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Between Regulation and Targeted Expropriation: Rural-to-urban Groundwater Reallocation in Jordan

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ABSTRACT: In response to rising urban water demand, some regions have reallocated water from irrigation to more valuable uses. Groundwater over-exploitation, however, continues to degrade aquifer quality, and states rarely succeed at stopping overuse. This study asks whether growing urban requirements enable the reallocation of groundwater from irrigation to higher value added uses in domestic and industrial consumption. The paper is based on a series of interviews with policy makers and academics in Jordan, combined with data from remote sensing analysis. The results find that regulatory measures such as tariffs and well licensing have a limited impact on agricultural water use when opposed by a broad coalition of interest groups; instead, a targeted expropriation n a single small area, combined with an expansion of supply, did succeed in reallocating 35 million cubic metres of groundwater. The results suggest that urban water needs do increase state interest in reallocation. That reallocation was successful in only one of the attempted basins suggests that donor-region resistance is a major factor in reallocation outcomes. We discuss the strategy of, for future reallocators, targeting only aquifers with low political and enforcement costs.

KEYWORDS: Groundwater management, water reallocation, water policy, water management, urbanisation, Jordan

INTRODUCTION

As the world's urban population and economy grow, demand for water in urban regions is increasing (World Bank, 2018). It is expected that, by 2050, urban water demand will increase by 80% (Flörke et al., 2018) and the number of urban dwellers living in regions with seasonal water shortages will grow from 500 million (in 2000) to 1.9 billion (McDonald et al., 2011). Padowski and Gorelick (2014) find that 36% of sampled surface-water-dependent cities are in closed basins where surface water is already overallocated among environmental, irrigation and urban demands. Growing needs have created new conflicts between rural and urban water users who are in competition for scarce resources (Garrick et al., 2019; Celio et al., 2010; Punjabi and Johnson, 2018; Hooper, 2015).

Once local supplies are exhausted, directing the water resources of rural regions to urban areas can be an attractive solution for cities (Garrick et al., 2019). 'Water reallocation' is the transfer of water from one sector or region to another, changing the allocation from the initial user to a new user (Marston and Cai, 2016). This paper analyses reallocation of water from rural areas (where water is used for agriculture) to urban areas (where it meets domestic and industrial demands). Reallocation may occur in a variety of ways, including through trading water use permits, setting new regulations, or diverting dam water. As the prefix implies, reallocation makes changes to the previous distribution of access; it "occur[s] when the existing allocation is physically impossible, economically inefficient, or socially unacceptable"

(Marston and Cai, 2016: 1) or, at least, when decision makers see the existing allocation as impossible, inefficient or unacceptable.

Agricultural water is often reallocated to urban use because agriculture is usually the largest consumer of water and yields less gross value added and employment per cubic metre than does domestic or industrial consumption (Schiffler et al., 1994; Rawlins, 2019; Acharyya, 2019). Proponents of the reallocation of groundwater specifically argue that the use of water for agriculture deprives future generations and prevents the water from being used for higher value added purposes; this, they argue, constitutes an implicit state subsidy (Tetreault and McCulligh, 2018; Schiffler et al., 1994).

Proponents of rural-to-urban reallocation have been criticised for overstating its economic gains, as water is rarely a limiting factor for non-agricultural production (Molle and Berkoff, 2009); it has been argued that reallocation of water to urban or industrial uses can in fact threaten the livelihoods of the global poor (Meinzen-Dick and Ringler, 2008). According to Meinzen-Dick and Ringler (ibid), reallocation risks reducing farmer incomes while increasing food prices; the affected farmers, furthermore, may not themselves benefit from growth in the sectors receiving the water. Some case studies advocate compensation for farmers (Komakech et al., 2012; Birkenholtz, 2016); extensive academic work around reallocation therefore focuses on equity and compensation mechanisms (Molden, 2007; Celio et al., 2010; Hoogesteger and Wester, 2015; Hommes and Boelens, 2017; Dai et al., 2017).

Earlier studies have focused on contexts in which urban users[1] are able to strongly influence state decisions (Komakech and de Bont, 2018; Punjabi and Johnson, 2018). Such an urban bias, however, is not universal (Pierskalla, 2016); in some states, farmers may be more influential than are those using water for high value added purposes. In the Texas legislature, for instance, landowners were able to prevent regulation of groundwater pumping until 1998, until forced to do so by the judiciary (Kaiser and Phillips, 1998); Australia's water markets also favour farmers by recognising even their lapsed rights and ignoring interactions between groundwater and surface water (Wheeler et al., 2014); in Yemen, tribal elites successfully oppose any groundwater regulations (Zeitoun et al., 2012), and in Morocco, state-sponsored megaprojects have served the interests of politically connected, wealthier farmers (Houdret, 2012).

Most work on water reallocation focuses on surface water, at least partly because groundwater reallocation is less common (Garrick et al., 2019); surface water reallocation is, in fact, four times more common than groundwater reallocation. There are several possible reasons for the relative infrequency of groundwater reallocation: 1) in the short term, overabstraction (rather than reallocation) offers a more tempting alternative; 2) groundwater regulations tend to be more expensive to enforce than surface water regulations; and 3) farmers in Jordan's highlands do not have surface water that they can use if groundwater is taken away from them.

With regard to the first point, the most important difference between surface water and groundwater, from a regulatory standpoint, is the lag between the overuse of groundwater and its consequences. Aquifers contain much more water than the quantity with which they are replenished annually; because of this, for years or decades, more water can be pumped out than enters without any evidence of shortfall. Most governments set a limit or target abstraction rate based on the hydraulic properties of the aquifer, including its recharge rate; abstraction above this amount is called overabstraction and often results in declining water tables and saltwater intrusion. Short-term overabstraction, however, simply pushes costs onto future generations. Political incentives almost always support greater consumption rather than demand management (Zeitoun et al., 2012; Molle and Closas, 2017); increasing consumption creates short-term growth and employment while a regulated decrease in consumption may induce economic recession, job loss, displeased interest groups, and potential social instability (Shah et al.,

[1] In this text, urban water users are referred to as municipal and industrial (M&I) users. In Jordan most domestic water is supplied by the Ministry of Water and Irrigation (MWI) and the Water Authority of Jordan (WAJ), and national statistics often count them together.

2019). Continued subsidies and tariff protection for groundwater agriculture present the most compelling evidence of these political incentives (Hussein, 2018).

In terms of the second point, that steeper costs are incurred in the enforcement of collective agreements on groundwater than on surface water (Molle and Closas, 2017; Blanco-Gutiérrez et al., 2011), because large numbers of wells are dispersed across the potentially hundreds of square kilometre surface of the aquifer, extensive resources are required in their regulation and monitoring. In the early stages of exploitation of their agricultural potential, many developing states provide incentives to increase agricultural production; this eventually results in an unsustainable rate of abstraction. Controlling such dispersed wells through top-down regulations such as well licensing, tariffs and quotas, however, relies on expensive and questionable data on farm-level water abstraction, although new cost-efficient technical solutions are beginning to been implemented (Sanz et al., 2016). Community governance evades the monitoring challenges but is dependent on specific community characteristics (Molle and Closas, 2017); in Mexico, for example, regulators argued that the impossibility of enforcement resulted in unsustainable concessions being made to industrial and agricultural users (Tetreault and McCulligh, 2018).

This article examines reallocation of groundwater in Jordan from 1997 to the present. It asks whether the changing political context that has emerged from growing urban needs has given rise to more successful reallocation of groundwater. Incentives to strengthen typically lax groundwater regulations could arise from the failures of public water supply in large cities such as what occurred in Amman in the summers of 1998 and 2007; that is, the threat of future urban shortages may overcome the political barriers that inhibit a more forceful state-centred response to aquifer decline.

