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Groundwater Balance Politics: Aquifer Overexploitation in the Orontes River Basin

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ABSTRACT: Aquifer overexploitation is widely used to describe negative effects on groundwater resources but has no agreed scientific definition. Usually viewed as a situation where average aquifer abstraction exceeds average recharge, a diagnosis of groundwater overdraft calls upon specific hydrogeological instruments, based on the groundwater balance approach. An analytical method for assessing changes in water flows and stocks through time and space, groundwater balance is also a tool for the investigation of knowledge construction and its embeddedness within power relations. We propose to discuss the politics of groundwater overexploitation diagnoses in Syria and more specifically the Orontes River Basin prior to the 2011 uprising and subsequent conflict. Groundwater overdraft at the national level became a matter of concern in official discourse in the late 1990s as diagnoses of groundwater overexploitation became commonplace in international reports. The steady increase in groundwater abstraction in relation to Syria's centralised agricultural planning from the 1960s onward had undeniable consequences on the hydro-social system. However, the way diagnoses of groundwater overexploitation – in particular groundwater balances – were constructed and used to support water policies implemented from the mid-1990s onwards question the rationalities and interests lying behind technical arguments and actions.

KEYWORDS: Groundwater overexploitation, groundwater balance, politics, Orontes River Basin, Syria

INTRODUCTION

This paper discusses the politics of groundwater overexploitation diagnoses in Syria, and specifically in the Orontes River Basin, prior to the 2011 uprising and subsequent conflict. Groundwater overdraft at the national level became a matter of concern in official discourse in the late 1990s as diagnoses of groundwater overexploitation became commonplace in the reports of international organisations. The steady increase in groundwater abstraction in relation to Syria's centralised agricultural planning since the 1960s had undeniable consequences on the hydro-social system. Yet, the way diagnoses of groundwater overexploitation – in particular groundwater balances – were constructed and used to support water policies implemented from the mid-1990s onwards questions the rationalities and interests lying behind technical arguments and actions.

Groundwater overexploitation, overdraft and overuse are expressions widely used by hydrogeologists, social scientists and policy makers alike. Numerous studies have raised concerns about the depletion of aquifers resulting from groundwater overabstraction ; at the local, regional (Hernandez-Mora et al., 2003) and more recently global scale (Wada et al., 2010; Gleeson et al., 2012). Aquifer overdraft is particularly addressed in arid and semi-arid Middle Eastern regions (Foster, 1991; Postel, 1999; Shah et al., 2000; Salameh, 2008; Voss et al., 2013; Al-Zyoud et al., 2015; Alfarrah and Walraevens, 2018) where the intense development of groundwater – particularly for agriculture (Giordano and Villholth, 2007) – exacerbates water scarcity. From an early interest shown by the hydrogeology community through the International Association of Hydrogeologists in the early 1990s (Margat, 1977; Foster, 1991; Simmers et al., 1992), groundwater overexploitation has very much become part of the water management vocabulary (Custodio, 2002).

The basic definition of groundwater overexploitation is a situation where groundwater abstraction exceeds a certain threshold representing the 'good' (i.e. safe, sustainable, acceptable, manageable or optimal) level of groundwater use. The threshold is traditionally defined as the rate of natural recharge, estimated using a groundwater balance calculation,[1] the general underlying principle of which is "the attainment and maintenance of a long-term balance between the amount of groundwater withdrawn annually and the annual amount of recharge" (Sophocleous, 1997: 561).[2] The long-term balance between abstraction and recharge lies behind the concept of 'safe yield', defined by Lee in 1915 and intensely discussed and modified ever since (Kalf and Wolley, 2005). With the sustainable yield, hydrogeologists suggested reducing the abstraction threshold to consider the environmental effects of anthropogenic groundwater use, for example reduced outflows to rivers or intrusion of salty water (Alley and Leake, 2004; Zhou, 2009). They introduced competing notions, such as induced recharge (Sophocleous, 1998) and capture (Brefehoeft, 1997), looking at disequilibrium caused by well discharge. Recently the optimal (Seward et al., 2006) and managed yields (Meyland, 2011) further suggested accounting for the complexity of aquifer dynamics.

There is no agreed scientific definition of groundwater overdraft due to the complexity of the processes involved (Custodio, 2000), the diversity of aquifers, the uncertainty over the hydrogeological data and models used to assess and describe the processes. Hence, the term tends to be applied negatively to a whole range of changes in aquifer dynamics. Yet, despite its ubiquity, there is often no clear definition of the hydrogeological processes at stake. For example, overdraft sometimes describes the consequences of intensive groundwater use without reference to detailed hydrogeological studies

[1] Groundwater balance compares the groundwater flowing in and out of a system, respecting the mass conservation principle. The basic equation estimates for a given groundwater system total inflow with total outflow. The remaining term is the change in storage (Schoeller, 1959; Freeze and Cherry, 1979). In an unconfined aquifer with no human interference total inflow includes the recharge from precipitation (natural recharge) plus recharge from surface water (rivers and water bodies) and inflow from other systems (aquifers, basins). Total outflow refers to natural evapotranspiration, recharge to rivers and water bodies and outflow to other groundwater systems. With anthropisation, human activity modifies water flows. Well abstraction adds groundwater draft to the equation and increases groundwater outflow. Irrigation practices and hydraulic infrastructure often induce an artificial recharge, increasing groundwater inflow. These changes are compensated by changes elsewhere in the equation. For example, in the case of a net increase in groundwater abstraction, the groundwater system will adapt by increasing groundwater inflow (from rivers, lakes, seas or other aquifers), decreasing groundwater outflow (to rivers, springs, lakes, seas or other aquifers), releasing groundwater from storage, and often all three.

[2] According to this principle, a decreasing groundwater table does not necessarily reflect aquifer overexploitation but is a sign of disruption to the aquifer's dynamic equilibrium, shifting it from a steady to an unsteady state (Luijendijk and Bruggeman, 2008).

or groundwater balances. Hydrogeologists have varied opinions about the usefulness of a concept that is so vague yet is so regularly embedded in powerful political discourse. Foster et al. (2006) underline that "[t]he term "aquifer overexploitation" is an emotive expression not capable of rigorous scientific definition. But it is a term which resource managers would be wise not to abandon completely, since it has clear register at public and political level" (Foster et al., 2006: 4). Custodio (2002) highlights the impossibility of providing a simple definition of groundwater overexploitation, since it engages tradeoffs between hydrogeological, economic, social and political issues. Preferring concepts such as intensive development of groundwater (Custodio and Llamas, 2003), he also warns against the dangers of overreaction and protectionist water policies since in some cases "there is more emotion and politics than data" (Custodio, 2002: 271).

Following both Foster's and Custodio's observations, exploring the politics of groundwater overexploitation requires investigation into two distinct yet related issues. The first is an examination of the interrelationship between the politics, policies and practices that have led to the intensification of groundwater abstraction to a point that exceeds a *given limit*; while the second is an exploration of how expert knowledge regarding this situation is constructed and used (Budds, 2009) to influence action.

