling catchment. Although the task is difficult, tackling unlawful water use has been a low priority in the water agencies that have been responsible for compliance in the past 20 years (although the establishment of a new, independent regulator in 2018 has reversed this trend). The absence of a culture of compliance, organizational instability and limited resourcing have meant that **compliance has relied heavily on custom and practice**, resulting in a lack of effectiveness, consistency and transparency[69].

A key issue of regulatory compliance is related to social capital[70] and the **distrust in the water authorities** that water users might experience, leading to a decreased legitimacy of official decisions and rules[71]. The reasons for this lack of trust are diverse and might include a history of inefficiency or ineffectiveness, or perceived unfairness or arbitrary decision-making on the part of the public administration. The reasons might also include a lack of ownership of the solutions to water-related problems due to the limited involvement of water users in the design of these potential solutions[72].

One of the problems associated with fully allocated water systems is the **lack of alternatives**: newcomers are unable to obtain a water right until another user relinquishes a license – thus the absence of an easy legal solution can lead potential new users to seek an illegal water intake or to engage in unregulated water trading[73].

Corruption is a relevant driver in some case studies. In Spain, administrative staff of the Guadalquivir River Basin Authority were convicted in 2018 due to corruption in allocating water rights[74]. In Pakistan's Punjab state, farmers regularly bribe water officials to obtain water over their legal quotas, as well as to lobby politicians to pressure water officials into such illegal behaviour. Both large-scale landowners, the feudal elite of the country, and sharecroppers benefit from the bribery and its political sponsorship[75].

2.3. SOCIAL NORMS

Sometimes social norms accept unauthorized groundwater abstraction and there is no strong social stigma attached to unlicensed groundwater use. In this context, **social tolerance can create a negative incentive**, because in a system where non-compliance is normalized, breaching the law can seem the most rational thing to do, especially if there are no alternative sources of water and breaching the law is necessary to access water[76].

Social acceptance of noncompliance can be partly explained and rooted in different perceptions and values of what needs to be preserved and how. For example, users in some cases perceive that they should use the resources that are locally available to achieve and sustain their socio-economic development: people or authorities who are not based in the area should not constrain that development. Others perceive the **value of natural ecosystems** differently from how it is established by law, and therefore do not share the nature protection goals pursued by the authorities. Additionally, society as a whole often reacts only to blatant damage to **common interests or goods**. There is also scarce literature on the illegal use of natural resources[77].

Finally, in some regions, **the local economy may depend on intensive water use**, e.g. in areas with large irrigated farming and associated activities (agricultural input services, food-canning industry, etc.). Therefore, strict enforcement of the law can lead to significant economic losses to the regional economy. This dependence of local economy from unauthorised water use contributes to explain why users continue illegal abstraction and/or collectively ask the administration for a negotiated solution, for example, the legalization of irregular uses or the import of water from other areas to decrease water stress locally (e.g. Loma de Úbeda[78] and Doñana, Spain).

3. CONSEQUENCES OF ILLEGAL WATER USE

Because illegal water abstraction increases the extractive pressure on a limited resource, it can jeopardize the **security of access for users** with water rights and can increase their **vulnerability during droughts**. Groundwater depletion caused by illegal abstraction can increase **energy pumping costs**. The Doñana (Spain) case study shows the negative effects for farmers with legal entitlements to water, as these have higher production costs[79] and can face water abstraction restrictions because of illegal over-abstraction, and also the negative impact on the consumer's perception of the agriculture in the area. Consequences can be local, but they also can **be experienced at a significant distance downstream by** aquatic biota and water users.

Sometimes illegal water use influences water pricing, the emergence of water markets or the need for additional water supply infrastructure[80]. Since illegal water use is not accounted for in official accounting, sound **water planning** is hampered by **inaccurate data** on water abstraction and the underestimation of real consumption.

In Australia[81], unlawful water withdrawal may also impact water markets: i) it increases the value of the water remaining in the system, and/or ii) it reduces the future **value of water** if water access rights are seen by the market as unreliable. If confidence and values are lowered, then this affects the **integrity of the water market** with significant impacts nationally, for the states, and private individuals[82]. Furthermore, water is allegedly 'stolen' from the environment and used for productive gain - undermining the significant amounts of money spent in Australia on environmental water to date - and threatening national welfare gains from environmental protection[83].

Widespread unauthorized groundwater abstraction can have **substantial negative environmental impacts** such as land subsidence (including damage to surface infrastructure), degradation of groundwater-fed wetlands[84], the alteration of river–aquifer dynamics[85] and drying up of springs[86]. In many cases, the decrease in quantity goes hand in hand with a decrease in quality, due to saline intrusion or an increased concentration of pollutants (e.g. fertilizers and pesticides)[87].

Unauthorized water extraction can also be associated with **other mirror practices**, such as the unauthorized transformation of protected areas or common lands into irrigated arable land[88] and the construction of water storage ponds. An overview of the consequences and their relationship is shown below.

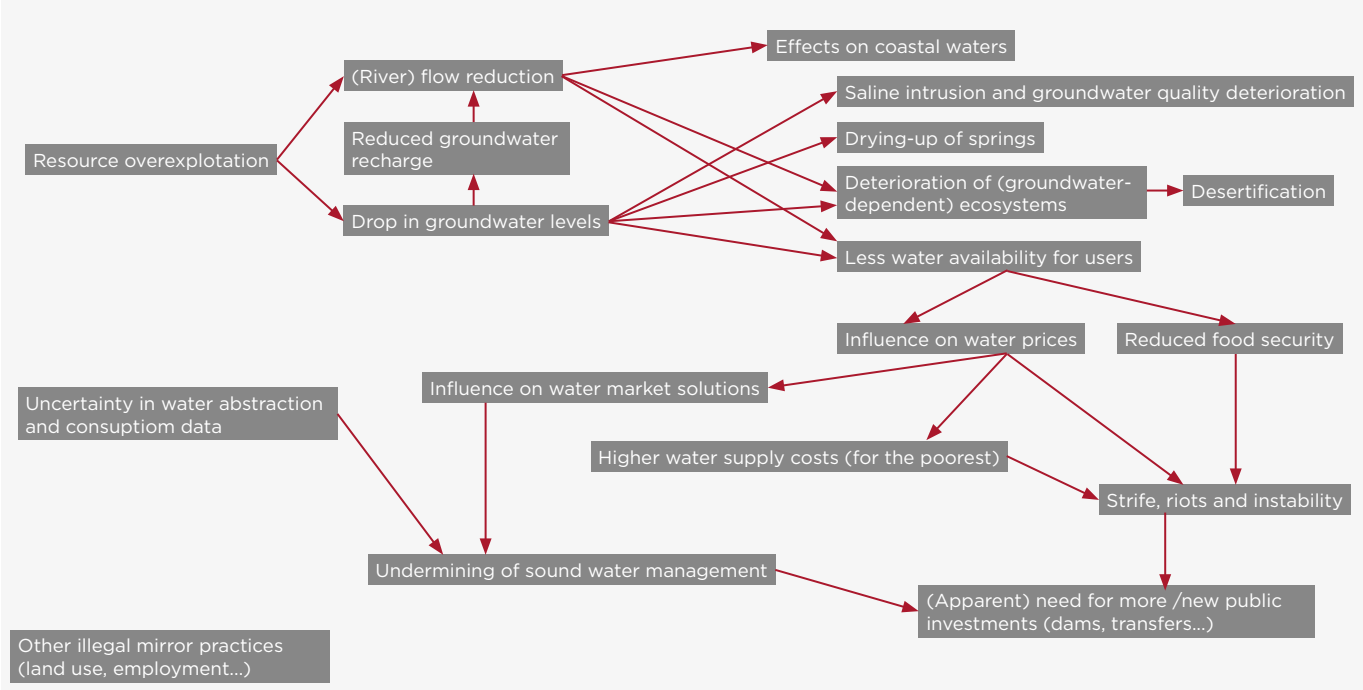

Figure 3: Consequences of illegal water use, and their interactions.