The article first summarises Jordan's urban supply shortages in the 1990s and 2000s. Second, it reviews a debate between donors, creditors, and elements of the Government of Jordan (GoJ) who supported reallocation from agriculture but disagreed about how it should be achieved: the World Bank proposed volumetric tariffs on all water users, including small farms, in order to close unproductive farms, while Jordanian negotiators proposed an expensive megaproject connecting Amman to distant underutilised aquifers (a hybrid solution combining reallocation with supply expansion). Following this, the article goes on to describe the implementation of the two strategies. Strong political resistance from northern farmers combined with high enforcement costs led regulators to focus on preventing new farm construction rather than reducing actual agricultural extraction. The subsequent section describes the closure of farms in southern Jordan's Mudawarra area in preparation for the Disi pipeline. We then compare the implementation of the two policies, discussing the extent to which they have shaped groundwater policies. We go on to comment on why expensive megaprojects remain popular in Jordan despite the low profitability of groundwater-based farming near Amman. Finally, the article discusses how the political and technical challenges to groundwater reallocation can be overcome.

METHODOLOGY

Interviews for this research were conducted in June and July 2018 and in April through August 2019. We interviewed 18 people; these included Ministry of Water and Irrigation (MWI) staff, academics, NGO staff, and development agency staff. The sample represented a broad cross-section of organisational types related to groundwater reallocation, although farmers were significantly under-represented.

Many respondents did not agree to be quoted or recorded; notes were therefore taken by hand and later transcribed. The interview style was semi-structured, with questions focusing on groundwater demand-management policies, reallocation, the strategies of farmers, and the selection of donor aquifers. We complemented the interviews with a comprehensive review of secondary literature which covered academic writing, media publications, reports from development agencies, and strategy papers directly from the Ministry of Water and Irrigation.

Respondents were aware that many water scholars support rural-to-urban reallocation and may overstate the benefits of this policy option; in order to elicit unbiased comment and thus resolve this problem, all respondents were first asked about the objectives of each policy without mentioning reallocation and only afterward were they asked directly about rural-to-urban transfers. Several policy makers stated that they did not have a rural-to-urban agenda; a donor agency staff working on the Highland Water Forum, for example, stated that they had intended to reallocate between wealthier and poorer farmers through crop selection and that rural – urban conflict had derailed the intended discussion.

POLICY RESPONSES TO RISING WATER NEEDS: POST-1997 DISCUSSION

Reallocation drivers

Already in the late 1990s, both the MWI and Jordan's creditors saw the growing urban demand for water as an important challenge. In a report released in 2001, the World Bank argued that the requirements of Jordan's municipal and industrial sectors would increase by 87% by 2016, that is, from the 342 million cubic metres (Mm^3) needed per year in 1998, to 639 Mm^3. These projections were frequently cited in policy-advocacy papers co-authored by leaders at the MWI; they supported the need for new urban supply policies including groundwater reallocation, and were, as it turned out, accurate to within ten percent of the actual change in consumption. Jordan's actual municipal and industrial (M&I) consumption grew more slowly than projected, but had still increased by 78% by 2016, from 275 Mm^3/yr in 1998 (World Bank, 2001) to 490 Mm^3 in 2016 (FAO, 2020). The absolute increase in consumption was 215 Mm^3/yr, nearly a quarter of Jordan's total water usage in 1998.

For decades in Jordan, M&I has consumed primarily groundwater (Nortcliff et al., 2008; MWI, 2016; MWI, 2017: 11). Already by 2001, however, the aquifers that Amman had been relying on were in a state of overdraft (World Bank, 2001). The Amman-Zarqa aquifer was being abstracted at 215% of its mean annual recharge rate (MWI, 1997, quoted in Venot and Molle, 2008). This overdraft was caused by both M&I and highland agricultural use. Wells operated by the Water Authority of Jordan (WAJ), an implementing body of the MWI, had started to fail in the Amman-Zarqa aquifer. In 1998 and 2007, algal blooms in a water treatment plant reduced supply to parts of Amman for weeks (Interview No. 9, MWI policy maker); the shortages prompted public displays of discontent with the government.

Alternatives to reallocation

In the 1990s and early 2000s, policy makers at the MWI, USAID Jordan, and the World Bank described in detail the available policy responses (Scott et al., 2003; Chebaane et al., 2004; Pitman, 2004; El-Naqa and Al-Shayeb, 2009); alongside intersectoral reallocation, they considered wastewater treatment, water use efficiency, transboundary negotiation, and supply augmentation, each of which Jordan attempted but none of which entirely removed the need for reallocation.

Water reuse was widely implemented, primarily through the treating of wastewater. By 2014, Jordan was recycling 123 Mm^3 of water per year, and the MWI has projected that by 2025 the flow will reach 240 Mm^3 (MWI, 2016). Treated wastewater (TWW), however, which in the Jordan Valley is mainly used by the agricultural sector, conflicts with local religious and cultural norms (Interview No. 13, an academic), making it unpopular among agricultural and domestic consumers.

Increasing the efficiency of both irrigation and municipal water use is widely proposed (Pitman, 2004; Scott et al., 2003); increasing the water efficiency of farms, however, is not likely to produce savings that are usable for domestic consumption as it encourages farmers to expand into the desert (Zeitoun et al., 2012; Perry et al., 2009; Salman et al., 2018). (Increasing urban efficiency could alter Jordan's reallocation drivers, but that question is beyond the scope of this paper.) In writing and interviews, policy makers highlighted the importance and success of efficiency improvements while arguing that those gains would not obviate the need for reallocation; similarly, Jordan's transboundary water policy has not strongly affected the reallocation drivers, partly due to the challenge of including groundwater in negotiations (Zeitoun et al., 2019a, 2019b).

Buying out farmers who use the northern aquifers was occasionally discussed by pro-reallocation actors but this did not reach the implementation stage. The reasons for this non-implementation were, first, because buyouts would be prohibitively expensive (Interview No. 9) and, second, because buyouts would displace the rural poor and would thus result in rural poverty and urban migration, which are key concerns highlighted by Jordanian policy makers (Interviews with MWI staff). Buyouts, furthermore, required trust between the government and northern farmers and effective surveillance of farmer adherence to agreements. Because land is not a limiting factor to agriculture in most of the highlands, buyouts or some water market designs could incentivise further water grabbing by new farmers (Molle et al., 2017).

Arguments for groundwater reallocation

From the point of view of the MWI, the World Bank and USAID, groundwater policies reducing agricultural abstraction were necessary if Jordan's M&I requirements were to be met, although many social actors, including the Ministry of Agriculture and the parliament, opposed reallocation (Zeitoun et al., 2012). The World Bank, the MWI and USAID all argued that efficiency increases and surface water reallocation alone were unlikely to make up for the decline in fresh groundwater and rising demand (World Bank, 2001; Scott et al., 2003).

The World Bank wrote in its 2001 Water Sector Review Update that,

> [i]rrigation use of Disi groundwater was to be reduced (…). Government policy calls for a massive reduction in abstractions by highlands pumpers. The bulk of the projected reduction in abstraction of renewable groundwater – by 86 Mm^3/yr until 2010 and by a further 36 Mm^3/yr until 2020 – will have to come from *reduced abstraction from highland agriculture* (World Bank, 2001: 8; emphasis added).