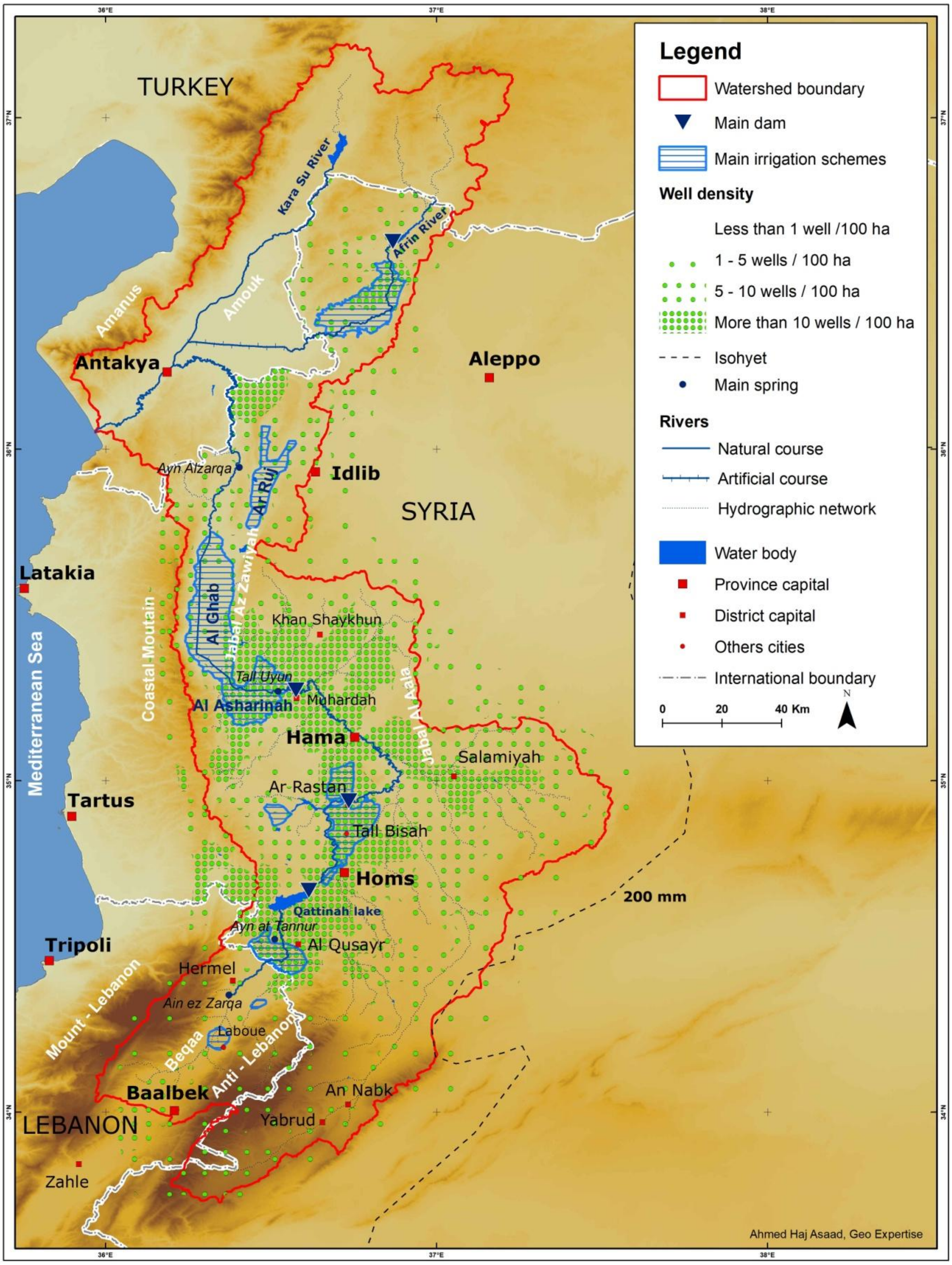
Based on field surveys conducted between 2006 and 2009, the analysis of programmatic and technical documents, as well as interviews with Syrian officials conducted between 2012 and 2016, this research examines groundwater overexploitation diagnoses and underlying balances produced in the 2000s in relation to Syria's irrigation policy. Such diagnoses in the Orontes River Basin were first used to support measures aimed at reducing groundwater abstraction and, more recently, to support the intensification of irrigation in areas of the basin with the most productive potential. Although intentionally not enforced for a long time, the measures were eventually implemented in the late 1990s, particularly in the eastern dry areas of the Orontes River Basin. However, their success in regulating water abstraction and improving water-use efficiency is questionable. In the early 2000s the Syrian state initiated a range of economic reforms that influenced an evolution in the Ministry of Irrigation's Orontes River Basin strategy during the mid-2000s. Once prioritising water conservation, the ministry then promoted increased irrigation in specific regions to maximise profitability. The reallocation of groundwater needed to increase water availability in these areas was supported by a groundwater model quite different from previous hydrogeological surveys.

GROUNDWATER EXPLOITATION AND REGULATION IN THE ORONTES RIVER BASIN

Developing surface and groundwater resources

The Orontes River Basin has a long history of water development dating from the Bronze Age and possibly earlier. Archaeological evidence indicates that the first developments are located in the upper reach and to the east of the basin. By the Roman-Byzantine period there was extensive construction of canals, dams and water wheels boosting the expansion of irrigation, mainly in the upper and middle course of the Orontes River (Chambrade and Saadé-Sbeih, 2015). The construction of the Qattinah Dam during that period secured water supply for the city of Emesa (Homs) and adjacent gardens (Calvet and Geyer, 1992; Boissière, 2005). Irrigated areas were located around Baalbek, Laboueh, Al Qaa and Al Qusayr (Figure 1) and fed by karstic springs and canals diverting water from the Orontes River. To the east underground channels collecting subsurface water – *qanats* – were used to supply drinking and irrigation water in the areas of An Nabk and Salamiyah, where 3500-4500 ha were irrigated from the *qanats* (Lightfoot, 1996; Al Dbiyat, 2009).

Figure 1. Irrigated areas in the mid-2000s, Syrian part of the Orontes River Basin.



The current infrastructure development in the Orontes River Basin is largely derived from the irrigation plan first conceived by the French administration during the early years of the Mandate for Syria and Lebanon (Weulersse, 1940) and completed soon after the Ba'ath Party took power in Syria in 1963. The plan comprised the rehabilitation of ancient water infrastructure as well as the expansion and creation of collective irrigation schemes supplied by surface water. It aimed to increase agricultural production by intensifying irrigation with water from the Orontes River and major springs spread along the valley. The expansion of irrigated land required draining the swamp areas of Al Ghab, Ar Ruj and the Amouk Graben – areas which had only partly been used in the Roman-Byzantine period (Thoumin, 1936; Besançon and Geyer, 1995). The drainage of these unproductive swamp lands also marked a step towards eradicating malaria (Lewis, 1949). The plan was implemented incrementally, upstream to downstream, before and after independence, with work progressing from the upper Orontes down to Ar Ruj Graben via the Homs Canal, the Homs-Hama perimeter and Al Asharinah and Al Ghab plains (Métral, 1984). Canals supplying Al Qusayr irrigation scheme were renovated in the 1920s and the Homs irrigation network was restored and extended in the 1930s. By the end of the 1930s most of the ancient water infrastructure, including the water wheels, was functional (Gibert, 1949; Delpech et al., 1997). The total irrigated area in the Orontes River Basin at that time is estimated at 15,000-30,000 ha, about 5000 ha of which was irrigated with groundwater (Weulersse, 1940). Irrigation progressively expanded to reach around 100,000 ha in the mid-1970s, mostly as a result of the Syrian policy of surface water development.

In 1936 the upper part of the Orontes River Basin lay within Lebanese territory while its downstream section came to belong to the Hatay Province ceded by France to Turkey in 1939. In the Syrian part of the basin Al Ghab irrigation scheme was the first large-scale hydraulic project undertaken by the Syrian state following independence and preceding the development of the Euphrates Valley (Figure 1). Initiated in 1952 during an era of economic liberalism, it was completed after the Ba'ath Party took power in a period of agrarian reform, nationalisation and transformation from a liberal to a planned economy (Hinnebusch, 1989). The project was part of a broader political strategy under the supervision of the Ba'ath Party to modernise Syrian society and its rural areas, imposing state control over water, land and production (Métral, 1984). The expansion of irrigated areas was a top priority and irrigation schemes' farmers in the Orontes River Basin were among the main beneficiaries of the agrarian reforms and planned agriculture until the second half of the 1970s. From this point onwards, Al Ghab scheme became a flagship project of the centralized agricultural policy. The goal was to irrigate 88,000 ha in the plains of Al Ghab and Al Asharinah and included the building of large dams (Rastan in 1960; Muhardah in 1961) as well as the construction of two gravity irrigation networks completed with drainage systems. Furthermore, state boards had a monopoly on the purchase of strategic commodities, such as wheat, cotton and sugar beet, at fixed prices. Meanwhile, the plan saw agricultural inputs and credit granted by state cooperatives and the Agricultural Bank (Métral, 1984).