4. STRATEGIES TO REDUCE ILLEGAL WATER USE

We have analysed case studies and strategies against two of the main barriers to sound water management:

- How to detect illegal water use?
- How to tackle illegal water use?

4.1. DETECTION OF ILLEGAL WATER USE

The identification and characterization of illegal use is usually the first necessary step in order to tackle it. In the next pages we describe possible strategies for this important step.

4.1.1. SETTING UP OF AN APPROPRIATE/ENFORCEABLE WATER RIGHTS SYSTEM

Most countries in the world do have some sort of water rights system in place, and it is considered 'best practice'[89]. Such systems are often in constant evolution, reflecting changing physical and socio-economic conditions. The laws and institutions in question must provide solutions to ever changing situations and challenges. In some of the case studies, we see significant gaps between the legal framework and its implementation and acceptance on the ground.

One key element of enforcement is the proper definition of a water rights system. Two main terms can be highlighted: a) an "**entitlement**" that confers the right to withdraw a share of the resource to the user; and b) an usufruct "**allocation**" which is the amount of water that can be distributed to legitimate entitlement holders depending on the available water (an "allocable pool"). If a water rights system lacks these attributes or their definition is not fully clear, water rights may be difficult to enforce or may not achieve their goal of ensuring a balance between supply and demand.

The experiences of Tablas de Daimiel, Pegalajar and Doñana[90] (Spain) show that **multi-stakeholder negotiations** can lead to the definition of a baseline for the agreement of an enforceable water rights system. Those cases also show that the river basin authority struggled to ensure the implementation of the negotiated agreement in the following years. In practice, the system's baseline moves constantly forward towards higher exploitation levels, including repeated compliance exemptions or even amnesty for illegal water users.

In Australia[91], the Murray-Darling Basin Plan has been challenged by a **lack of clarity regarding roles and responsibilities** and **insufficient control capacity by the river basin authority**, as metering, enforcement and other activities are carried out by different administrations at the state level[92].

The Australian case study[93] shows the challenges of having a proper water right system for protecting environmental flows in **unregulated or unsupplemented[94] rivers** (both referred to here as unregulated rivers), as highlighted by the Four Corners program for the Barwon–Darling. The program raised questions about whether current management rules in the Barwon-Darling allow environmental water to be taken by consumptive licence holders[95]. Unregulated systems in the northern Basin are inherently challenging to manage because:

- Measurement tends to be less accurate as there has been less investment in stream gauging and modelling. Besides, there are significant volumes of unmetered take such as harvesting of floodwaters before they enter the river channel and extraction data is not publicly available nor used to adaptively manage flow events.
- Flows are highly variable with long periods of low or zero flows.
- Storage structure tends to be privately owned and there are **relatively few public infrastructures within the main river stem**. Any active management must be exerted through largely privately-owned infrastructure.
- Fixed rules for 'commence to pump' and 'cease to pump' are defined by the levels of water flows. Unless there are other restrictions, if the water is flowing above the cease to pump level, then entitlement holders can pump from the river. The application of these rules is complex and can **lack transparency**.
- Flow rules are vulnerable to changes in industry structure, irrigator behaviour and technology. For example, the consolidation of entitlements into larger holdings, the construction of large private stor-

ages and bigger pump sizes increase the capacity to **pump from individual high flow events**. However, these high flow events may be important to recharge connected aquifers or for water supply downstream.

Often, providers of illegal water supply to areas lacking legal water acquire **substantial political capital and power**. In India, local politicians and water tanker owners can seek to disrupt government efforts to extend legal pipes and wells to marginalized communities, so that they do not lose their profits and political power[96].

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

SETTING UP OF AN APPROPRIATE/ENFORCEABLE WATER RIGHTS SYSTEM	
Strengths	**Weaknesses**
• A clear water allocation system defines the terms for water withdrawal and is the basis for enforcement • Increased transparency on water allocation criteria and water rights registers can lead to equitable access to water	• Rather complex to be implemented in unregulated rivers, as often data or gauging stations to control flows are lacking • Negotiations and agreements on the baseline (e.g. which plots or users are considered as legal or illegal at the time of entry into force of a new water rights system) can be rather difficult and time-consuming • Need for continued follow-up and enforcement

4.1.2. IMPROVED/INCREASED AND INTEGRATED CONTROL OF WATER USES ON THE GROUND

Control on the ground is fundamental to detect illegal water abstractions, particularly when the illegal water use is dynamic, as e.g. mining operations reported in South Africa that only stay for a limited time at the same place. Ideally, control activities are **usually undertaken by trained and specialized officials**, as these have the required executive functions, access to public databases, and a comprehensive understanding of the resource pool and its uses. However, human and financial capacities of authorities to implement control activities on all abstraction points at times are insufficient to effectively carry out the task. Control on the ground is thus often dependent on **cooperation by other water users, NGOs or concerned citizens**.

In the South-African Northern Cape region, the task of controlling water use is performed by approximately 10 officials. With an estimated number of 10,000 water users, responsible water use through self-regulation is required. In this area, the most effective detection of illegal practices is reporting by other users, concerned citizens and inspections and investigations from departmental officials. In some specific areas, as reported for the case study on illegal water use by Alluvial Diamond mining along Vaal and Orange river (South Africa), the most effective detection is by direct inspection of the areas of the river where alluvial diamond mining occurs. This can be done by dedicated officials, as the area is relatively limited and manageable.

Inspections on the ground carry the risk of physical aggression to officials, as they have been reported e.g. recently in the Segura[97] and Guadalquivir basins in Spain[98] and in Peru[99], where drones have been used to ease control of large areas or hidden wells.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

IMPROVED/INCREASED AND INTEGRATED CONTROL OF WATER USES ON THE GROUND	
Strengths	Weaknesses
• Field data provide (legal) evidence and can indicate where water is abstracted or conducted/stored • The control can also build on information provided by other water users and concerned citizens	• Resource-demanding activity • Detecting and registering infringements can be complex if the water rights system is unclear • Inspectors might be physically threatened or even harmed by illegal water users • Water meters are relatively easy to manipulate

4.1.3. DEVELOPMENT AND MAINTENANCE OF AN INVENTORY, REGISTER OR DATABASE OF WATER USES

One of the lessons learned from the Australian case study is the importance of addressing **the lack of transparency and of improving reporting channels**[100]. In the case of New South Wales, this includes recommendations for:

- The establishment of a new Natural Resources Access Regulator, responsible for all enforcement and compliance activities, and operating at arms' length from the relevant government departments;
- Increasing investment in compliance and enforcement activities;
- Requiring (and enforcing) **a commitment to universal metering ('no meter, no pumping')**; and
- A semi-public inventory of water use, e.g. including information on allocated water rights, water sources and uses, and - if applicable - the specific cropping system and irrigation area limits, can facilitate citizen contributions to detecting illegal water use. The public part of the registry might exclude personal data, as they are often protected by law.

Developing such a registry/inventory is complex and can take years to be implemented. In Spain, the Water Law establishes the completion of a National Registry of water rights by the end of 2020, but it remains unclear if this will be achieved and how 'open' the system will be to external consultations.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

DEVELOPMENT AND MAINTENANCE AN INVENTORY, REGISTER OR DATABASE OF WATER USES	
Strengths	**Weaknesses and risks**
• It provides improved knowledge and data, which is key for water planning and allocation of water rights • It provides a basis for officials and citizens to detect illegal water use	• Some water users, authorities or stakeholders might be reluctant to water metering or the publication of data about water usage being published and therefore advocate against it • It requires financial and staff resources, including capacity building for managing the database • It requires paying attention to compliance with data protection, critical infrastructure and civil protection regulations • It requires continuous updating

4.1.4. IMPROVED MONITORING WATER ABSTRACTION, I.E. VIA REMOTE SENSING

The use of remote sensing in agriculture has strongly evolved in the last decade. Remote sensing is a consolidated tool for agricultural monitoring at global (e.g. GEOCLAM initiative) and national levels due to the availability of periodical observations, the increasing number of available data sources and the

existence of archives of imagery. At farm scale, the availability of new sensors, i.e. drones and airborne sensors, and the improved spatial resolution of commercial Earth Observation (EO) satellites have triggered the development of new precision farming services.