The World Bank's assistance evaluation was still more explicit:

> Increasing groundwater withdrawal is contrary to government's stated policy. (…). However, this intent is thwarted by an unwillingness to apply regulations for agricultural water use which has led to excessive withdrawal for agriculture. Not only is this in direct competition with urban consumers, it also increases pumping costs (…). The only way to cut the overdraft is to reduce agricultural use and increase water use efficiency. (…). [T]he current system of prices is too low (Pitman, 2004: 8).

The same document goes on to argue that urban users and agricultural users should pay the same (higher) price for water. An MWI policy maker who was involved in these negotiations stated that, "[t]he idea of the World Bank and the international organizations to solve the water problem [was] to take the agricultural water".

Although the MWI disagreed with the methods of reallocation proposed (as discussed below), they did agree that some reallocation was necessary. A scientist at the MWI stated that, "[t]he ministry does not like to use the water for agriculture. We are a Ministry of Water and Irrigation, but our main target is to provide water for domestic use" (Interview No. 11). The 2003 publication, *Facing Water Scarcity in Jordan*, which Hazim El-Naser co-authored while MWI minister, emphasised the costs to stability and to the rural poor of reallocating groundwater out of agriculture, though it supported reallocation in vague terms. The MWI supported a different strategy of reallocation (Macoun and El-Naser, 1999: 107; Interview No. 9, MWI policy maker); in general, it was more concerned about the side effects of reallocation than were the World Bank or donor agencies, although it still found some forms of it necessary.

Most of the donor community supported the World Bank position. USAID's deputy director for the Water Resources and Environment Office wrote in a scathing report in 2008 that, "[the fact that] 63% of fresh water supplies go to agriculture demonstrates a conscious (…) GoJ decision to short [i.e. neglect] domestic and industrial water, regardless of health and economic implications" (Hagan, 2008); the document also implies that Hazim El-Naser, having left the MWI in 2005, should be reappointed. The German development agency, GIZ, and the Food and Agriculture Organization (FAO) have both also released documents supporting reallocative policies (Mesnil and Habjoka, 2012; Salman et al., 2018); also in interviews conducted by Zeitoun et al. (2012), donors were found to express their support of reallocation

Many other interest groups nevertheless remained strongly opposed to reallocation (Keulertz, 2014; Hussein, 2018; Zeitoun et al., 2012; Hagan, 2008; and almost all interviewees); these included agricultural elites, farmers, the Ministry of Agriculture and perhaps the public (Zeitoun et al., 2012). Powerful political families with interests in agriculture also resisted both discussion and implementation (Keulertz, 2014; Hussein, 2018), and the parliament, which was disproportionately drawn from rural areas, opposed increases in tariffs and tariff collection (Yorke, 2013, 2016; Hussein, 2018); families within the 'shadow state' (such as the Masri family) strongly opposed response plans despite urban water shortages (Keulertz, 2014; Hussein, 2016).

For the World Bank, the MWI and most donor agencies, the urban supply issues necessitated policies to constrain the agricultural use of groundwater for the express purpose of protecting or increasing M&I supply; despite this consensus, however, there was strong disagreement about how water should be reallocated and, critically, who should be dispossessed.

The 1997 law introduces water tariffs

In 1997, at the insistence of the World Bank and the German Kreditanstalt fur Wideraufbau Bankegruppe (KfW), a new water bylaw was passed as a condition for the approval of new loans. The law imposed a tariff on highland groundwater agriculture and terminated produce price controls, wheat subsidies and pastoralist subsidies. Despite these sweeping policy changes, the Jordanian government continued to protect inefficient agriculture (Pitman, 2004; Hussein, 2018).

The water fee was a key area of contention, as creditors requested amounts high enough to incentivise reduced agricultural water use. The GoJ refused to raise the tariff above JOD (Jordanian dinar).025 (US$.03) per cubic metre, prompting the KfW to cancel a portion of their loan. After the 1997 tariff law was passed, farmers successfully lobbied the GoJ to amend the law so as to increase their allowance of free water to 150,000 m^3 per year (Venot and Molle, 2008); this generous free quota directly contradicted the intent of the law by protecting unprofitable farms. Over the following decade, tariffs were relaxed and sporadically enforced. USAID and the World Bank both perceived the lack of implementation and further reform as constituting mismanagement and as abandonment of the critical need for reallocation. The mounting need and perceived inaction set the context for the following policy debate within the pro-reallocation groups.

Reallocation by incentive in the northern highlands

The World Bank and USAID both pushed for further liberalisation of the water sector. With fuel subsidies removed and a tariff on all groundwater use, unprofitable farms would close; this would reduce aquifer overdraft and thereby increase M&I supply. Three main types of policies were recommended: the removal of direct and indirect subsidies for irrigated agriculture in the highlands; the application of volumetric tariffs for farms to internalise the future costs of overpumping; and the outlawing of new wells for agriculture. We refer to this suite of policies as the incentive solution because it aims at increasing the cost of groundwater for farmers and decreasing their subsidies and protections. The clearest statement of this position was made by the World Bank:

> [Overdraft reduction] is thwarted by an unwillingness to apply regulations for agricultural water use which has led to excessive withdrawal for agriculture. (…). [T]he only way to cut the overdraft is to reduce agricultural use and increase water use efficiency. The most effective way to do this is through pricing (Pitman, 2004: 7).

Advocates of the incentive solution supported reducing energy subsidies and phasing out protective food tariffs and immigration visas, which constitute indirect subsidies to agriculture. Farmers are often granted visas to import Egyptian migrant workers, who provide cheaper agricultural labour or can be loaned to urban construction for a fee (Al Naber, 2018).

Advocates of this policy most frequently cited economic arguments for reallocation (Pitman, 2004; World Bank, 2001; Hagan, 2008), specifically the low economic value of the agricultural sector. Because the northern aquifers of Azraq, Amman-Zarqa and Yarmouk have large rain infiltration, they are renewable and thus can serve indefinitely as a stable, energy-cheap supply for Jordan's M&I needs. As the World Bank pointed out, the GoJ would not need to spend hundreds of millions of JOD on megaprojects like the Disi pipeline or the Red Sea-Dead Sea Water Conveyance if agricultural water use were significantly reduced; furthermore, allowing Jordan's only renewable aquifers to be degraded reduces Jordan's future options and will potentially require energy-intensive megaprojects later on. Advocates of reallocation have also argued that farm shutdowns are inevitable as salinisation and energy costs make farming increasingly uneconomical (Hagan, 2008).

Reallocation by targeted expropriation and megaprojects in the south

The MWI sympathized with the donors and creditors argument but felt the policy was too extreme in its effect on farmers. They instead proposed the Disi pipeline – which the GoJ had begun advocating in the 1990s (Schiffler et al., 1994) – as both a reallocation and an expensive way to enhance supply. In 2003 the MWI under Hazim El-Naser submitted a loan proposal to the World Bank for the construction of a pipeline from Jordan's far south Disi aquifer to Amman, for M&I use. The project was intended as a supply enhancement in that it would increase abstraction from the aquifers by 40 Mm^3/yr from its inception; it was also a reallocation as the MWI proposed to shut down all farming in the area and redesignate 60 Mm^3/yr of water from inception. The pipeline would therefore reduce the pressure to reallocate in both the Northern Highlands and the Jordan valley (Macoun and El-Naser, 1999).