In the 1950s and 1960s the expansion of groundwater-fed irrigation was considered neither promising nor desirable by international (IBRD, 1956)[3] and public bodies. However, as a result of illegal but tolerated individual initiatives, the Orontes River Basin witnessed intensive groundwater development, first in its arid margins, then in areas assigned to rainfed agriculture and finally as a backup for failing state water supply systems. The first wave of well digging and intensive groundwater abstraction took place in dry, eastern areas in the 1950s, particularly in the Salamiyah district, which benefited from favourable conditions for cotton production, such as shallow groundwater easily accessible with recently introduced pumping technology and high prices for cotton due to the Korean War. Groundwater irrigation was further encouraged by funding from private investors in association

[3] The IBRD report stressed the need to investigate groundwater resources primarily to improve the provision of drinking water in such areas as the Hauran and Djebel Druze where supplies for human consumption were inadequate and in the Syrian Steppe where water for livestock was needed. The exploitation of major aquifers, requiring heavy investment and high operating costs, was considered profitable only for crops having a high return per hectare (IBRD, 1956: 43).

with landowners (Al Dbiyat, 1980; Jaubert and Geyer, 2006). As a result, irrigated areas for cotton reached a maximum of 14,000 ha in 1956.

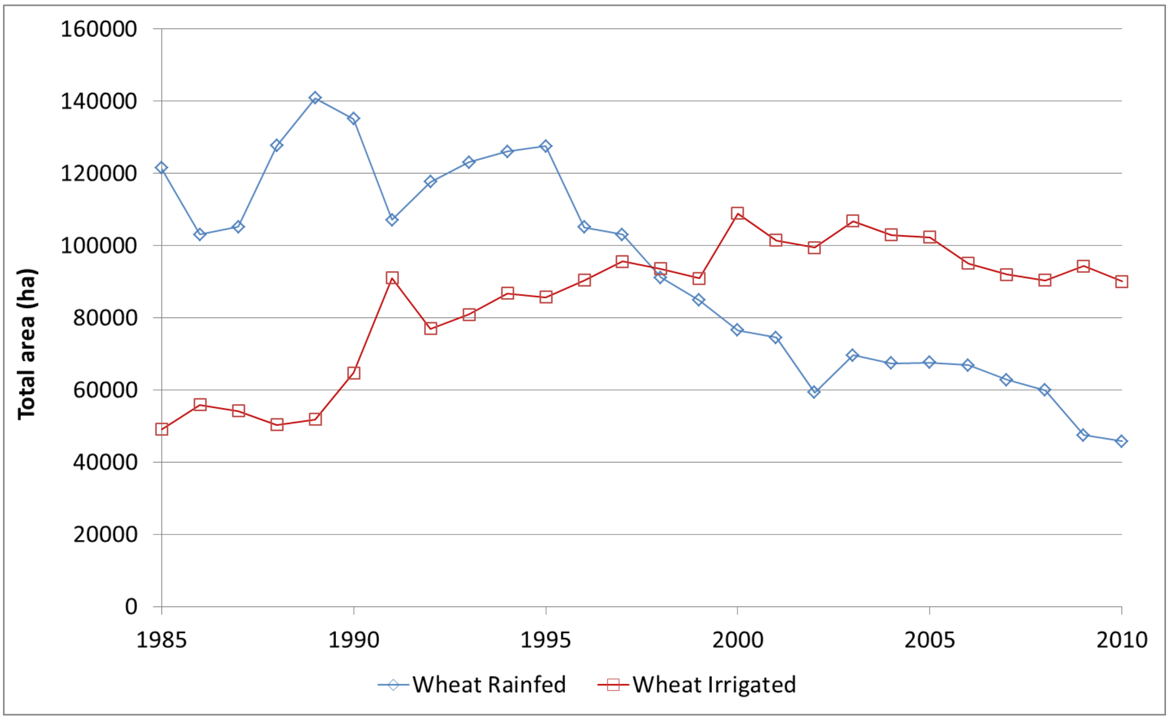
The second wave of groundwater abstraction began in the 1970s in the Homs depression, the south-eastern part of Hama and the Muhardah area. Despite lying outside the state irrigated schemes, farmers exploiting groundwater in these regions – considered relatively propitious for rainfed agriculture by the Syrian administration – benefited directly and indirectly from the centralised agricultural policy.[4] In the 1980s a sharp fiscal and foreign exchange crisis encouraged a limited economic opening and the development of the private sector (Hinnebusch, 1997). The latter remained under narrow control by a 'nomenklatura', which ruled over imports and distribution networks, putting each citizen in a situation of 'illegality', tolerated or otherwise, constantly threatened with penalties and the whims of arbitrary power (Métral, 2013). Agricultural policy reforms introduced a shift from 'strict planning' to 'indicative planning' (Huff, 2004). An increase in wheat prices in 1987 from 2-3 SYP/kg to 10 SYP/kg encouraged farmers to grow irrigated wheat (Figure 2), while subsidised diesel and fertilisers contributed to the profitability of investment in groundwater irrigation (Aw-Hassan et al., 2014). The drilling of new wells rose sharply, particularly in the areas of Muhardah, Al Qusayr, Tall Bisah, Khan Shaykhun and the Homs Plain (Figure 1), and continued to increase throughout the 1990s before stabilising in the 2000s (TNO, 2008). As a result, the area irrigated with groundwater grew dramatically from a few thousand hectares in the early 1950s to around 195,000 hectares in the 2000s. The total irrigated area from surface and groundwater reached around 300,000 ha in the entire basin (Droubi and Shamali, 2013).

Initially taking place in areas at the margin of the state production plan, groundwater-fed irrigation expanded in state-managed irrigation schemes as a result of operational difficulties and a failure to supply sufficient surface water to the collective irrigation network, with Al Ghab irrigation scheme in particular facing severe physical constraints. In the mid-1980s Al Ghab and Al Asharinah perimeters were renovated, with drainage and irrigation networks improved. The construction of dams on the Orontes River and its tributaries increased the storage capacity of winter surplus rainfall to secure water provision. However, from the mid-1990s both irrigation schemes experienced difficulties to provide sufficient water, due to water exploitation practices in the Upper Orontes and variable rainfall. Low rainfall during the 1993-2001 and 2005-2008 periods, and intensive extraction of groundwater in the upper and middle reaches of the basin, contributed to a reduction in spring discharge and declining aquifer levels. Combined with the use of surface water in the upstream irrigated areas of Al Qusayr and Homs-Hama, this resulted in declining river discharge and insufficient dam storage.[5] Consequently, in 1998-1999 and 1999-2000 Al Ghab and Al Asharinah irrigated areas had virtually no supply from the collective irrigation network and came to depend entirely on springs and groundwater abstraction. Conversely, during the 2002-2003 season high rainfall and releases from Ar Rastan reservoir caused flooding in Al Ghab Plain. In the 2000s structural problems, such as the fragmentation of holdings, accelerated a reduction in the average size of a holding from 2.5 to 0.4 ha. The inefficient distribution of water further contributed to a decline in productivity.