Remote sensing can play an important role in supporting the detection of illegal water abstractions for irrigation of agriculture. Several projects and initiatives have explored the potential of remote sensing for detecting and assessing water over-abstraction and illegal water abstraction[101].

A key lesson learned is that the identification of illegal water use is possible on an operational level, although it is not an easy task due to two main factors:

- The **difficulty of getting accurate maps of irrigated crops at a high resolution over large areas** through remote sensing. A review study on the topic of remote sensing of irrigated agriculture[102] highlights that, in 2010, studies to map irrigated lands were still relatively rare in comparison to publications dealing with mapping land cover including agriculture. The main reason was the complexity associated with trying to map land use as opposed to land cover. Automated methods using appropriate remote sensing data are in general able to detect grown crops when the vegetation fraction cover over the land is high (i.e. land cover). In contrast, the detection of irrigation (i.e. land use) often demands additional knowledge and understanding of local irrigation and agricultural practices, in particular for crops that can be irrigated or just rain-fed in the same region or for crops with low vegetation cover, e.g. woody crops; an aspect that can be addressed by appropriate field validation. However, science and practice have advanced considerably since 2010, mainly driven by the launching of the Sentinel 2 twin satellites, which provide dense time series of free images at a high spatial resolution as shown by Calera et al. (2017)[103] as well as by Foster et al. (2019)[104]. A practical example of a country-wide classification of irrigated crops is the operational SPIDER-SIAR[105] service offered by the Spanish Ministry of Agriculture for peninsular Spain on an annual basis.
- The **lack of reliable geographical information on the spatial distribution of water rights for irrigation**. The knowledge of how much water can be used and where irrigation is allowed represents the basis for the identification of illegal water use. This information is often out of date, difficult to obtain or does not have an accurate spatial representation. If this information is not reliable enough, the analysis will very probably lead to results that will be questioned by water users.

In the Doñana case study, the **combination of a broad set of satellite images (i.e. Landsat images) with field data**, complemented by visual interpretation of multiannual aerial photography has been useful to detect irrigated areas located outside of the permitted areas and to determine when forested areas were illegally transformed into farming land. Good knowledge of agricultural practices at the local level helped producing improved results in the detection of irrigation in comparison to broad-scale automated methods.

Another lesson learnt from that case study refers to the **difficulties arising when the spatial distribution of water rights is not provided at the plot level**. The case study experts recommend to map water rights using a high spatial resolution, e.g. a resolution similar to the one of the land cadastre. The European project DIANA[106] has concluded that the European system of EO satellites COPERNICUS allows for reliable large-scale operational monitoring of agricultural water abstractions, efficient irrigation management and hydrological planning at all scales. DIANA was implemented in a range of pilot cases in Spain, Italy, and Romania and has developed a commercial service platform that helps water managers and authorities optimize the identification and inspection of non-authorized water abstractions for irrigation. The DIANA services are leveraging EO data provided by Copernicus and other data sources as well as state-of-the-art models for the identification of (non-authorized) irrigated areas and the estimation of abstracted water volumes. They have already been successfully rolled out in Spain and Italy (under the brands Hidrogestor[107] and Irrisat[108], respectively). The project combines available information from different sources, such as at water authorities on individual water users, water rights and EO (Copernicus missions, Landsat and MODIS), and complement it with verification of non-compliance through inspections on the ground.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

IMPROVED MONITORING WATER ABSTRACTION, I.E. VIA REMOTE SENSING	
Strengths	**Weaknesses**
• Remote sensing can be used to detect illegal water use on large areas with reduced costs and in near real time. • Past and current images can be compared to identify changes • It is particularly useful in areas that are not easily accessible. • It can be used as evidence in Court • It enables water use monitoring without entering the irrigated property (illegal water users could hamper the access of inspectors to their land)	• Verification on the ground is usually needed • Good knowledge of agricultural practices at the local level is helpful • Detection may be hindered by a lack of detail or reliability in the spatial definition of the land unit where water rights have been granted • It requires specialized technical capacity

4.1.5. INTEGRATED DATA MANAGEMENT

Better coordination across administrations (e.g. allowing for a borehole drilling authorization or energy supply only in those cases where water abstraction has been previously authorized) and explicit information on the entire authorization procedures can lead to a reduction of new cases of illegal water uses.

Checking consistency across administrative datasets can improve the identification of illegal water uses, or even cases of corruption. It is, however, a complex task due to the heterogeneity of administrative databases. Administrations may also be reluctant to engage resources in tasks that can show pitfalls of their administrative procedures and undermine their authority.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

INTEGRATED DATA MANAGEMENT	
Strengths	**Weaknesses**
• When similar/related datasets are available it can be quite straightforward and cheap to combine them	• It depends on the willingness of different administrations to check consistency between different datasets • The complexity of crossing different databases can be high • It is based on procedural issues that might not apply to all the illegal water users. Thus, some illegal uses may remain undetected

4.2. MANAGEMENT OF ILLEGAL USES

Given the reported presence of illegal water use across the world, **we consider that there is no "silver bullet" to tackle illegal water use**. However, within the case studies and literature, different strategies have been (partially) successful. Often several strategies have been combined to have a faster/stronger impact, and negotiations and trade-offs have also been reported by many case studies.

4.2.1. INVOLVEMENT OF WATER USERS IN LAW ENFORCEMENT AND CONTROL

Throughout the world, the **enforcement of water regulations faces significant challenges**. Often police and other law enforcement authorities cannot detect infractions in real-time, and legal processes can become extremely lengthy. Some real-time monitoring can be achieved through technological fixes, but swift law enforcement action requires major changes in police duty and justice prioritization and is thus costly not only financially, but also in terms of opportunity costs[109].

Institutional incentives can foster voluntary compliance with the regulation and, therefore, influence the individuals' behaviour beyond the (often weak) threat of punishment. Voluntary compliance works best where the authorities are expected by the society to ensure lawbreakers are dealt with and punished. However, in many societies, illegal water use is not seen as a high legal priority.[110]

However, **such approaches are complex** and depend on the administrative set-up. In the Australian case study[111], the Murray-Darling Basin Authority (MDBA) was established to be a 'voice for the Basin as a whole', operationalised through a Basin Plan that set sustainable diversion limits (SDLs) on water withdrawals, with States being principally responsible for enforcement against individual water users. In the course of the implementation and the subsequent plan review process, numerous stakeholders expressed considerable frustration that the MDBA did not respond adequately to allegations of serious breaches on water allocation restrictions[112] . This was against the backdrop of almost complete inaction by certain Basin State Governments to enforce water laws as they applied to individual water users.

In France, the Water Law requires the creation of agricultural collective management organisations (OUGC, for "*Organismes Uniques de Gestion Collective*"). The intention of the law is to encourage users to proactively manage agricultural abstraction within priority areas facing chronic overexploitation of water resources. Once a global abstraction cap is defined for priority catchments and aquifers, these organisations are required to allocate the amount reserved to agriculture among individual farmers. The OUGC is conceived as an administrative institution to improve local knowledge of agricultural abstraction, pool individual demands, share water (in an equitable way) and communicate with authorities to obtain and manage water use licenses. While **compliance monitoring and policing remain in the control of public administration**, the OUGC has an important role in ensuring that farmers are informed about their allocations, rights and obligations and in ensuring that the total amount allocated respects the abstraction cap. It thus has a double role in representing farmers' interests and supporting the implementation of the law. Recent experiences show that OUGC can improve the knowledge on illegal abstraction since the **first step in implementation involves field surveys to record abstraction points[113]** . It also can reinforce local control on agricultural abstraction as some OUGCs set up more systematic ways to report abstracted volumes of water, for example by establishing an online reporting system or automatic continuous remote metering systems. Finally, greater local control and co-management of agriculture abstraction within a collective abstraction cap is expected to reinforce local norms and self-regulation, as neighbouring farms may report illegal water use that could hinder the capacity of the OUGC to remain within its collective water allocation.