In the 2004 proposal, the MWI promised to shut down all agriculture in the southern desert in order to compensate for increased pumping to northern cities (Interview No. 9, MWI policy maker). The 2004 proposal summary contains two Sankey diagrams that show the rerouting of all southern aquifers to M&I uses; they also describe large farm concessions as being a threat to the aquifer and imply that these will be dealt with. The actual statement that the farm concessions will be closed down is found on page B-118 of the full proposal. Macoun and El-Naser (1999: 114) conclude their proposal with two statements that justify the Disi expropriation solution over the incentive solution:

> In the face of resistance of well owners by Government to meter and regulate water use, would a strategy based on a more cooperative approach have any greater prospect of success? (…). In a situation where water throughout the arid Middle East is allocated by administrative decree rather than pricing and market forces, how should policy best move increasingly limited water resources away from traditional low value agriculture toward more economically productive uses?

That same Sankey diagram implied that water for highland irrigation should be reduced only marginally. By replacing half of highland groundwater with treated wastewater substitution, only a 10% reduction would be needed. The implication was that the pipeline would substitute for flows from northern aquifers to the urban sectors, which would bring them into sustainability without a major reduction in highland farmer water use. While they still intended to enforce a weaker version of the incentive solution, the MWI felt that a major reduction was either unrealistic or undesirable or both in the Northern Highlands, but not the Disi region.

This statement raises the question of why the MWI targeted much stronger policies toward the southern desert and if those policies outperformed the World Bank proposal.

IMPLEMENTATION OF THE INCENTIVE POLICIES

After the reappointment of Hazim El-Naser in 2010, which was supported by USAID and other donors, the MWI intensified its efforts to reduce or constrain agricultural abstraction in the northern highlands; in this, the MWI received technical assistance from USAID and GIZ and political support from the Prime Minister. Despite the stronger response and political support, the MWI remained unwilling or unable to close farms through tariffs and licenses and instead focused on ensuring fees are paid. Enforcement of constraints on agricultural abstraction of water has focused on preventing the expansion of farming.

The reader may be surprised that the MWI's senior leadership, despite preferring the pipeline, has attempted to implement licensing and tariffs in the north; in this, it is likely that the funding requirements of the pipeline and the WAJ's poor financial situation have played a role and that donor pressure and the personal commitment of the minister were also influential. Furthermore rapid expansion of agriculture, particularly into Jordan's deep aquifers, continued to threaten urban water supply (Interview No. 1 MWI policy maker).

Characteristics of northern highlands aquifers

All of Jordan's renewable aquifers with MWI-defined safe yields above 20 Mm^3/yr are found in the northern highlands (Molle et al., 2017). The most important basins are the Yarmouk Basin in the far north, the Amman-Zarqa Basin which runs from south of the capital to the Syrian border, the Dead Sea Basin south of Amman, and the Azraq Basin in the desert east of Amman. Much of this region has seen declining water tables and increasing salinity rates caused by overpumping. A US geological survey (Goode et al., 2013) projected that average saturated aquifer thickness would decrease by 30 to 40% by 2030 and that it would reach 0 in 5% of evaluated locations; these are trends that have affected both farmers and the well-drilling staff of the WAJ for decades, with a farmer even interrupting our interviews at the MWI to discuss his multiple well failures (Interview No. 11, MWI policy maker).

Due to their distinct agricultural history, the northern highlands have many small- and medium-sized farms that are owned by elites and non-elites; northern farmers also have a closer cultural relationship with farming than do the Bedouin in the Disi area. The highlands have a long history of agriculture which, until the 1960s, was primarily rainfed fruit trees (Al Naber, 2018). From the 1960s to the 1990s, the state supported the settlement of the Bedouin and their increased involvement in agriculture. A boom in production and profit in the 1990s was supported by a combination of low energy costs, improved well-drilling, cheap and fertile land and cheap Egyptian labour (Elmusa, 1994); agricultural profitability, however, has since declined. Interviewees in the MWI and Jordanian academia emphasised the socio-economic diversity of farmers, particularly the presence of small, marginally productive farms; this diversity has been confirmed in the Yarmouk and Amman-Zarqa Basins by Venot and Molle (2008; though data collection was in 2003), and more recently by Al Naber (2018) and Mesnil and Habjoka (2012). Farmers are divided between 'prestige farms' that are usually growing unprofitable olive trees, small Bedouin vegetable growers, and large farms with higher margins that produce cash crops such as grapes, stone fruit and alfalfa. The authors have personally observed Bedouin shepherds to be a constant feature of the landscape, though they are under-represented in official statistics.

Limited regulation in the Jordanian highlands, 1997 to 2010

From 1997 to 2010, the tariff and licensing system rapidly deviated from that envisioned by the World Bank. In 2004, tariffs were reduced when current well owners were granted a generous quota of 150,000 m^3 before the charging of fees began, and a 92% fee reduction for the next 50,000 m^3. From the MWI's perspective, the fee reduction appeased the lobbying farmers, induced them to register their wells, and prevented mass non-payment. The MWI successfully lobbied to have the discount partially reduced in 2018 (Interview No. 9, MWI policy makers).

These low fees and high quotas meant that even if fees were collected, they would not cause significant water savings (Venot and Molle, 2008). The World Bank advocated for tariffs with no quotas to drive the most unproductive crops (often olive trees) out of production; the generous quotas, however, effectively exempted the most unproductive farms as the larger farms tended to be more profitable and tariffs fell on the larger, more productive farms. Modelling by Venot and Molle showed that if the fees are paid at their full rate, farmers can maximise profits by expanding the cropped area, a perverse incentive. While tariffs were intended by the World Bank to close small, unprofitable farms, these farms are protected by the quotas; large farms, on the other hand, are too profitable to be affected, meaning that medium-sized farms benefit from expanding, assuming that fees are in fact collected. Expanding the area under production and increasing efficiency, however, in practice tends to increase groundwater depletion; while water which is wasted on an inefficient farm often falls back into the aquifer, greater efficiency without a reduction in consumption increases profitability while degrading the aquifer more rapidly. Perversely, this early quota system therefore exempted small, non-profitable farms while profitable farms could respond by increasing aquifer depletion.

The volumetric tariff system became increasingly complicated, with new exemptions applying to wells that were registered at different times; in 2014, Al Naber found five different legal categories for wells, each with their own quotas and tariffs (Al Naber and Molle, 2017). This Kafkaesque system resulted partly from the need to constantly create new incentives for registration, as the number of wells is too high to police without some cooperation. These quotas and registration timelines gave generous exemptions and free quotas to wells registered before earlier deadlines; wells that had been registered more recently, or were unregistered, paid higher fees and had lower, or no, free water allowances, resulting in much higher bills that could close farms if collected (Interview No. 6, MWI staff).

Implementation was sporadic, at least until 2012. This lack of implementation resulted partly from social pressures inside the ministry, as anti-reallocation actors opposed pro-reallocation discourse (Zeitoun et al., 2012). The MWI only assigned an employee to collect fees in 2005 (Venot and Molle, 2008) and, as of 2006, only 25% of farmers in the eastern part of the Amman-Zarqa Basin were paying any bills (Molle et al., 2017); negotiations led to a reduction of arrears to 30% of their value in 2010 (ibid). Every investigation describes tampering with volumetric meters by farmers as routine (Al Naber and Molle, 2017; Al Naber, 2018; Hagan, 2008; Venot and Molle, 2008). USAID staff reported that water sector officials refused to discuss the incentive solution for fear of their careers (Hagan, 2008). Lax implementation led USAID to openly discuss withdrawing donor support in Jordan's water sector (ibid).

Strengthened regulations and the illegal wells campaigns

In 2012, Abdullah Ensour was appointed prime minister and Hazim El-Naser was reappointed head of the MWI. With Ensour's support, El-Naser intensified the enforcement of licensing and tariffs and publicly confronted anti-reallocation elites within the state. Despite this political support, the new campaign did not match the World Bank's vision for reallocation in which low-productivity farms would be forced to close. Instead, preventing the spread of agriculture and extracting tariffs remained the main strategies; even, so, farmers have continued to resist and circumvent the tariffs and licenses and the area under crops has continued to increase.