[4] At the national level, agricultural planning distinguished between areas irrigated with surface water, such as Al Ghab and Al Asharinah irrigated schemes, and areas dedicated to rainfed agriculture. Support for the latter was based on an administrative division of the country into five agro-climatic zones with specific production and land-use plans established for each. Zone 1, with more than 350 mm of average annual rainfall, and Zone 2, with 250-350 mm of average annual rainfall, received a large share of the agricultural budget. Semi-arid Zones 3 and 4 were regarded as less favourable for rainfed agriculture and farmers had limited access to credit and agricultural inputs in Zone 3 and no access at all in Zone 4. Zone 5, with less than 200 mm of average annual rainfall, was dedicated primarily to pastoralism (Jaubert and Geyer, 2006).

[5] Around 200 Mm^3 extra was required to balance the irrigation requirements of Al Ghab and Al Asharinah schemes.

Figure 2. Increase in irrigated areas for wheat production in the *mohafazat* of Homs, Hama and Al Ghab.



Data: National Agricultural Policy Centre, Syria

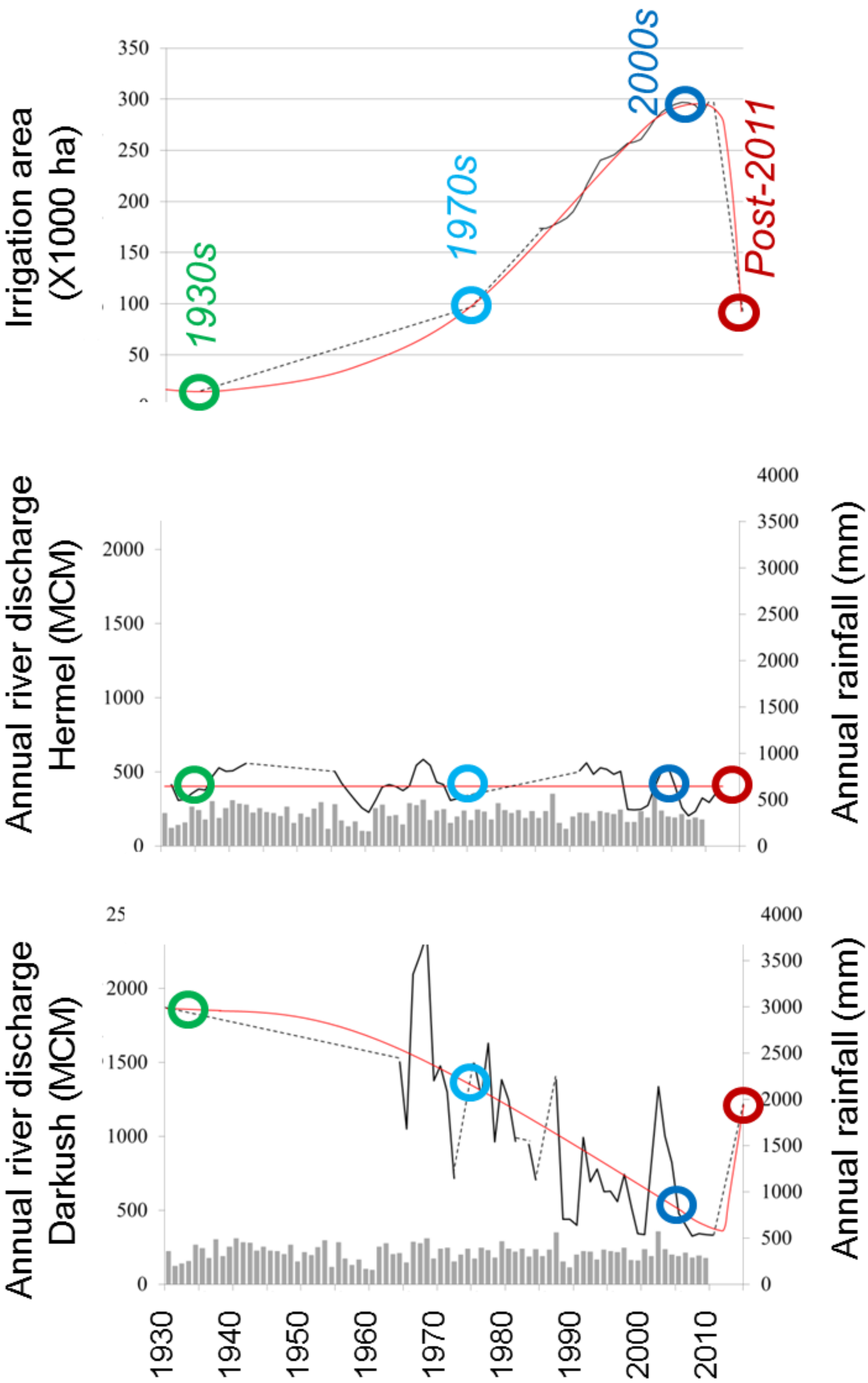
The intensive use of surface and groundwater profoundly modified the dynamics of the Orontes River, as well as the basin's springs and aquifers. The Orontes River discharge decreased sharply in the middle and downstream sections of the basin. At the Darkush gauging station, close to the Turkish border, the average annual discharge dropped from 1850 Mm^3 per year in the 1930s to 1250 Mm^3 in the 1970s, dropping further still to 600 Mm^3 in the 2000s[6] (Figure 3). Moreover, major springs and groups of springs witnessed significant decreases in discharge. Those located in Al Qusayr area, including Ayn at Tannur, supplying the city of Homs, decreased by a third. Springs at the eastern edge of Al Ghab Plain, which had been a source of significant discharge in the 1960s (an average of 13,000 litres per second) dried up in the 1990s (Zwahlen et al., 2016). Dropping groundwater tables were observed in areas such as the Salamiyah, Al Ghab and Al Asharinah plains in the 1970s (JICA, 1996). In eastern areas of the basin in the 1960s most *qanats* dried out (Jaubert and Geyer, 2006). Between 1990 and 1999 reports stated that piezometric levels had decreased by over 50 m in Al Asharinah area and over 30 m in the Salamiyah plain (Varela-Ortega and Sagardoy, 2001).

Groundwater regulation until the late 1990s

The steady increase in water abstraction for irrigation was acknowledged by the administration and a set of measures was introduced in the late 1950s to regulate the use of surface and groundwater. The first law on irrigation water, passed in 1958, required prior authorisation for the digging of new wells. According to a 1972 law regulating the use of water from wells and small dams, the right to use surface or groundwater required a licence – a point which was reaffirmed in the 1996 decision and the 2005 water law. Licences were first delivered by the Ministry of Public Works (before 1983), then by the Ministry of Irrigation (between 1983 and 2012) and most recently by the Ministry of Water Resources.

[6] The remaining baseflow is ensured by a major karstic spring close to the Turkish border – Ayn Alzarqa.

Figure 3. Changes in irrigated area and river discharge between 1930 and 2013.



Source: Saadé-Sbeih et al., 2016.

The licence specified the maximum volume of water that could be abstracted annually from a particular well, the area to be irrigated and, in some cases, conditions on drilling, groundwater abstraction and exploitation techniques. The authorised volume depended on the type of aquifer and its location within a specific water basin. For shallow aquifers, this volume was in principle estimated according to the aquifer's safe yield. For deep aquifers, the maximum volume was to be established in light of tradeoffs between economic benefits and the conservation of non-renewable groundwater, based on the mining yield concept (JICA, 1996).

Much legislation was drafted from the 1960s onwards to protect local aquifers by limiting the permitted irrigation areas and restricting pumping rates per hectare in specific areas. These measures also prohibited well drilling and certain water-intensive crops, such as cotton (JICA, 1996; Kirata, 2004). For example, the total irrigated area in the Salamiyah district was limited to 2000 ha in 1959, corresponding to the expansion of irrigated areas from *qanats* in the 1930s-1940s estimated by Lewis (1949). In 1965, following the decrease in groundwater table and the drying out of *qanats*, well drilling was prohibited in the same area. A 1973 ruling reiterated the need for well-drilling licences. Finally, new decisions limited summer irrigation to 1200 ha in 1990 and banned cotton in agro-climatic Zones 4 and 5 in 1992 and rainfed and irrigated cultivation two years later in Zone 5.