In Spain, the participation of water users' institutions in water resources affairs is mostly directed to **ensure access to water for users rather than to pursue the improvement of the state of the resources and the associated ecosystem at basin or aquifer scale**[114]. Nonetheless, some groundwater communities in the Llobregat area (Spain) have been successful in controlling abstraction. These communities have their own system to fine transgressions and to report them to the competent water authority.

The case of the Mancha Oriental aquifer self-regulation merits special attention. This aquifer (9,962 km^2, 125,000 ha irrigated, over 9,000 farms) was threatened to be closed for water abstractions due to heavy over-exploitation in the late 1990es. The Central Irrigation Board of Mancha Oriental implemented a system for monitoring and managing groundwater abstractions based on EO data. The system was developed by University of Castilla La Mancha in the framework of the public-private partnership project ERMOT (Evolución de Regadíos Mediante Observación de la Tierra), with funds from the Irrigation Board, the River Basin Authority, and the Regional Government of Castilla-La Mancha. This contract has been renewed annually since 1997 and the Irrigation Board has developed capacities to integrate and use it in their routine procedures. The functioning of this governance model of aquifer self-regulation (also referred to as "model Mancha Oriental") requires the definition of an Annual Irrigation Plan ("Plan de Explotación") that is agreed by all members of the Irrigation Board in November each year. Then, the Irrigation Board technicians perform continuous EO-assisted monitoring and control, where the EO-based maps help them detect "suspicious" fields and target field inspections. EO-assisted monitoring is being supported by well-calibrated flowmeters on the ground. Over the years, the abstractions have been reduced substantially and the water table level has been stabilized. Any detected non-compliance is handled by two levels of sanctioning (one internal by the Irrigation Jury and one external by the River

Basin Authority), both well accepted by the farmers so that the number and amount of sanctions have dropped below 0,1% of total water abstraction in the aquifer.[115]

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

INVOLVEMENT OF WATER USERS IN LAW ENFORCEMENT AND CONTROL	
Strengths	**Weaknesses**
• The involvement of engaged users can help to mitigate the lack of resources at authorities • Collective abstraction rates can lead to peer control • Awareness-raising about water scarcity and illegal water use can be a side-effect of this strategy	• It can lead to corrupt practices if the process is not transparent • The compliance can be hampered by close social or neighbourhood relations between the controller and the controlled

4.2.2. ADMINISTRATIVE ACTION, CLOSURE OF ABSTRACTION POINTS AND FINES

Some authors recommend enforcing **water regulation strictly, including through punitive means**[116]. The policing of water needs to become a part of the kit of tools that communities and policymakers can use to ensure an adequate, equitable, and sustainable use of water for people, agriculture, industries, and natural ecosystems. However, some water regulators and NGOs believe that adversarial approaches to water management - policing, fines, legal proceedings and suits - , are counterproductive and that the best water management emerges from **non-confrontational cooperation** among a broad set of stakeholders. They question whether unauthorized water use should be called illegal and suggest that such a 'label' will prevent achieving buy-in from the relevant stakeholders.

Administrative action is usually the first step to be taken, e.g. via an administrative report or request to the water user and/or landowner, followed by a response or allegation action by the water user. According to the country's legal set-up, a final notice may be sent to require the water user to stop the illegal water use and to mitigate possible damaged caused by the illegal use. In South Africa, this can be achieved within 14 to 30 days depending on the relevance of the water use.

The **administrative enforcement process is** however **often lengthy and time-consuming**.[117] In the South African case, this type of enforcement is quite effective as most water users are inclined to comply. The illegal activities are stopped, but the transgressors are reluctant to do costly rehabilitation. They vacate the land and remove their equipment within a day or overnight. In the Spanish Doñana case study, acceptance of enforcement is much lower as hundreds of farmers are affected, and **public protests** and non-implementation of administrative decisions have been seen, including the delays of administrative processes over years due to the lack of cooperation from municipalities[118].

Administrative enforcement and negotiation processes shall include elements to Assess the current situation, Define exemptions, Allocate adequate means, Make registration simple, Balance incentives (carrots vs. sticks), and Build legitimacy.[119]

- For some authors[120], water-related compliance and enforcement arrangements in New South Wales were ineffective until a 2017 documentary exposing water theft and misconduct by government officials resulted in the establishment of a new, independent regulator and improved metering laws (although the latter are yet to be implemented). However, prior to this, the following issues were pervasive:
- The overall standard of New South Wales compliance and enforcement work was very poor.
- Arrangements for metering, monitoring and measurement of water extractions, especially in the Barwon–Darling river system, were not at the standard required for sound water management and expected by the community.
- Certain individual cases of alleged non-compliance remained unresolved for long periods of time.
- There was little transparency to the public in relation to water regulation arrangements in New South Wales, including the compliance and enforcement arrangements which should underpin public confidence.

Administrative actions require continuity and follow-up. For example, the Pegalajar aquifer (Spain) was declared to be overexploited in the mid-1990s, and only in 2006, the compulsory Annual Management Plan was approved. However, in 2008 out of the 11 measures included in the Plan, only three of them – addressing urban water supply alternatives – had been implemented. Over the past decade, no further investments were made, whilst (illegal) abstractions have increased due to expanded irrigation and urbanisation.

In the Doñana case study administrative action was taken only after **international pressure** for stronger control and enforcement was made by UNESCO, the Ramsar Convention and the European Commission via a pilot legal process and the decision to refer Spain to the Court of Justice of the European Union (EU). This decision was based on Spain's failure to take adequate measures to protect the aquifers that feed the Doñana Wetlands, as required by EU water legislation (Water Framework Directive, Directive 2000/60/EC)[121]. As a consequence, the water administration closed some wells and irrigation ponds[122], though the latest River Basin Management Plan again ignores completely the topic of illegal abstractions[123].

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

ADMINISTRATIVE ACTION, CLOSURE OF ABSTRACTION POINTS AND FINES	
Strengths	**Weaknesses**
• If it is politically and administratively supported, this can be a rapid response • It has better implementation chances if supported by political/public action or international pressure, e.g. UNESCO, Ramsar Convention, European Commission	• Is usually a lengthy process, often with lacking political and administrative support • The impact depends on the social awareness of illegal water use; can lead to demonstrations against the enforcing authority • It usually requires continued action

4.2.3. LEGAL ACTIONS AND FINES

Taking legal action against illegal water use is often a time- and resource-consuming process that might not necessarily stop water usage in the meantime. In addition, **to date, very few criminal cases have been investigated sufficiently to be heard in court** and very few convictions have been sentenced. This statement from the South African case study applies to many other case studies: other references mention "very protracted, very complex investigation… trawling through thousands of documents and calling in forensics accountants because of the sheer scale of the activities"[124].

Linked to the Spanish Doñana case study, the Huelva's environmental prosecutor's office complained[125] about the lengthiness and low success rate of such legal investigations. The office detected illegal water use as a problem in 2005 and managed 36 court sentences until 2017 (in an area with estimated 2,000 illegal boreholes[126]). Regarding the 36 sentences, the prosecutor acknowledged success in raising awareness about illegal uses having legal consequences, but also barriers to implementation due to:

- The physical obstruction of the police to seal boreholes in the field;
- The time-lapse between enforcement actions and the recovery and restoration of the affected ecosystems;
- The delay in judicial processes, even leading to the prescription of prison sentences (according to the Spanish regulation); and
- The complexity of quantifying ecological damages, especially for small-scale irrigation plots.

Penalties will not create adequate deterrence effects if **effective prosecution is sporadic and uncertain**. In California, a major recent effort by the State Water Resources Control Board to better enforce water regulations appears to have failed. In July 2015, the board imposed unprecedented penalties on

two Central Valley irrigation agencies for illegally taking water from the river. The Byron Bethany Irrigation District, serving 160 farms and 15,000 people within the community of Mountain House, faced a penalty of $1.5 million for pumping water from the Sacramento-San Joaquin River Delta, while the West Side Irrigation District supplying about 45 farmers faced a fine of up to $10,000 each. Those prosecutions were perceived across the state as a sign of the state's new wherewithal and capacity to regulate water rights holders, as well as to crack down on illegal water sourcing. Yet the cases were not taken further and in May 2016, the board moved to dismiss both cases[127].