After 2012, protecting highland groundwater for future M&I uses was at least able to be openly discussed in the MWI. Hazim El-Naser advocated for reductions in water use in television advertisements (Al Naber and Molle, 2017). Criticism of the MWI by the parliament led to an exchange of gunfire between gendarmes protecting El-Naser on the way to close a well (Interview No. 9, MWI policy maker). Hani Mulki, appointed prime minister in 2016, was less willing to defend the MWI's policy (ibid). Despite the departure of Ensour and El-Naser, in 2019 interviews, all management-level MWI staff spoke about protecting drinking water (referring to the M&I supply). In contrast to Hagan's (2008) description of sanctioned discourse, the bounds of acceptable discourse did shift permanently.

In 2013, the MWI began a well-publicised campaign of shutting down illegal wells and fining farmers for violations (Al Naber and Molle, 2017); the following year, the MWI added a new category of illegal wells with a higher tariff of JOD.035 (US$.04)/m^3 and no quota. The MWI began denying other government services to farmers with outstanding debts, such as the ability to sponsor visas or register land sales; they confiscated drilling equipment caught operating without a license and published the names of delinquent well owners in order to embarrass them into paying. According to Al Naber and Molle (2017: 138), "the Minister has decided to use dynamite to close wells, to ensure that they cannot be used again, while ordering pictures to be taken for each case".

Farmers resorted to ingenious and diverse strategies for resisting the government's determination to reduce agricultural water use: they applied for well-cleaning licenses, then used them for deepening and drilling; they transferred water by pipe between farms to disguise its origin; they increasingly tried to bribe and intimidate, to the extent that one farmer attempted to bribe an MWI scientist on a fact-finding mission (Interview No. 11, MWI staff); one farmer even went so far as to hide a well beneath his bed (Al Naber and Molle, 2017). Resistance to the policy also increased at the lower levels of the WAJ, with lower-level basin officials refraining from reporting new wells to protect them (Personal communication, 2018).

Despite the stronger enforcement of policy on illegal wells, the MWI did not transform the negotiation of water tariffs to reduce agricultural use during the terms of Nasser (2011-2018) and Ensour (2012-2016). Volumetric meters became less useful in the 2010s due to both tampering and the logistic challenges of checking thousands of meters; instead, water usage came to be calculated via a table of crop types and water requirements per area, which was created by the Ministry of Agriculture. The local WAJ office sends engineers to measure (or estimate, given their time constraints) the cropped area for each crop; the area figure is then multiplied by the values in the table. It is well known by staff of the WAJ and the MWI that this table systematically under-reports water use.

In 2018-2019, the USAID-funded Water Management Initiative (WMI) taught MWI and WAJ staff remote sensing for water accounting. The WMI measured water use in the Azraq aquifer using the Surface Energy Balance Algorithm for Land (SEBAL) for evapotranspiration (ET), a technique which calculates crop water use from surface temperature, albedo and air temperature (Sanz et al., 2016; Gobbo et al., 2019). The study found that the official MWI figures The study found that the MWI had underestimated farm water use in the Azraq basin by 25 Mm3 and that, rather than 35 Mm3, the actual water-use figure was 60 Mm3. (Personal communication). According to the MWI, the safe yield of the aquifer itself is 25 Mm^3. Because SEBAL relies on surface energy balance, it accounts for under-irrigation, as is common on unprofitable farms (Al Naber, 2018); their estimate was five standard deviations from the ministry estimate. Were it implemented, the remote sensing technique would both raise fees and more accurately assess water use; water accounting using SEBAL-ET in Spain was found to have a cost of €6.6/km^2 (Sanz et al., 2016).

As of 2019, however, remote sensing was not being implemented for water accounting (Interview No. 6 MWI staff). The current system allows several actors to control recorded water use: the Ministry of Agriculture, which sets the crop-area-to-water conversion table; the field staff who measure usage; and the basin managers who forward the information to the MWI (Interview No. 6 MWI staff). Each of these actors can reduce or exempt fees, which they are most likely to do as a form of social relief. Remote sensing is instead being redirected towards identifying hotspots of increasing water use, identifying new illegal wells, and gross undercounting of water use. When asked why not calculate fees using the SEBAL-ET instead of the crop table, one basin manager stated that, "I cannot use the remote sensing data without violating regulations of the Ministry of Agriculture. We recommended [changing to remote sensing] (…), if they do not want to listen that is another thing" (Interview No. 7 MWI staff). Another staff member responded that, "there would be a revolution (*thawra*)" (Interview No. 9 MWI staff); it is unclear if he meant that farmers would simply stop paying the tariff entirely or that there would be general political instability, or both.

Evaluating tariffs and licensing as reallocations

Government records show reductions and stagnation in groundwater extraction for irrigation (Interview No. 6, MWI policy maker); these records, however, contradict independent studies that find a consistent, decades-long expansion of the area under crops. Distortions in the data were most likely caused by top-down pressure on basin managers, who lack the tools or mandate to dramatically change farmer behaviour (Molle et al., 2017).

None of these changes are designed to close existing unprofitable farms, with the exception of illegal recent entrants. Since 2004, quotas and tariffs for farms registered prior to several benchmark years have not increased; this includes most farms in the Amman-Zarqa Basin, which has the highest recharge rate and is being exploited at 190% of its safe yield (MWI, 2017). Both the strengthening of the MWI in 2012 and the introduction of remote sensing technology resulted primarily in policies that targeted illegal wells and non-payment of fees. The 2014 law created a tariff of JOD.035 (US$.04)/$m^3$ for the most recently registered wells; this steep penalty was intended to scare farmers into registering their wells and to deter new entrants. This tariff is less than the original World Bank proposal, without counting for inflation; it is also 10% of just the energy costs of Disi water. Ultimately the effect of the policy is to slow or stop the expansion of agriculture and not to close unprofitable farms. As one MWI staff member answered when asked if wells are being closed,

> I don't think there are closing of wells in Jordan, even if these wells are illegal. If the government finds illegal wells, all the government can do is turn it over to the courts. (…) I have never heard of any [completely drilled and in use] wells being closed except in the Disi area. (Interview No. 1 with MWI policymaker)

Since 2012, the MWI has been strengthened politically and technically, but it has never adopted the World Bank plan of closing unprofitable farms. Either the pro-reallocation camp in Jordan is not interested in closing farms or they cannot build a strong enough coalition to do so. Interviews with ministry staff supported both explanations, with one quote summarising a repeated theme:

> When you talk about water we are also talking about rural livelihoods. (…). [I]t's hard to make a targeted policy to reduce export agriculture (…), the policies may end up on poor people and not on the exporters. If you have a lot of poor people that you are fighting [for their] livelihoods, then you will have a difficult time coming to an agreement and making policies (…). We do want to use the "water for the most valuable thing, but you also need to protect these communities" (Interview No. 11 with MWI staff).

The MWI as an institution is hesitant to close unprofitable farms, as doing so would encounter stronger political opposition. In the Highland Water Forum, for example, farmers struck down a resolution to study, "closing down unfeasible agricultural investments regardless of their legal status"; they amended it to describe only regulation violators (Highland Water Forum, 2013: 8). Profitable farms, which tend to be legal (Interview No. 9, MWI policy maker), were expected to survive the original World Bank tariff of JOD.06 (US$.07)/$m^3$, assuming they are asked to pay the full tariff.