However, none of the water-use regulations passed since the 1960s was enforced until the late 1990s (Jaubert and Geyer, 2006) and several factors explain this laissez-faire policy. Syrian groundwater regulation relied on the control of individual abstraction practices by state services. The implementation of such regulation was made technically difficult because of the high number of wells, requiring substantial financial and human resources beyond the capacity of state services. The lack of enforcement also reveals conflicting interests at the heart of the Syrian agricultural policy and populist 'social contract' (Hinnebusch, 1990). Primarily, tolerating unplanned groundwater development helped to achieve production targets that would not otherwise be met. This was especially important for wheat, since the national objective was to achieve self-sufficiency – particularly in the late 1980s, when Syria was highly dependent on foreign financial aid (USSR and Arab states). According to the National Agricultural Policy Centre, between 1973 and the end of the 2000s, two thirds of the increase in Syria's irrigated land came from individual wells, most of which unlicensed. In the early 1980s 50% of the total irrigated land was irrigated with groundwater; in 2001 it was over 80%. In the early 2000s the Orontes River Basin counted around 50,000 wells – over 50% of which were unlicensed. In dry areas, the failure to enforce regulations was also a way to counterbalance restrictions on access to credit and inputs. In areas benefiting from state irrigation schemes, the lack of enforcement was a means to assuage farmers' growing grievances over the management of irrigation networks and the shortage of irrigation water.

Groundwater overexploitation and the enforcement of restrictive measures in the Orontes River Basin

The enforcement of regulatory water-use measures began in the 1990s when, following the collapse of the Soviet Union, Syria attempted to strengthen cooperation with international organisations. Discourses on the global water crisis (Gleick, 1993; Postel, 1992), as well as concerns over the supply to state-irrigated schemes, may have contributed to an increased awareness of water supply and management problems in Syria. They also provided a basis for international cooperation. In 1995 a study on water resources was carried out by the Japanese Cooperation Agency (JICA, 1996). In 2000, at the request of the Syrian government, the World Bank conducted an assessment of the country's irrigation sector. The objective was explicitly to identify projects that could be submitted to the World Bank or other international funding agencies (World Bank, 2001). The report highlighted that groundwater management was of major importance for the country. The actual state of groundwater resources was, however, difficult to assess precisely due to the lack of up-to-date data.

Groundwater deficits: The foundation of groundwater overexploitation diagnoses

The first surveys of the Orontes River Basin were conducted during the French mandate and mostly focused on surface water. Investigations by French and Syrian scientists, such as Dubertret, Duraffourd, Frolow, Thoumin and Mazloum, as well as hydrological data measured by mandate bodies, served as a basis for the irrigation plan mentioned previously (Weuleresse, 1940). After the drawing of international borders, the birth of modern Lebanon, Syria and Turkey, and the retreat of French troops in 1946, the production of hydrometric data and studies evolved differently – in accordance with national trajectories, hydrocracy development (Molle et al., 2009) and international alliances.

In the early years of the Syrian Arab Republic scientific and technical studies on the Orontes River Basin were mostly associated with the development of the Middle Orontes (Ré, 1966) and the establishment of the collective irrigation schemes of Al Ghab and Al Asharinah (Moussly, 1951; Kerbe, 1987). However, several surveys started investigating groundwater resources as reservoirs feeding the main springs of the Orontes River Basin. The pioneer work of Ibrahim Abd El Al (1967), a Lebanese engineer, highlighted the importance of Syrian-Lebanese limestone mountains for the supply of the karstic springs of Ain ez Zarqa, considered to be the main spring feeding the Orontes River, and Tall Uyun upstream Al Asharinah Plain. Meanwhile, the springs along the western and eastern borders of Al Ghab Graben were investigated by Voûte (1961). Studies on Syrian groundwater resources multiplied and were discussed in international forums, such as the International Association of Scientific Hydrology (Burdon et al., 1954) and UNESCO conferences (Burdon and Mazloum, 1958). They relied on preliminary, larger-scale groundwater surveys as well as geological surveys (for example, Dubertret, 1933).

Groundwater was the object of an intensive scientific campaign in the 1970s, with financial and technical assistance from the USSR. From 1974 to 1979 the Ministry of Public Works – the agency then responsible for water resources development in Syria – conducted a large number of hydrological and hydrogeological surveys on several basins (JICA, 1996). With the support of Soviet scientists and engineers, it estimated the availability of surface and groundwater, identifying irrigation, domestic and industrial water supply projects. The Soviet company Gruzgiprovodkhoz produced a significant amount of geomorphologic and hydrogeological data on the Orontes River Basin and calculated large-scale surface and groundwater balances. These studies served as the foundation for a master plan for water resources development, issued in 1982, before the creation in 1983 of the Ministry of Irrigation. Further studies on other basins were carried out until the late 1980s as part of the technical cooperation with the Soviet company Lengiprovodkhoz. The latter conducted feasibility studies on water use in the Barada/Awaj Basin in 1986 and in the Steppe Basin in 1987. With the fall of the USSR, the production of hydrogeological studies reduced significantly.

No major hydrological or hydrogeological exploration was performed between the end of the 1980s and the mid-2000s. Hydrogeological studies conducted in the 1970s and 1980s served as the basis for various water resources reviews produced since the end of the 1990s. The later ones presented significantly different water balances, yet they agreed on a common point: the overexploitation of groundwater resources. Diagnoses of groundwater overdraft were publicised between the mid-1990s and the early 2000s (Saadé-Sbeih and Jaubert, 2011). They relied on the recycling of Soviet reports and groundwater balances by international organisations and the Ministry of Irrigation, while piezometric levels measured by the Ministry of Irrigation completed the corpus.

Conducting a study for water resources development in the mid-1990s, the Japanese cooperation JICA indicated that there had been a "serious shortage of groundwater resources" since the late 1970s in five national watersheds, including the Orontes River Basin (JICA, 1996: 102). Based on the groundwater balance produced by Gruzgiprovodkhoz for the year 1976, the JICA estimated a total groundwater inflow for the Orontes River Basin of 1270 Mm^3 per year (Mm^3/y) and a total groundwater outflow of 1262 Mm^3/y, of which 309 Mm^3/y was abstracted from wells.[7] Based on the JICA report, the World Bank (2001) estimated the total renewable water resources to be around 3900 Mm^3/y and total water use around 2730 Mm^3/y in the Orontes River Basin.[8] Despite a large positive water balance of 1170 Mm^3/y, the World Bank concluded that the Orontes River Basin was critical, along with the Barada/Awaj, Aleppo and Khabour basins, since its surface water had been fully exploited and its groundwater overexploited. The latter diagnosis was supported by the affirmation of a negative groundwater balance, not included in the report, as well as declining groundwater tables. A few months after the release of the World Bank report the FAO published a study comparing irrigation policy scenarios (Varela-Ortega and Sagardoy, 2001). It estimated the available water resources for the year 1999-2000 to be 1831 Mm^3/y in the Orontes River Basin – 964 Mm^3/y from aquifers – for a total water use of 2687 Mm^3/y.[9] The estimated deficit reached 856 Mm^3/y and was explained as the depletion of the groundwater resource.

The reports give widely varying water balances for the same basin, yet, due to their lack of detailed information on the assumptions and methods used, these cannot be explained. Contradictions can also be found within a single report's water balances and conclusions. Beyond the water balances' inconsistencies, which reveals poor circulation of datasets between Syrian and international water experts because of their sensitivity (Elhadj, 2003; De Châtel, 2014), groundwater overexploitation diagnoses were applied to the Orontes River Basin as a whole, with no detailed assessment of the areas under intensive groundwater abstraction and no historical perspective.