Other water users, citizens or NGOs may want to take independent legal action. **However, obtaining water use data about individual licenses from government agencies is challenging**, due to data protection and lack of willingness to share data transparently. This, in turn, makes it extremely difficult for third parties to acquire the evidence necessary to claim for the enforcement of water laws. Another barrier to enforcing **water laws** is their **complexity**. In Australia, the rules contained in water sharing plans are highly technical, making it difficult for the community to interpret them[128].

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

LEGAL ACTIONS AND FINES	
Strengths	**Weaknesses**
• It can raise awareness about the risk of severe legal consequences of illegal uses • Action is often started by third parties, based on freedom of/ access to information laws • Successful cases set up jurisprudence that can speed up new cases	• Individual legal processes can be too sporadic and not enough to solve illegal water use problems in areas where these are important • Long and resource-intense processes (in proportion to the overall problem magnitude) • It might be difficult to obtain individualized water usage data from the government agencies (especially when these have not acted previously and might be blamed for non-action). • The water laws are often complex, e.g. on water allocation and entitlements

4.2.4. CAPACITY BUILDING OF WATER USERS TO HELP THEM TO COMPLY WITH ABSTRACTION RESTRICTIONS

Higher emphasis can be placed on the role of individuals' choice in water use[129]. The implementation of a Farm Advisory Service (FAS) is required in all EU Member States (Regulation (EU) No 1306/2013) to help farmers understand EU rules, and it can also support farmers on environmental issues. In terms of legal water use, EU Member States advisory services may provide farmers with information on: 1) sustainable, low-volume irrigation systems and how to optimise rain-fed systems in order to promote efficient water use; and 2) information on reducing water use in agriculture, including crop choice, on improving soil humus to increase water retention and on reducing the need to irrigate (Annex I of Regulation (EU) No 1306/2013). However, little information is available on the type of advice provided through the FAS.[130]

Additional experiences exist besides the FAS. For example, in the Castile-La Mancha region (Spain), WWF Spain and The Coca-Cola Foundation have developed the ACUAS farm advisory tools to support farmers in the compliance with water use restrictions and plan for adequate water use at the beginning of the irrigation campaign[131]. The Irrigator Communities of Mancha Occidental I and Rus-Valdelobos engaged in the program, and in 2016, 59 farmers revised legal water use of 63 plots, totalling 2,800 hectares. According to the project manager, irrigation advice provides better results when combined with farmers' capacity building and raising awareness about the impacts of illegal water use on the environment and other water users. In Spain, WWF is also training the auditors of certification labels for farming products.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

CAPACITY BUILDING OF WATER USERS TO HELP THEM TO COMPLY WITH ABSTRACTION RESTRICTIONS	
Strengths	**Weaknesses**
• The emphasis is placed on the role of informed individuals' choice • Easy-to-use tools can be developed for managing irrigation adapted to water use restrictions • It provides an opportunity for raising awareness	• It requires time and effort as one-by-one amongst farmers awareness needs to be generated • Free riders can damage the trust-building process and harm the overall results • It is effective to stop illegal water uses only when complemented by administrative or legal actions

4.2.5. ESTABLISH CROSS-COMPLIANCE OF AGRICULTURAL SUBSIDIES

Cross-compliance is a **mechanism that links EU agricultural subsidies to compliance by farmers with basic standards** concerning the environment, food safety, animal and plant health and animal welfare, as well as the requirement of maintaining land in good agricultural and environmental conditions.

Since 2005 in the EU all the farmers receiving direct payments are subject to compulsory cross-compliance, based on the Council Regulation 1307/2013[132] and Commission Regulation 640/2014[133], which establish a harmonized basis for the assessment of non-compliance and calculation and application of administrative penalties. These are based on the terms of reoccurrence, extent, severity and permanence of a non-compliance. Furthermore, an obligation is fixed on the control authority to take actions necessary to verify that the beneficiary has remedied the findings of non-compliance. EU cross-compliance **penalties** in Spain vary in 2018 between 1-5% of the received subsidies[134].

One of the '**Good agricultural and environmental condition'** (GAEC) assessment criteria (GAEC number 2) included in cross-compliance addresses 'where use of water for irrigation is subject to authorization' and requires '**compliance with authorization procedures**'. In theory, this criterion aims to penalise illegal water use in irrigation agriculture, and due to the fines it makes illegal water use less attractive to farmers. A study by the European Commission informs that "only the obtaining of a water licence is checked in all [Member States], and only eight case-study Member States verify the compliance of farmers with the authorisation order (ES, FR, HR, IT, NL, PL, RO, FI). In France and Poland, appropriate means to measure the volumes of water withdrawn are required and verified under GAEC2"[135].

The European Commission Directorate General for Agriculture and Rural Development considers that "the rate of non-conformity is quite low in most of the Member States" [136]. However, **in Spain**[137] **approximately 8-10% of the inspected holdings are not conform** with the requirement GAEC2. In the publicly accessible reports on cross-compliance, no information is displayed about the fines and their impact on the subsidy amounts received by those farmers who irrigate without authorization. In England, the Rural Payments Agency, in coordination with the Environment-Agency, has checked farm compliance with GAEC2 and levied a reduction in payment where requirements of abstraction licenses have not been met.

However, the practice of cross-compliance seems to be distant from providing real solutions. A report by the European Court of Auditors[138] concluded that the information available did not allow the European Commission to assess adequately the effectiveness of cross-compliance. The performance indicators did not consider the level of non-compliance by farmers and the Commission did not analyse the reasons for the infringements. Furthermore, the sanction system did not ensure a sufficiently harmonized basis for calculating administrative penalties for farmers across the EU who did not comply with the rules. The application of the severity, extent, permanence and intentionality factors when calculating penalties for similar cases, varied significantly between the Member States. Furthermore, the European Commission's website on cross-compliance[139] is outdated (e.g. legal references) and does not inform about the implementation results of cross-compliance.

The main advantage of the cross-compliance strategy lies in **addressing financial flows** to agricultural holdings with penalties, and the easiness of control, in the frame of a package of checks related to the agricultural subsidies. The main barriers are related to the low level of **penalties to really drive behavioural change** (eradicate illegal water use), and the **opaqueness of information**.

In summary, the following strengths and weaknesses of this strategy can be listed as follows:

ESTABLISH CROSS-COMPLIANCE OF AGRICULTURAL SUBSIDIES	
Strengths	**Weaknesses**
• It addresses financial flows (driver) to agricultural holdings • It can build on existing field inspection and control and requires few additional resources	• The currently applied penalties (1-5% of some perceived subsidies) do not provide enough incentive to discourage illegal water use • The (EU) cross-compliance regulation does not necessarily apply to all farm support subsidies, so it might not affect all agricultural illegal water abstractions • The information publicly displayed about cross compliance is usually poor, opaque or even non-existent

4.2.6. POSITIVE INCENTIVES

4.2.6.1. Certification of legal water use

Different certification standards exist for agricultural products, and some of them include references to the legality of water use. GLOBALG.A.P. is a global organization to develop and assure standards for Good Agricultural Practice., the most important for fruit and vegetables sector Some 10-15 years ago, GLOBALG.A.P., the German retailer REWE and WWF developed jointly a pilot certification standard to **seek sustainable water use for fruits and vegetable production**, and one of the compliance criteria was 'Where required by law, there must be a written permit/license for irrigation water use, from the competent authority on this subject', classified as a 'major must' for certification purposes.

The standards in place since 2019 (Version 5.2[140]) require GLOBALG.A.P.-certified farmer's to undertake a risk self-assessment and to ensure that their farm complies with an 'authorization to use' water for the volumes required by the crop; and that its water extraction rates will not adversely affect flora and fauna associated to or dependent on the water source. An exact criteria about legal use of water is considered as a minor and not as a major.