In 2012, three factors could have explained why tariff and licensing policies had not closed farms, reduced agricultural water consumption, or prevented its increase. First, few relevant policy actors were affected by the problems of urban supply (expense, poor quality, rationing and future supply shortages); the pro-reallocation group was thus unable to launch strong demand-management policies. Second, lack of interest from the leadership of the state, particularly the Prime Minister, resulted in weak regulations (Hagan, 2008). Third, enforcement of licensing and tariffs faced steep practical challenges and high transaction and political costs.

Based on information accrued during the last seven years of enforcement, we can now identify the most important factors. The fact that after 2012, under Abdullah Ensour and Hazim El-Naser, the MWI made progress on deterring illegal farms and incentivising efficiency rather than closing non-viable farms, suggests that the personal investment of senior state administrators was not the deciding factor; if the deciding factor was in fact enforcement cost, then the SEBAL-ET system could have been used for water accounting rather than identifying illegal wells. Ultimately, the main reason that strong policies to close unprofitable farms and in that way reduce overabstraction in the highlands did not occur was the government's refusal to create unemployment and close farms in that area. The evidence suggests that the critical factor was resistance from both local implementers and other government bodies such as the parliament and the MoA. This result agrees with Yorke's (2013) theory that the monarchy has built a network of mutual dependence with highland landowners which is expressed through landowner appointments to ministries and their over-representation in the parliament; this mutual dependence prevents the monarchy from acting directly against the interests of highland farmers as the highland solution requires (ibid). The monarch has responded to urban water needs by imposing tariffs on farmers and shutting down some new illegal farms, but it has not changed incentives enough to reduce abstraction.

IMPLEMENTATION OF THE DISI REALLOCATION

This section argues that reallocation by expropriation in the south succeeded in transferring a significant amount of water (at least 30 Mm^3/yr) from agriculture to M&I use. First, we summarise the history of desert agriculture on the Disi; we then describe the conflict between the MWI and water users in Mudawarra which led to the farm closures in 2013. We use remote sensing to show that the shutdowns did occur and have continued but that several farmer groups were exempted. Finally, we discuss the role of urban water needs in farm shutdowns.

Context

The Disi aquifer is a fossil aquifer in Jordan's southeastern desert. It straddles the Jordan – Saudi border near the tourist destination of Wadi Rum; it also extends deep into Saudi Arabia as part of the Rum-Saq-Tabuk system, where it has enabled large-scale desert agriculture (Salameh et al., 2014). The aquifer lies near the surface, which keeps pumping costs low, and it has low salinity which makes it attractive to users (Vengosh et al., 2009). Exactly how much water can be pumped from the Disi aquifer for how long is subject to debate, but estimates in the MWI's public statements range from 80 Mm^3/yr for 50 years to 100 Mm^3/yr for 200 years (Ferragina and Greco, 2008; Salameh and Gedeon, 1999).

In 2008, a team led by researchers from Duke University found that while the water is chemically pure, it contains active radium isotopes in concentrations that are 10 to 20 times in excess of EU guidelines (Vengosh et al., 2009); the radium is most concentrated in the Mudawarra (confined) section. The annual effective dose from using groundwater in Maan and Aqaba (which include the Disi) is 2.2 millisievert per year (mSv/yr) (Alomari et al., 2020), which is six times higher than the average in northern highlands groundwater (ibid). In practice, the MWI mixes groundwater and surface water to disperse the dose, resulting in a dose of 0.4 mSv/yr (El-Naser et al., 2016). Mixing most likely does not reduce the total number of cancer cases but disperses them across a broader population (Vengosh et al., 2014). Alomari et al.'s dose-to-risk formula suggests that using Disi groundwater, rather than northern groundwater, for domestic consumption increases the lifetime cancer risk for Amman's residents by several thousandths in absolute risk (Alomari et al., 2020). The MWI was aware of the higher activity of Disi water by 2006 (El-Naser et al., 2016).

In 1984, the Government of Jordan granted four agribusinesses licenses to rent land on the Disi, renewable by the Ministry of Finance every five years; until then, the water had been used solely for the M&I needs of nearby Aqaba and by small farming projects growing produce for the local market. The concessions were originally intended to increase Jordan's food independence and imitate successful projects in Saudi Arabia (Yorke, 2013), and possibly to establish a prior claim on the shared resource (Ferragina and Greco, 2008). The contracts required that half of the rented land be used for wheat and barley; by the 2000s, however, it was exclusively used to produced cash crops for export (Yorke, 2013). No sources documented the total land area being rented; the contracts did not limit extraction nor did they establish any monitoring system, though annual extractions of 65 to 80 Mm^3/yr are commonly quoted by ministry staff. Most interviewees expressed a suspicion that, given the lack of independent monitoring, actual extraction was actually higher. By 2013, the water table in the confined Disi had dropped by 25 metres (Salameh et al., 2014).

The concessions are owned by four well-known private families that trade support for the regime for policy influence and preferential treatment (Yorke, 2013). The Masri family has the largest concessions on the western part of the aquifer near Disah city and the locally owned farms. The three other concession holders operate farms in a shallower section of aquifer far to the east of Disah city; this area is called Mudawarra or sometimes, due its geological features, the 'confined Disi'. These three Mudawarra farms lack a large local population so they depend almost entirely on Egyptian migrant workers (Interview No. 9, MWI staff).

According to Keulertz (2014: 271), the largest concession holder, the Masri family, had privileged access via shares in the Arab Bank that they had been granted by the monarchy. Each agribusiness was associated with an influential family which used political appointees to support their resource access (ibid). Former Prime Minister Adnan Badran was a shareholder and supported his agribusiness in a tax dispute, creating a public scandal (Yorke, 2013). Yorke described this pattern as,

> special interest groups [that] were able to use their personal positions to lobby for access to water for their farms – which provided employment for their followers, to manipulate political ties to the centre, and (…) forge coalitions with citizens who would otherwise oppose their interests (ibid: 68).

Yorke's description suggests that the three concession holders in Mudawarra were more vulnerable to expropriation because they lacked a base of non-elite supporters.

Farm closures and the Disi-Amman Conveyance

By the start of construction in 2008, it was clear that sharing the aquifer between agricultural and M&I consumption would undermine the return on the expensive investment by exhausting the aquifer earlier. The fresh water in Disi, where the MWI eventually placed wellfields, lies underneath the saline Khreim aquifer, which may leak into the freshwater. The MWI's estimates of aquifer volume were contested by geologists who suggested lower estimates (Salameh et al., 2014). As the MWI was already putting forward exaggerated claims that the aquifer could supply 125 Mm^3/yr for 50 years, sharing the aquifer with agribusinesses that were extracting 70 to 80 Mm^3/yr would jeopardise the billion dollar investment.

Jordan launched a construction tender call for the Disi to Amman conveyance project in 2001 which was unsuccessful due to low funding (Ferragina and Greco, 2008). The farm concessions expired in 2002 but were renewed by the Ministry of Finance; this showed a lack of commitment to creditors, which was sorely needed after the tariff conflicts (Pitman, 2004). In 2006, the bid for the water conveyance was relaunched and a contract was finalised with GAMA Energy for US$ 1 billion which did not including operation and maintenance. Much of the funding came from Jordan's creditors, not including the KfW and the World Bank (Arab Banking Corporation, 2009); the United States provided US$ 250 million from the Overseas Private Investment Corporation (Development Finance Corporation [formerly OPIC], n.d.), L'Agence Française de Développement (AFD) and its subsidiary Proparco together provided US$ 150 million (AFD, 2020), and the European Investment Bank loaned US$ 166 million (European Investment Bank, 2009). At least US$ 100 million was loaned by the Social Security Company of Jordan (Ferragina and Greco, 2008).