Coping with groundwater overexploitation? Groundwater policy and its contradictions

Diagnoses of overexploitation were used to justify the policy shift in the mid-1990s regarding the use of groundwater and the introduction of measures to reduce consumption, but their vagueness made it impossible to devise a strategy or prioritise areas for intervention. Particular attention was paid to groundwater overexploitation and integrated management in programmatic documents announcing a reform of the water sector (World Bank, 2001; Ministry of Irrigation, 2003; State Planning Commission, 2006). In an apparent attempt to regain control over unregulated groundwater abstraction, legal measures primarily targeting groundwater users were enforced in the late 1990s and early 2000s (Varela-Ortega and Sagardoy, 2001), with well-drilling outlawed in 1999. In 2000 a Ministerial Council decree allowed unlicensed wells to be regularised under certain conditions that were more stringent in arid areas, particularly in the eastern margins of the Orontes River Basin.

The enforcement of restrictive regulatory measures was combined with moves to modernise the irrigation sector, 'rationalising' water use and protecting surface and groundwater resources. The water policy of 2003 (Ministry of Irrigation, 2003) relied on studies conducted by the Ministry of Irrigation and selectively on recommendations made by the World Bank in its 2001 report. In 2005 the Ministry of Agriculture and Agrarian Reform launched the National Plan for Water Sector Modernisation, aiming to improve water-use efficiency with the diffusion of modern irrigation techniques. However, it faced difficulties related to legal limitations, since only owners of licensed wells could apply (Molle and Laiti, 2003). Neither did it apply in state irrigation schemes (Balanche, 2012), despite very low water-use efficiency (Varela-Ortega and Sagardoy, 2001). The most drastic and controversial measure was the

[7] The remaining groundwater outflow corresponds mostly to spring discharge and groundwater flow to other basins, such as the downstream part of the Orontes River Basin located in Turkey, or lateral groundwater flow to the Steppe or the Coastal Basins.

[8] The report defined total renewable water resources as the 'maximum potential supply in absence of any other constraints' (World Bank 2001:viii), with no other details of how this potential has been estimated. It is therefore not possible to know if it is based on total annual rainfall, or recharge. The report also used indistinctly the terms 'water use' and 'water consumption'. It is thus difficult to figure out what the remaining term (1170 Mm^3/y) represents.

[9] The report did not distinguish between surface and groundwater use.

removal of subsidies on energy and agricultural inputs. Despite the conflicting economic and social dimensions of the measure, subsidies on diesel were gradually removed after 2006 due to ever decreasing oil revenues. Subsidies on fertilisers were removed in 2009.

The apparent perpetuation of productivist objectives and geographical preferences was challenged, however, by a shift in water allocation priorities. Agriculture became the sector with the lowest priority, reflecting both reduced political interest and the integration of management principles, such as the economic efficiency of water allocation among economic sectors. In the early 2000s (JICA, 1996; World Bank, 2001) there was no official document defining allocation priorities, but a consensus existed between ministries to prioritise drinking water, agriculture and then industry. The Ministry of Irrigation's 2003 water strategy altered this implicit consensus by explicitly stating that priority must be given first to drinking water, then to industry/tourism and finally to 'modern' agriculture. This sequence was reiterated in the 2005 water law.

Implementation of groundwater regulation

Measures enforced in the eastern areas of the Orontes Basin comprised a strict ban on cotton production, well-drilling and water sales. Infringements by farmers or borehole drillers were subject to a fine and up to six months' imprisonment. They limited the amount of irrigation water to 7000 m^3 per hectare as well as the area authorised for wheat production and imposed the installation of water meters on existing wells, registered and unregistered. These measures were sustained by a rapid assessment of water management in Salamiyah based on a series of observations, such as the drying out of the *qanats* in the 1960s, the reduction of irrigated land in the 1970s, the increasing number of dry wells and the decline of groundwater levels since the 1950s (ICARDA, 2002).

The regulation had almost no effect in terms of groundwater abstraction since the ban on cotton led to an increase in wheat production that exceeded the authorised area. The limitation of irrigation water to 7000 m^3 per hectare was not a constraint since irrigated wheat in the area concerned requires about 4000 m^3 per hectare. The ban on water sales was not enforced; it would have strongly affected olive producers relying on purchased water to irrigate their orchards. Conversely, no restrictive measures were enforced in intensive groundwater abstraction areas, such as Al Qusayr and Muhardah (Aw-Hassan et al., 2014) in which restricting groundwater use was a highly sensitive issue.

The location of the measures and their effect in terms of groundwater abstraction raises the question of their rationale. Measures were indeed implemented in a way that limited their impact on the production of strategic crops and thus on groundwater abstraction. Wheat production was not affected in the dry areas and neither were strategic crops in the intensively irrigated areas of the basin. It can be noted that the World Bank assessment recommended implementing economic measures, such as the removal of subsidies for the production of wheat and increasing fuel prices for motor pumps. These indirect measures could hardly be applied immediately and authorities opted for direct coercive measures in selected areas (Saadé-Sbeih et al., 2014).

FROM GROUNDWATER OVEREXPLOITATION TO GROUNDWATER REALLOCATION

The most recent assessment conducted in the Orontes River Basin takes a different perspective. In 2002 a Dutch private research institute, Deltares/TNO, initiated the first and sole general numerical groundwater model of the Middle Orontes River Basin as part of the Dutch-Syrian Water Cooperation (TNO, 2008). It was contracted by the Dutch Institute for Inland Water Management and Waste Water Treatment (RIZA) – a public research centre with expertise in national and international policy-making. The main aim of the Syrian-Dutch collaboration was to plan, under the supervision of the Ministry of Irrigation, the Integrated Water Resources Management (IRWM) of the Orontes River Basin and to update work carried out with Soviet assistance in the 1970s and 1980s.

Development of the general groundwater model of the Orontes River Basin

The assessment started with the design and construction of a local groundwater model of the Upper Orontes during a first phase (2002-2005), followed by the development of the general groundwater model of the Orontes Basin in a second phase (2005-2008). Surface water was intended to be integrated in a third phase but the work was interrupted by the start of the Syrian crisis in 2011. Departing from previous vague diagnoses of groundwater overexploitation, the assessment provided a detailed picture of the groundwater situation through the calculation of groundwater balances for specific historical periods and areas. The main outcomes of the study were recommendations to decrease groundwater abstraction in several irrigated areas and the identification of potential areas to supply additional groundwater resources for drinking water. The results were used to discuss a new Syrian water policy, reiterating previous policy orientations and addressing allocation priorities, drafted by a special committee created by Deputy Prime Minister Abdallah Dardari and gathering water experts from different Syrian ministries.

The study consisted of the development of a groundwater model in two stages.[10] The first was a steady-state model representing the conditions of the 1950s, assuming no groundwater abstraction in the basin. The second was an unsteady-state model simulating seven stress decades between 1950 and 2018. The final report (TNO, 2008) highlighted the assessment's limitations. Questions were raised over the accuracy of the model and its results by the heterogeneity of the datasets in terms of quality, spatial distribution and completeness, as well as by the difficulty in collecting reliable piezometric data. The modelling constraints and the choice of the MODFLOW software package meant the model was not able to correctly represent groundwater dynamics in the dry, eastern areas of the Orontes River Basin.[11]

Based on the calculation of the global groundwater balance, the system was represented as adaptive, compensating intensive well abstraction with decreasing volumes of groundwater in storage (TNO, 2008: 42). It also showed well abstraction as appearing to have reached a limit, as the volume of groundwater abstracted by wells had remained almost constant since the 1990s (about 2150 Mm^3/y for the whole basin (TNO, 2008: 41)). With the exception of the 2008-2018 period during which a decrease in rainfall was foreseen, abstraction from wells remained lower than the recharge (2387 Mm^3/y on average) at all times. The global groundwater balance was considered unsatisfactory, however, since it erased spatial differences and "smoothed out (…) the fact that only a few areas [were] really affected by over pumping of groundwater" (TNO, 2008: 42).