In 2009, Coop, a Swiss retail company started to apply an internal standard regarding water use in the Doñana region (Spain), supported initially by WWF Spain. In 2018, Coop joined forces with GLOBALG.A.P. to develop an add-on certification for sustainable water management at farm level, called 'SPRING - Sustainable Program for Irrigation and Groundwater Use'[141]. This schema includes criteria to check the 'legal conformity of water sources and extraction rates'.

Regarding the certification of organic products, the overall EU regulation on organic farming is not yet very restrictive on illegal water use, but some specific production standards as e.g. Naturland (Germany) and Biosuisse (Switzerland) also include legal use of water as a criterion for their labelling.[142]

These **certification standards can influence acquisition protocols of "responsible" retailers and consumers** and may target agricultural production which is not directly subsidized (as fruits and vegetables in the EU). Given the significant market value of such fruits and vegetable production, regulatory or financial constraints might be less relevant than market-based decisions.

On the negative side, a **multitude of barriers** appeared when certifiers validated compliance criteria in Spain, with e.g. municipal documents being presented although these were not the competent authority for water rights, or 'preliminary' documents being prepared to overcome possible market constraints. Significant efforts were made for training certifiers.

In summary, some strengths and weaknesses of this strategy can be listed as follows:

CERTIFICATION OF LEGAL WATER USE	
Strengths	**Weaknesses**
• It targets acquisition protocols of "responsible" retailers, and the consumers differentiate such products • It is applicable to agricultural production that is not subsidized	• It is complex to translate "illegal water use" into certification standards which can be validated via 'compliance criteria' by auditors • Training of auditors is needed to detect non-compliance

4.2.7. RAISING AWARENESS ABOUT THE CONSEQUENCES OF OVER-ABSTRACTION

Implementing measures to reduce over-abstraction and control illegal abstractions is often unpopular amongst water users, but also the wider civil society, as such measures may jeopardise jobs and benefits. Such measures can be backed by awareness-raising on the consequences of over-abstraction and promoting a **common understanding and knowledge about the resources at stake**.

Promoting societal perception changes is usually a long-term process. A campaign about illegal water abstractions for strawberry production next to Spain's Doñana World Heritage wetland was supported by different TV programs[143], resulting in subsequent actions by retailers and authorities.

One of the risks in public awareness-raising campaigns on illegal water use is that the messages addressed to final consumers can be misinterpreted and can lead to unintended negative consequences, e.g. product boycotts which can also affect legal farms. However, as shown in WWF's Doñana case study, increased awareness can create opportunities to implement other strategies, involving farmers, authorities and consumers.

In summary, the following strengths and weaknesses of this strategy can be summarised as follows:

RAISING AWARENESS ABOUT THE CONSEQUENCES OF OVER-ABSTRACTION	
Strengths	**Weaknesses**
• It opens opportunities to address/implement other strategies • It can permeate the whole society, from water users to administrations, businesses in the value chain or legal institutions	• Final consumer actions have often a rather limited impact on the producer (illegal water user)

5. LESSONS LEARNED AND RECOMMENDATIONS

Illegal water use is driven by a variety of factors. The net benefits from water use and deficiencies in governance and institutions can be considered as active drivers that foster illegal use, whilst social norms are underlying factors that make action against illegal water use more difficult to be socially and economically accepted. Illegal water abstraction can jeopardize the security of access for users with formal water rights, can have negative environmental impacts and can drive other mirror practices, such as the unauthorized transformation of protected or public lands into irrigated land.

The review of the existing literature and case studies shows that there is a **growing concern** amongst water practitioners about illegal water use. While there are some cases where civil society or administrations have acted against illegal water use, usually over a longer timeframe of **several years**, in general **little action** has been taken and limited resources have been spent so far on detecting and tackling illegal water use.

In none of the case studies that were reviewed for this report illegal water use has been fully eradicated. However, some of the **strategies or their combinations**, have provided **partial/temporary success**, reducing the exposure to and impact of illegal water use and have contributed to the growing concern around this issue.

STEP 1 Strategies to detect illegal water use	STEP 2 Strategies to tackle illegal water use
1. Setting up of an appropiate and enforceable water rignts system.	**1.** Involvement of water uses in law enforcement and control.
2. Development and maintenance of an inventory, register or database of water uses.	**2.** Administrative action, closure of abstraction points and fines.
3. Improved and integrated control of water uses on the ground.	**3.** Legal actions and fines
4. Improved monitoring of water abstraction via remote sensing.	**4.** Capacity building of water uses to help them comply with abstration restrictions
5. Integrated data management.	**5.** Establishment of cross-compliance requirements in agricultural subsidies
	6. Positive incentives
	7. Raising awareness about the consequences of over-abstraction

Figure 4: Overview of strategies to detect and tackle illegal water use.

We have identified the following **five strategies to detect illegal water use**, usually the first step in action:

1. **Setting up of an appropriate and enforceable water rights system**. The experience suggests that a well-designed and well-maintained water allocation system is the basis for water rights enforcement. Transparency on water allocation criteria is key for any effective legal enforcement. Nonetheless, water rights systems can be rather difficult to implement in unregulated rivers, as often gauging stations to control flows are lacking. Similarly, the enforcement of water rights can be challenging for groundwater uses. When it is necessary to define a baseline for future enforcement (e.g. which plots or users are considered as legal or illegal at the time of entry into force of a new water rights system) negotiations can be rather difficult and time-consuming and can be hampered by information gaps or lack of political will.

2. **Development and maintainance of an inventory, register or database of water uses.** This strategy contributes to generating a dataset that can be used for important activities such as water planning, the allocation of new water rights and the enforcement of existing ones. Once such an inventory is set up, it is much easier to identify those water uses that are not part of it and therefore are likely to be out of the law. The development of an inventory of water uses requires financial and staff resources, both to set it up and to maintain it up to date.

3. **Improved and integrated control of water uses on the ground.** Field inspections and, in general, the collection of information on the ground are key to assess the level of enforcement of water rights and detect unlawful behaviours. Field data provide evidence and can indicate where water is abstracted or conducted/stored. This strategy, however, is costly and time-consuming and, in conflictive areas it can entail the risk of physical aggression of officials by illegal water users. In some circumstances, it is possible to engage other water users and concerned citizens in data collection, as a way of increasing the capacity of the administration on the ground.

4. **Improved monitoring of water abstraction via remote sensing.** Remote sensing can be used to detect illegal water use on large areas with reduced costs and in near-real-time. It is particularly useful in regions that are not easily accessible or where it is necessary to compare current land uses with past ones. This strategy can be implemented without accessing the property and it is often accepted as evidence in Court. However, ground-truthing is often necessary to set fines. Specialized technical skills and a good knowledge of local agricultural practices are needed to ensure the correct processing and interpretation of satellite data. Detection of illegal practices may be hindered by lack of detail or reliability in the spatial definition of plots which hold water rights.

5. **Integrated data management.** Combining and cross-checking the information contained in different data sets related to water (e.g. water rights, drilling permits, agricultural production, livestock activity) can be useful to identify cases of non-compliance. This strategy can yield very useful results but is technically and administratively complex as it often requires the agreement of different agencies and because it can be challenging to relate to different databases.

We have identified the following **seven strategies to tackle illegal water use**:

1. **Involvement of water users in law enforcement and control.** This strategy has the advantage of generating additional on-site resources that can help overcome the lack of resources of the public administration. Abstraction irregularities can be better identified and managed when compliance checks are carried out by peers. As a drawback, the involvement of stakeholders can generate some confusion among water users and stakeholders, and foster corruption if the process is not transparent. The compliance can be hampered by close social or neighbourhood relations between the controller and the controlled.

2. **Administrative action, closure of abstraction points and fines** can be a rapid response action. Its impact depends on the social awareness of illegal water use. Tt can provoke demonstrations or violence against public officials that must enforce the administrative action on the ground.