In 2008, the government offered the four agribusinesses farmland in Sudan that had been acquired by a military-owned company; the offer, however, was turned down (Keulertz, 2014). In 2009, the government committed publicly to withdrawing the farm concessions, only to renew them a year later (ibid). In 2013, with the completion of construction of the pipeline the farms operating in the Mudawarra area were forced to close after lobbying by Hazim El-Naser with the support of Ensour. According to an MWI policymaker, "No one wanted to cooperate [with the shutdowns]. Not the Ministry of Finance, not the Ministry of Agriculture, because they think supporting farmers is their mandate, the influential farmers. [Those opposed to the shutdowns] knew everybody and they kept hammering [aggressively lobbying]" (Interview No. 9).

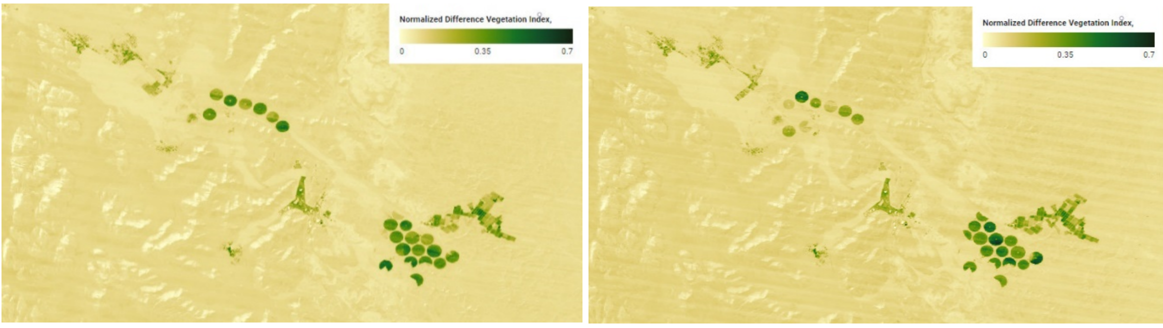
As of 2019, the farms remain closed (Figure 1), although the Masri farms in the west were mandated to reduce consumption but not close completely. Despite the long delays in implementation, Mudawarra is the most impactful groundwater reallocation project in Jordan. The GoJ further demonstrated its commitment through a 2015 agreement with Saudi Arabia that banned agriculture both in Mudawarra and in an area reaching some 40 kilometres south into Saudi territory (Eckstein, 2015).

The pipeline was both supply enhancement and reallocation. The MWI stated that water extraction before the shutdowns was 30 to 35 Mm^3/yr; staff noted, however, that this number comes from the companies themselves, who had strong incentives to underestimate consumption to keep tariffs and public pressure low. The WMI SEBAL-ET study in Azraq found extraction to be double the WAJ numbers, so 35 Mm^3/yr is likely an underestimate. In any case, the reduction in agricultural extraction is dwarfed by the 125 Mm^3/yr increase in M&I extraction (MWI, 2017). A monitoring well in the area shows the rate of aquifer decline increased by a factor of 10 in 2013, which corroborates that the reallocation was a small part of the total supply increase (MWI and BGR, 2019).

As Figure 2 shows, only the farms in the Mudawarra area were closed; in the Disah area, some 40 to 50 kilometres away, locally owned farms continued to operate, as did the Masri-owned farms, and the expansive gardens for the hunting lodge of an Emirati Sheikh. Ministry policy makers argued that these wells were too far to affect the M&I fields and that the Masri family was too influential to shut down the farms. It may be relevant that, in 2009, a Masri family member was appointed Minister of Agriculture (Keulertz, 2014), but distance to the wellfields is also plausible.

Figure 1. Left (2012): Normalised Difference Vegetation Index (NDVI) map of Mudawarra (the confined Disi aquifer).

Figure 2. Disah area (the unconfined Disi) in 2012 (left) and 2014 (right).



Note: The town of Disah is in the bottom left; locally owned farms were not affected; the three-pointed object near the centre is the hunting lodge, which was also exempted. The Rum company (owned by the Masri family) was mandated to reduce their water use from 35 Mm^3/yr to 15 Mm^3/yr. Some change in the cropped area is visible but does not conclusively show either compliance or noncompliance. The Normalised Difference Vegetation Index does not correlate uniformly with water use and with noise due to weather, seasonal variations, and with Landsat's own schedule limits comparability.

DISCUSSION AND CONCLUSION

Having traced the implementation of both tariffs and licensing and the Mudawarra farm closings, we can revisit our core question: Do growing urban needs allow more successful reallocation of groundwater by changing the political context? The first section notes the characteristics of Mudawarra that may explain why farms were closed there and not in the northern highlands; the second section answers our guiding question; the final section provides suggestions/advice to other reallocating states on how to target reallocations.

Why shutdowns primarily in Mudawarra?

The previous sections argued that only in Mudawarra did the GoJ attempt to close farms en masse as a strategy for driving down agricultural groundwater use. In the northern highlands, the licensing and tariff system did charge farmers for use and some subsidies were removed; tariffs high enough to close farms, however, were only applied to recently created 'illegal wells'. What characteristics explain the targeting of a small patch of desert in Jordan's far south?

Mudawarra farms were uniquely reliant on imported workers and had no Jordanian-owned small farms and few non-seasonal Jordanian workers. The staff of the Mudawarra farms were mostly, or all, Egyptian migrant workers; closures, therefore, there did not create mass unemployment (in Jordan). For the local Bedouin, the largest impacts were the loss of fodder for grazing, reduced seasonal employment, and the loss of business selling to the migrant workers (Interview No. 5 with scholar); their own farms, in the west near Disah, were exempted. In the words of one MWI staff member, "Here [in Disi Mudawarra,] there were no social consequences to care about. These rich farm owners had no problem losing a bit of business. The people in the north if you take their water they will come to Amman and start collecting money". This is an explanation that was most often cited by interviewees.

Closing the Mudawarra farms also required lower transaction and enforcement costs. One MWI policy maker commented that,

> [t]he government went for the easiest solution, to make a deal with many farmers, separate farmers is not easy. It is easier to make a deal with a small number of companies. I was not there when they made this decision, but if you ask me, this is my idea (Interview No. 1).

Furthermore, most farmer resistance strategies rely on disguising water sources among farms (Al Naber and Molle, 2017); in an area of tens of square kilometres with almost no cultivation, preventing new farmer entry is less expensive. Excepting elite conflict, the Mudawarra decisions avoided most of the pragmatic constraints on the MWI's efforts to control agricultural groundwater, including rural poverty, transaction costs and enforcements costs.

Additionally, closing the Mudawarra farms came with an attractive increase in water supply; the reduction in agricultural water use was roughly one quarter of the increase in urban use. The high capital costs of building the pipeline required the increased sustainability of water that resulted from, and thus justified, the farm closures, as building pipelines to multiple smaller sources is less efficient.

The loan structure may also have increased the leverage of the donors. MWI staff referred to 'triggers' placed on Jordan by USAID (through OPIC, who reportedly provided the loan). The MWI staff implied that the closures were required under the contract, but OPIC does not release the text of its contracts so verification was impossible. Distrust of Jordan's promises is plausible, especially after Ross Hagan's paper and after Jordan's past reneging to the World Bank on the privatisation of its tomato factory interests (Pitman, 2004). About US$ 250 million, however, was also fronted by Jordan and its social security fund (Keulertz, 2014), and the contract called for operations payments to GAMA Energy whether or not water flowed (Interview No. 2, MWI staff), so the GoJ had strong reason to close the farms either way. One MWI employee even suggested reproducing the build – operate – transfer (BOT) model to increase political will (Interview No. 3). As a result, unlike in the north, funding the pipeline gave Jordan's donors and creditors leverage to force farm closings.