The TNO study then focused on selected irrigated areas, where groundwater overdrafts were expected, and compared the lowering of the groundwater table between 1950 and 2007 with local groundwater balances calculated for 2007. It proposed two water balance-based indicators to describe the groundwater abstraction situation. The choice of the indicator was key for defining critical areas in terms of groundwater overdraft. The TNO simulation showing the lowering of the groundwater table identified four areas with deep pumping cones, i.e. groundwater depressions between 50 m and 100 m, which were, in magnitude order, around the towns of Muhardah, Tall Bisah, Khan Shaykhun and Al

[10] For the development of the global model, the Deltares/TNO hydrogeology experts worked in collaboration with the Ministry of Irrigation and the affiliated Water Resources Directorate of the Orontes Basin in Homs, as well as with the Arab Centre for the Study of Arid Zones and Dry Lands (ACSAD) based in Douma. The results were not made public. The Ministry of Irrigation and ACSAD carried out the data collection, taking geological data and hydraulic parameters from USSR maps and reports from the 1960s and 1970s. A group of Syrian ministry representatives agreed the recharge coefficient for each hydrogeological unit. The General Company of Hydraulic Studies in Homs (GCHS) provided groundwater levels monitored in 2003 and the Orontes Basin Directorate provided the 2007/2008 levels for model calibration. Groundwater abstraction was calculated based on well statistics as the product of the number of wells and an assumed average well discharge corrected to close the water balance. The database was handled by ACSAD.

[11] The calibration of the model used the levels in deep aquifers, ignoring both superficial aquifers and perched Paleogene bodies – the most exploited aquifers in the eastern part of the basin. These have been exploited since the mid-1850s, using *qanats*, which brings another perspective to the pristine image of the pre-1950s groundwater system.

Qusayr (Figure 4). These areas of intensive groundwater irrigation showed a recharge/abstraction ratio of between 0.2 and 0.5, meaning that groundwater abstraction was higher than local recharge by a factor of 2 to 5. Other irrigated areas, such as Ar Ruj, the Homs depression and Salamiyah, witnessing groundwater drawdowns between 5 and 10 m since 1950, with locally deeper pumping cones, presented a ratio higher than 1, meaning that groundwater abstraction was lower than the local recharge in 2007.[12]

A second indicator – the ratio between the effective recharge and abstraction – inverted the picture. Effective recharge took into consideration the 'radial inflow', i.e. the groundwater flowing in from the surrounding areas minus that flowing out. This considered the relative position of a particular area within the basin, and its function either as groundwater 'supplier' or 'recipient', distinguishing areas of infiltration and discharge. This indicator showed groundwater abstraction in infiltration areas, such as Salamiyah and the Homs depression, to be problematic, since they supply downstream areas – although their contribution to the groundwater flow is marginal compared to the recharge areas located in the western parts of the Orontes River Basin (Figure 4). Conversely, this indicator showed the areas of Muhardah, Tall Bisah and Al Qusayr to be less critical due to their location in groundwater exfiltration areas.

Based on these indicators, the TNO study made a series of recommendations based on two principles. The first was the general principle of keeping a "positive balance between natural groundwater recharge from precipitation and abstractions" (TNO, 2008: 51). The second pertained to geographical and sectoral priorities for the allocation of groundwater abstraction. Drinking water was given priority in infiltration areas, especially in the eastern parts of the basin where irrigation was to be gradually abandoned. Abstraction for irrigation was only acceptable in discharge areas of the "lower parts of the Orontes Valley close to the river" (TNO, 2008: 61), with groundwater levels < 50 m and positive radial inflow.

The TNO assessment concluded that irrigation was not adversely affecting Al Ghab Graben and could possibly even be intensified. In Ar Ruj Graben irrigation was possible but needed to be controlled. In the case of the Salamiyah area, there was to be a ban on irrigation to secure water supply for domestic purposes. In the other irrigated areas, the study suggested reducing groundwater abstraction for irrigation based on a compromise between the recharge and effective recharge approaches.[13]

Integrated water resource management for whose benefit?

The TNO assessment for integrated water management was commissioned in 2002 – a year after the launch of the baseline studies of the Agropolis, also known as Al Ghab Special Economic Zone (SEZ) project (Syrian Arab Republic and UN, 2010). SEZs were established as part of the economic liberalisation reform led by Deputy Prime Minister Abdallah Dardari, with specific regulation aimed at easing state control of the economy in favour of private investment. Acting as pilot areas, SEZs were an important part of the reform strategy.

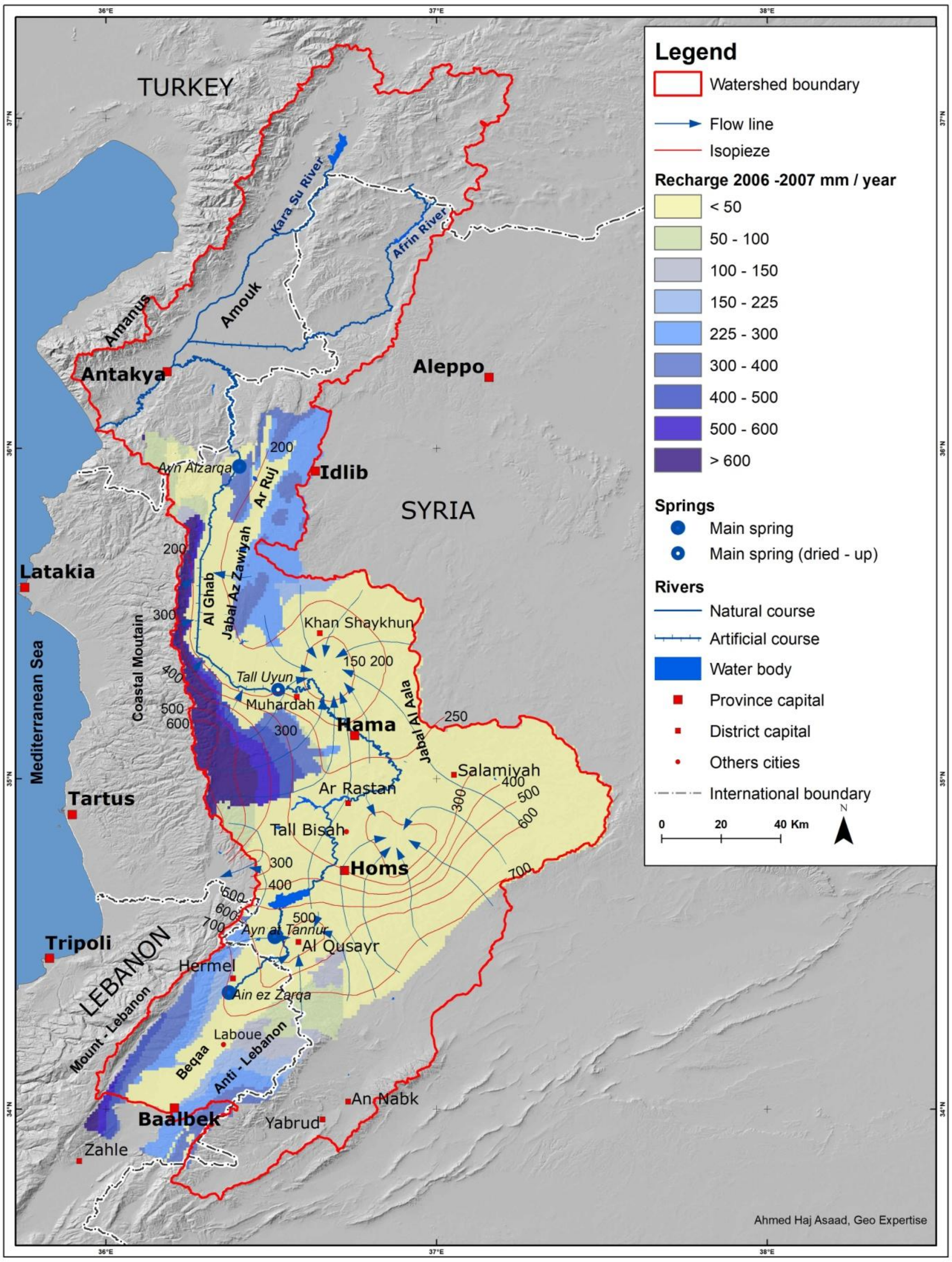
The Agropolis project intended to address Al Ghab paradox: how an area with such potential for agricultural production could have become one of the poorest rural areas in the country. In fact it was the result of several interrelated factors, ranging from the fragmentation of land holdings to insufficient water supply and poor resource management. The TNO assessment provides an answer to the water supply issue by indicating that groundwater availability in Al Ghab irrigation scheme could be secured, while reducing groundwater exploitation in the upstream areas, in particular the dry, eastern areas of the basin. To this end, the assessment recommended a ban on irrigation in the eastern areas to restrict