3. **Legal actions and fines.** This type of action at times is triggered by third parties that collect data independently or taking advantage of the right to access information about environmental issues. It is much easier to implement when supported politically or by international agencies such as UNESCO, Ramsar Convention or the European Commission. The implementation is usually a lengthy process, and sometimes it has little political and administrative support. When infractors are convicted, their cases can contribute to raising awareness about the fact that illegal uses can have negative legal consequences, thus being a deterrent to new unlawful behaviours. Moreover, they can help set up

jurisprudence that can speed up the processing of similar cases in the future. Nonetheless, there are barriers to the implementation of this strategy. Water laws are often complex and having reliable data about water uses can be challenging, especially when several government agencies are involved in data collection or reluctant to provide such data. Moreover, legal action requires long and resource-intense processes.

4. **Capacity building of water users to help them comply with abstraction restrictions.** This strategy emphasizes the role of individuals' choice to reduce illegal practices. It includes improving water use efficiency to reduce consumption or supporting the regularization of some uses when they are legally viable with easy-to-use tools. The strategy can be impacted negatively by free-riders and is more effective when combined with enforcement actions by authorities.

5. **Establishment of cross-compliance requirements in agricultural subsidies** This strategy addresses the financial flows to agricultural holdings and therefore can be very effective in discouraging illegal practices. This strategy, however, can not be applied to water uses that are not the recipient of subsidies; and often data on infringements, administrative action and fines are not shared fully and transparently.

6. **Positive incentives.** The establishment of acquisition protocols for "responsible" retailers and consumers can be an effective way of creating positive incentives for those producers who use water legally and put pressure on those who are outside the law. This type of measure can be applied to any agricultural product, including those that do not receive public subsidies (see above). Its implementation requires to translate the concept of "illegal water use" into clear certification standards and requires having well-trained auditors to detect non-compliance. At times this can be challenging because the legality of water uses can be nuanced and is not always 'black or white".

7. **Raising awareness about the consequences of over-abstraction.** This strategy helps prepare the ground for other strategies by making the society aware of the need to act. However, this strategy by itself is not enough to bring change in water use practices on the ground.

Based on the existing experiences and remaining barriers, we cannot provide water managers with "silver bullets" to tackle the illegal use of water. The complexity and local circumstances of illegal water use will require exploring different strategies and pathways, and we hope that the experiences shared in this report will be useful for water practitioners.

6. REFERENCES

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END NOTES

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[2] O'Donnell, 2018

[3] Bea et al., 2020

[4] e.g. Dworak et al, 2010; De Stefano & Lopez-Gunn, 2012; Felbab-Brown, 2017; Molle & Closas, 2020

[5] http://www.leakssuite.com/concepts/iwa-water-balance/; see also slide 2 of http://www.watersummit.co.za/assets/files/presentations_2017/gauteng/day_2/wegelin___iwa_water_balance_calculation.pdf.

[6] Le Quesne et al. 2007

[7] Felbab-Brown, 2017

[8] E.g. Dworak et al., 2010

[9] De Stefano & Lopez-Gunn, 2012

[10] De Stefano & Lopez-Gunn, 2012

[11] EASAC, 2010

[12] Felbab-Brown, 2017

[13] Elisabeth Malkin, "Big Mexican Farms Suck Up Water, Leaving Villages High and Dry," The New York Times, May 20, 2016, https://www.nytimes.com/2016/05/20/world/americas/mexico-water-farms-drought.html?_r=0; quoted in Felbab-Brown, 2017; also Molle & Closas, 2020 and OECD, 2015

[14] Seemann, 2016 quotes MINAG, 2009 that a significant number of users is using the water illegally. See also https://ojo-publico.com/especiales/acuatenientes/the-water-lords.html and https://ojo-publico.com/especiales/acuatenientes/power-and-impunity-the-companies-that-control-water-in-the-desert.html which refers to the irrigation development in the Ica valley and reports at least 314 of the 474 boreholes in Pampas de Villacurí area working without permit

[15] E.g. https://www.theguardian.com/environment/2018/may/17/chilean-villagers-claim-british-appetite-for-avocados-is-draining-region-dry

[16] Rinaudo et al., 2012. Molle & Closas, 2020

[17] According to Greenpeace, the Ministry for Agriculture made a non-official statement in 2017, referring to more than 1,000,000 illegal boreholes in Spain, accounting only for those abstracting more than 7,000 m^3/yr. Such data would imply that approximately 50% of the total irrigation area is supplied by illegal abstractions. More at: https://es.greenpeace.org/es/noticias/los-pozos-ilegales-nos-roban-el-agua/.

[18] Rodríguez-Cabellos, 2016 quoted in OECD, 2017. The Guadiana River Basin Agency declared provisionally overexploited the aquifer in 1987 and formally in December 1994. The European Union approved a 100 M€ aid from 1993 to 1997, for farmers in the Upper Catchment Area to reduce irrigation. However, this did not reduce the planned pumping, the drilling of illegal wells continued, and groundwater reserves decreased further. A lobby to support illegal pumping was created by farmers' unions, municipalities, water user associations, and even members of the Region's Government. The efforts of the basin authority in 2005 to take illegal pumping to courts largely failed, largely due to strong political pressure. After that, the policy initiative was the Special Plan for the Upper Guadiana (CHGN 2008), aimed at curbing overdraft by pouring 5.2 billion € in the region, with 810 million € earmarked to buy groundwater rights. The plan was cancelled in 2012 (Custodio, Sahuquiillo & Albiac, 2017).

[19] According to the DIANA project there is an estimated 1,000,000 unauthorized wells in Spain which abstract more than 7,000 m^3/yr each. In Aquifer 23 (Western La Mancha, Guadiana basin) in 2008, the water authorities estimated that 22,000 unauthorized boreholes existed, compared to 16,000 registered wells (CHG, 2008). In the Guadalquivir River Basin, in 2006 the River Basin Authority reckoned that 10% of the existing 100,000 wells were illegal.

[20] E.g. https://www.eldiario.es/murcia/medio_ambiente/cuarta-regadio-Mar-Menor-ilegal_0_780072468.html

[21] The DIANA project refers to an estimation of about 1.5 million unlicensed wells in Italy. In eight regions (Abruzzo, Molise, Puglia, Campania, Basilicata, Calabria, Sicily and Sardinia), about 830,000 hectares are irrigated legally, while the total irrigated area reaches about 1.6 million hectares. In the Puglia region alone, it is estimated that there are 300,000 unauthorized wells, which provide for one third of the total irrigated area in that region. Also Dworak et al., 2010

[22] Dworak et al., 2010

[23] Koronia lake ecosystem was degraded dramatically due to over-exploitation of surface and ground water for mainly agricultural use through illegal abstraction. As a result, water budget was modified and water level declined progressively (Alexandridis TK, Takavakoglou V, Crisman TL, Zalidis GC, 2007; Zalidis GC, Takavakoglou V, Alexandridis T., 2004). Also Dworak et al., 2010

[24] OECD, 2020

[25] DIANA project DIANA project, but also OECD, 2020: "In Romania, reducing non-revenue water due to illegal connections (often associated with irrigation water use) and under-metering should be prioritized in the short term."

[26] WPI, 2012; Molle & Closas, 2020

[27] https://worldview.stratfor.com/article/algeria-desert-nation-fighting-maintain-water-supplies (accessed 30 September 2018) refers to illegal drilling — potentially in the order of tens of thousands of illegal boreholes. Molle & Closas, 2020

[28] Frija et al., 2013; Molle & Closas, 2020

[29] The absence of an integrated agricultural policy, has led to fluctuating prices encouraging farmers to illegally consume more water for quick, guaranteed profits (Abdulmagid Abdudayem & Albert H.S. Scott, 2014).

[30] https://www.reuters.com/article/us-egypt-rice-insight/egypts-rice-farmers-see-rough-times-downstream-of-new-nile-mega-dam-idUSKBN1HU1O0, accessed 30 September 2018

[31] Israel reported that illegal practices, especially on farms, have become a serious issue affecting allocation and transfer of water resources (OECD, 2015, page 78)

[32] Felbab-Brown, 2017; Molle & Closas, 2020

[33] For the cultivation of the mild narcotic qat, Felbab-Brown, 2017 Molle & Closas, 2020

[34] Dogdu and Sagnak, 2008, quoted in EEA, 2009.