Taken together, these factors suggest that it was unusually easy to reduce agricultural groundwater consumption in Mudawarra: the GoJ had to deal with much less unemployment, the cost of enforcement was lower, it came with a large supply increase, and the loans gave Jordan's creditors greater leverage. These are unusual advantages for a groundwater reallocation project. We cannot conclude from the Jordanian evidence, however, that urban water needs will cause groundwater reallocation in the absence of these favourable conditions.

The tremendous downside of the Mudawarra plan is the cost of the pipeline. While the Disi-Mudawarra to Amman pipeline was an effective and durable reallocation, it was the most expensive available option (except for the Red Sea-Dead Sea Project) (Pitman, 2004; Hagan, 2008). Unfortunately, the MWI has never published a retrospective comparison of the costs of the Disi pipeline with increasing M&I use of the Jordan Valley or northern aquifers. First, both the energy and capital costs are roughly proportional to the distance of transport and the height difference. The Disi pipeline is 6 times the distance from downtown Amman to Azraq (the furthest northern aquifer) and over 12 times the distance to the Jordan River. The highland aquifers are at roughly the elevation of Amman so little lifting is required, while the Jordan Valley is the lowest available source. From 2008 to 2013 the WAJ's total cost recovery decreased from 70 to 57% due to the Disi pipeline and a coincidental increase in energy cost (MWI, 2016). By 2017, the WAJ had added JOD 2.4 billion (US$ 3.4 billion) to Jordan's deficit; the World Bank, at that point, advised it to raise the domestic water price by 40%, which has since reduced the deficit (ibid). The radiation concerns described above are also a significant downside.

Foreign observers have expressed surprise that even pro-reallocation actors in Jordan support expensive megaprojects (Schiffler et al., 1994; Pitman, 2004; Greenwood, 2014; Bonn, 2013); the 2012 to 2019 period, however, shows the limited ability of tariffs and licenses to achieve large reductions in groundwater use. Unwillingness at all levels of government to create rural unemployment suggests that the World Bank's northern strategy was beyond the cabinet's ability. While the pipeline strategy was massively expensive, it was within the state's capacity to carry out without rewriting Jordan's social contract. Unfortunately, easy access to foreign credit for megaprojects may delay the reform of this social contract.

To what extent did urban need enable reallocation?

In order to understand the extent to which growing urban needs allow for more successful reallocation of groundwater by changing the political context, this paper has explored the two sets of policies in Jordan for reallocating groundwater from agriculture to M&I use. In Jordan's northern highlands, the World Bank and the MWI have attempted reallocation through groundwater licensing and tariffs. The published works of the World Bank and of USAID, and the statements of MWI staff show that protecting the domestic and industrial sectors was a strong motivation for the licensing and tariffs; the regulations, however, failed to reallocate groundwater, though they have slowed the growth of agricultural extraction. In the Disi aquifer, by contrast, an explicit strategy of groundwater reallocation was not only attempted but was able to achieve tangible and durable changes. In both cases, urban requirements contributed to greater political commitment but did not overcome most structural challenges to the reduction of irrigation.

In the northern highlands, the World Bank advocated the closure of unprofitable farms through a volumetric tariff system. Because of political resistance from rural regions and implementers and the reluctance of Jordanian policy makers to increase rural poverty – partly out of stability concerns – tariffs were redirected towards wealthy farmers and new illegal farms. In 2012, a supportive prime minister and the appointment of a pro-reallocation minister to head up the MWI led to stronger enforcement of tariffs on wealthy farms and restrictions on illegal farms. Remote sensing technologies that could have driven up tariffs were negotiated away from water accounting due to pressure from the Ministry of Agriculture. Ultimately, reducing agricultural water use by the many small citizen-operated farms of the highlands would require policies outside of Jordan's window of discourse or ability to implement; tariffs and licensing, however, have probably reduced the growth rate of irrigation by increasing the costs of starting new farms.

Without the Amman water crises and demand drivers, the Mudawarra closures would have been implausible; closing the Mudawarra farms was, in the end, unusually easy compared to farms defended by broader coalitions of interest groups. Evidence for the large impact of urban water needs would be stronger if both Mudawarra and unconfined Disi farms had been closed, as promised by Macoun and El-Naser (1999). Urban requirements had a moderate effect on the expropriation in the Disi. They spurred a successful and sustained reallocation but did not overcome most barriers to groundwater reallocation, as shown by its continued use in the unconfined (Disah) area.

Based on these results, reallocation drivers in basins with low supplies of surface water do increase the probability of regulations that are stronger than average; based on global experience and the small volume of reduced extraction in Jordan (Molle and Closas, 2017), however, the chance that regulations or expropriation will reverse consumption trends themselves remains low. The value of urban supply may motivate a strong state response without overcoming the high political and practical barriers to successful reduction of irrigation extraction.

The rejection of cash-transfer solutions (Hagan, 2008), the preferential treatment of Mafraq farmers (Yorke, 2013), and the references to social stability furthermore suggest that political economy strongly influences outcomes. The rentier states of the Middle East share distributional characteristics such as over-reliance on state employment, a preference for in-kind transfers rather than cash, and a high tolerance for economic distortion (Hertog, 2017). The predictions from Jordan's case are more robust for other Middle Eastern rentier states.

Insulating urban groundwater sources from agricultural competition

In Jordan, successful rural – urban groundwater reallocations have been concentrated in a single region (Mudawarra). This region had few Jordanian workers or smallholders, low transaction and enforcement costs, and excess water capacity. All of these factors made groundwater reallocation from this area more attractive to the GoJ than from the highlands or western Disi, suggesting that some groundwater resources are much easier to reallocate than others. Planners of reallocations in other areas where urban water supply needs to be protected may therefore benefit from focusing their efforts on aquifers which share these characteristics.

A critical weakness of the World Bank's proposal to reallocate by incentives is that this dispersed enforcement over a large and diverse area, a problem that reducing subsidies would not have had. First, the decision to apply tariffs uniformly brought the pro-reallocation coalition into conflict with a many powerful interest groups like the Mafraq farmers; the latter were able to occupy the floor of the parliament in protest until generous free quotas were granted. The Mudawarra closures instead challenged a much smaller set of interest groups. Second, imposing tariffs forced the government to negotiate with a large and diverse set of farmers, including prestige farms, mid-level farms and profitable export farms; this strained the GoJ's ability to negotiate and created opportunities for farmers to evade regulations. The Mudawarra water transfer avoided these challenges by creating a preserve where urban interests could control all water use and no longer needed to monitor individual farmer use.

As a recent World Bank report, *Water Scarce Cities: Thriving in a Finite World*, advises urban water suppliers:

> Because cities often share their water resources with various stakeholders and sectors, their portfolios must include sources they can control without competition from other users. Local, city-specific aquifers can be managed at the city level, which decreases vulnerability to other users' demands (World Bank, 2018: 12).

The authors go on to suggest the recharging of aquifers located directly beneath cities in order to increase the city's autonomy. We argue that the Mudawarra solution effectively created an urban-controlled aquifer on Jordan's periphery, rather than beneath its cities. With no other users left, Mudawarra became an urban water 'preserve' that was insulated from other users' demands. Because of the incentives for overabstraction and the generally high enforcement costs to groundwater reallocation, creating such preserves may be worth exploring elsewhere.

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