[12] The local recharge being the water percolating in the irrigated area concerned.

[13] In critical areas, such as Muhardah, Tall Bisah, Khan Shaykhun and Al Qusayr, the assessment suggested halving groundwater abstraction for irrigation.

the use of groundwater resources for drinking water only – a recommendation which comes under scrutiny. Primarily, as the authors themselves admit, the hydrological model employed in the report is not adapted to dry areas. Thus, it is difficult to precisely evaluate the potential increase in water availability in Al Ghab that would result from a ban on irrigation in the eastern part of the basin. What is certain is that it would be detrimental to farmers in the dry areas, despite olive producers making efficient use of water (Saadé-Sbeih and Jaubert, 2012), but the report's groundwater model did not take water-use efficiency into account.

Figure 4. Schematic diagram of the organisation of the subsurface flow, 2007-2008, Lebanese and Syrian parts of the Orontes River Basin.



Source: adapted from Zwahlen et al. (2016) and Al Charideh (2013).

Not all the report's conclusions are so questionable, however. Since the decline in both surface and groundwater availability in Al Ghab irrigation scheme is the result of significant expansion in irrigated areas upstream, the reports suggests reducing groundwater abstraction in the areas of Al Qusayr, Muhardah, Khan Shaykhun and Homs. This would seem to be the first option to be considered as it addresses the main source of the water availability problem.[14] However, reducing water consumption in these areas is a politically sensitive topic – far more so than in the marginalised eastern dry areas. Furthermore, imposing a reduction in water consumption could jeopardise economic development projects requiring water, such as the Homs regional development programme, including the Qattinah tourist resort (Al Baath Universität and HTW, 2010).

A cooperation agreement for Al Ghab development programme was signed in February 2010 between the Syrian government and the United Nations, with the involvement of the UDNP, the FAO and UNIDO (Syrian Arab Republic and UN, 2010). The decline in water availability in the area and various diagnoses of overexploitation of groundwater resources could have undermined the project in the eyes of potential international donors.

A question remains over whose interest the Agropolis project ultimately served. The creation of an SEZ aroused the suspicion of farmers in Al Ghab area and representatives of their union, as, despite documentation stating that they were the intended beneficiaries, the project also stresses the need to restructure the irrigation scheme (Syrian Arab Republic and UN, 2010). With an average holding size of 0.4 ha and the construction of houses on agricultural plots, a restructuring including the reallocation of land rights seemed inevitable. Consequently, there were fears that at least part of the land could be taken over by private investors. Given that the combination of state economic control and the creation of SEZs in the 2000s served crony capitalism (Hinnebusch, 1997; Cammett et al., 2018), the fears were not unfounded. The Agropolis project relied on the private sector for the development of the agro-industrial and tourism sectors. Thus, while the role of private investors in agricultural production was not addressed in the project document it could not be excluded. The issue remains unresolved since the project was frozen in 2011 as a result of the Syrian crisis.

CONCLUSION: POLITICS OF GROUNDWATER OVEREXPLOITATION

The politics of groundwater overexploitation in the Orontes River Basin in Syria can be divided into three overlapping sequences with different approaches to aquifer exploitation: laissez-faire, restricting use and reallocating resources to specific areas. The steady increase in groundwater exploitation – encouraged by a centralised agricultural policy (Barnes, 2009) – was acknowledged by the administration since the 1950s but no regulatory measures were enforced until the mid-1990s. Detailed hydrogeological studies were conducted in collaboration with Soviet institutes during this period but were not used for effective planning purposes. The longstanding laissez-faire policy had both an economic and political rationale. Groundwater became the first source of irrigation water allowing a significant increase in irrigated areas and the production of strategic crops. Politically, tolerating the multiplication of unregistered wells was a way to preserve farmers' interests and support in areas marginalised by the centralised agricultural production plan. In areas benefiting from state-managed irrigation schemes tolerating unregistered wells was a means to compensate for surface water supply and management deficiencies.

The collapse of the Soviet Union opened a new sequence. Hydrogeological studies were significantly reduced but groundwater overexploitation gained momentum in official discourse. Several surveys stressing groundwater mismanagement issues were produced from the mid-1990s until the early 2000s

[14] Following the decline in irrigation since 2011 in the upper and middle reaches of the basin due to the conflict the flow of surface water has significantly increased in Al Ghab Plain. Springs that had dried up in the 1980s have been reflowing since 2013.

with varied results but a common overall diagnosis of groundwater overuse. The vagueness of this diagnosis permitted different responses, conciliating divergent agendas, at the national and international level. As such, the concept of groundwater overexploitation served the Syrian government and international organisations. The former used it to justify a shift in irrigation policy and to identify projects that could benefit from international funding, while the latter used it to promote economic liberalisation reforms, such as the removal of all subsidies on agricultural production and inputs, as recommended in the World Bank irrigated sector assessment commissioned by the Syrian government in 2000.

However, stressing the overall overexploitation of groundwater was counterproductive with regard to projects requiring an increased availability of groundwater for irrigation, such as Al Ghab Special Economic Zone (SEZ). The integrated water management assessment of the Orontes River Basin, commissioned by the Syrian government in 2002, suggested groundwater reallocations. By recommending a reduction in groundwater abstraction in areas to the east and in the upper reach of the basin, it concluded that abstraction could be increased in Al Ghab area, thereby confirming, intentionally or otherwise, the viability of the SEZ as far as water was concerned. Supposedly neutral water management guidelines, relying on assessments of groundwater flows and balances, thus appeared to become highly political.

In the reviews and assessments produced in these sequences, groundwater overexploitation was in turn ignored, ubiquitous and overwhelming but only loosely defined and, finally, historically as well as geographically contextualised. The concept appeared malleable, combining intrinsically linked material and discursive dimensions. The term had no fixed scientific definition but carried a strong emotional content used to justify decisions and actions by Syrian and international actors. Its discursive power also resided in its ability to circulate between diverse technical, institutional and political spheres, at different scales and to serve different agendas. Overexploitation diagnoses and their use in the Orontes River Basin thus revealed multiple rationalities and conflicting interests related to the access to, and allocation of, groundwater resources (Molle, 2009). Yet, while the groundwater overexploitation diagnoses of the late 1990s and early 2000s seemed to match Custodio's description of "more politics than data", the latest diagnosis shed lights on a situation where groundwater politics, policy and data were closely intertwined.

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