[35] Molle & Closas, 2020

[36] Barret et al., 2017 refer to the Koram and Keroai areas.

[37] Although illegal capture of water occurred during the Soviet period, it has become increasingly common over the past decade. Presently, under-funded and over-burdened local ministries of water management, WUAs, local authorities and farms are often unable to curb rent-seeking by farmers with enough informal connections or money to capture an unfair share of water. Farmers in the upstream portions of the irrigation and drainage systems account for most illegal water withdrawals. For example, those in the upper reaches of Kadamjan District (Batken Province, Kyrgyz Republic) have knocked holes in 2 km out of 5.5 km of concrete flumes and installed pipes and hoses in order to steal water above the established limits (World Bank, 2003). References are also made in Anderson & Swinnon, 2008.

[38] Felbab-Brown, 2017

[39] Felbab-Brown, 2017

[40] Kumar et al., (2013) consider illegal water diversion as rampant in canal irrigation.

[41] Ferdinando, 2006

[42] Personal communication by Dr Saulyegul Avlyush, October 2018

[43] Jiang, 2017 refers to uses of private groundwater pumps that are often illegal as pump owners hold no permits; and to water right enforcement problems.

[44] Speed et al., 2013:43

[45] Felbab-Brown, 2017

[46] Felbab-Brown, 2017

[47] Felbab-Brown, 2017

[48] Felbab-Brown, 2017

[49] Felbab-Brown, 2017

[50] The public water utility, the Ghana Water Company, Ltd. (GWCL), had previously been able to provide water to about half of the country's population of 20 million. But it started losing money for a variety of reasons, including unpaid bills and illegal connections. https://www.un.org/africarenewal/magazine/october-2007/bringing-water-africa%E2%80%99s-poor, accessed 30 September 2018

[51] E.g. http://www.sabcnews.com/sabcnews/water-dept-warns-engaging-illegal-water-use-prosecution/

[52] The Water Project, "Water in Crisis – South Africa," The Water Project, https://thewaterproject.org/water-crisis/water-in-crisis-south-africa.

[53] Felbab-Brown, 2017

[54] "Firm Crackdown on Illegal Water Connections," Tanzania Daily News, May 12, 2015; quoted in Felbab-Brown, 2017

[55] "Water Thieves Fined Shs 3.8 Billion," The Observer, October 7, 2015; quoted in Felbab-Brown, 2017

[56] http://www.bta.bg/en/c/PE/id/1875389

[57] https://financialtribune.com/articles/energy/80967/tehran-residents-warned-again-about-water-consumption (accessed 30 September 2018) refers to 32,000 illegal water wells in Tehran Province alone

[58] Felbab-Brown, 2017

[59] https://www.indiatoday.in/india/north/story/private-tankers-fulfiling-delhi-water-demands-illegal-means-india-today-164177-2013-05-24 as for urban/domestic use

[60] Felbab-Brown, 2017

[61] 2030WRG, 2016:6

[62] Felbab-Brown, 2017

[63] De Stefano, Lucia & Elena Lopez-Gunn, 2012

[64] De Stefano, Lucia & Elena Lopez-Gunn, 2012, citing Stålgren, 2006

[65] Van Dyk, 2018

[66] Molle & Closas, 2020

[67] De Stefano, Lucia & Elena Lopez-Gunn, 2012, citing Dumont et al., 2011

[68] O'Donnell, 2018

[69] Murray-Darling Basin Authority, 2017:13

[70] Pretty & Ward, 2001

[71] Lopez-Gunn & Martinez-Cortina, 2006

[72] De Stefano, Lucia & Elena Lopez-Gunn, 2012

[73] Rinaudo et al., 2012

[74] https://www.diariodesevilla.es/juzgado_de_guardia/actualidad/Detenidos-funcionarios-CHG-fraude-legalizacion_0_1263174227.html

[75] Felbab-Brown, 2017

[76] De Stefano, Lucia & Elena Lopez-Gunn, 2012, citing Dumont et al., 2011

[77] De Stefano, Lucia & Elena Lopez-Gunn, 2012, citing Gavin et al., 2009

[78] Rubiales García del Valle, 2011

[79] Planelles, Manuel (2019): El robo hídrico en España (1) El epicentro del saqueo sin castigo del agua de Doñana. El País: https://elpais.com/sociedad/2019/02/08/actualidad/1549640461_307654.html

[80] Albiac et al., 2006: 732

[81] O'Donnell, 2018

[82] Loch et al.,2017:3-6

[83] Loch et al.,2017:7

[84] E.g. WWF, 2006 on the Guadiana wetlands (Spain) and WWF,2016 on Doñana wetlands

[85] de la Hera, 1998

[86] E.g. Castillo Martín, 2008 on the Fuente La Reja spring in Pegalajar (Spain)

[87] Andreu et al., 2008 referring to the Crevillente aquifer on the Mediterranean coast, Spain; Elisabeth Malkin, "Big Mexican Farms Suck Up Water, Leaving Villages High and Dry," The New York Times, May 20, 2016, https://www.nytimes.com/2016/05/20/world/americas/mexico-water-farms-drought.html?_r=0, referring to Mexico's Guanajuato state, and deep aquifer pollution with arsenic and fluoride.

[88] De Stefano & Lopez-Gunn, 2012

[89] Molle & Closas, 2020

[90] Bea et al., 2020

[91] O'Donnell, 2018

[92] Garrick et al., 2018

[93] O'Donnell, 2018

[94] Rivers that do not receive an additional flow supplement, e.g. via an inter-basin water transfer

[95] Murray-Darling Basin Authority, 2017:67-68

[96] Felbab-Brown, 2017

[97] https://www.laverdad.es/murcia/yecla/inspector-denuncia-encanonado-20180925010818-ntvo.html

[98] https://www.wwf.es/?48160/WWF-condena-la-agresin-a-un-guarda-del-Ministerio-de-Transicin-Ecolgica-por-agricultores-ilegales-de-Doana

[99] https://ojo-publico.com/especiales/acuatenientes/poder-e-impunidad-las-empresas-que-controlan-el-agua-en-el-desierto.html

[100] Matthews, 2017b

[101] IMPEL, 2017

[102] Ozdogan et al., 2010

[103] Calera, A. at el., 2017

[104] Foster et al., 2019

[105] http://maps.spiderwebgis.org/login/?custom=spider-siar

[106] DIANA has been developed from January 2017 to December 2019 in the framework of H2020 (Grant Agreement 703109), see diana-h2020.eu and https://cordis.europa.eu/project/id/730109

[107] www.hidrogestor.es

[108] www.irrisat.com

[109] Felbab-Brown, 2017

[110] De Stefano & Lopez-Gunn, 2012, citing Theesfeld, 2008

[111] O'Donnell, 2018

[112] Murray-Darling Basin Authority, 2017:14-15

[113] Rouillard, J.J. & J.F. Rinaudo, 2020

[114] Custodio et al., 2017

[115] Calera, A. at el., 2017

[116] Felbab-Brown, 2017

[117] Molle & Closas, 2020

[118] E.g. https://www.huelvainformacion.es/provincia/alcaldesa-Almonte-declarar-sobreexplotado-precipitado_0_1327667676.html and http://agrodiariohuelva.es/2019/06/24/los-agricultores-de-lucena-del-puerto-impiden-a-los-tecnicos-de-la-chg-iniciar-el-sellado-de-los-pozos/ in June 2019

[119] Moll & Closas, 2020

[120] Matthews, 2017

[121] European Commission - Press release 24 January 2019: Commission takes Spain to Court for failure to protect the Doñana Wetlands http://europa.eu/rapid/press-release_IP-19-466_en.htm

[122] https://elpais.com/sociedad/2019/08/03/actualidad/1564826144_108790.html

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