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Matthew Cook
University of Minnesota, Morris

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Matt Cook

Dr. Brands

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I. THE PROBLEM

Terms:

Arab League: Refers to Jordan, Lebanon, and Syria. In this context, other member states are not of immediate importance.

Greywater: Meant to include treated wastewater (non-sewage), rainfall runoff, and captured flood waters, among other reusable non-potable water sources.

Hydropolitics: Another term for water politics; matters having to do with parties positioning and vying for control of or access to water resources.

MCM: Shortened form of "million cubic meters." Volume measurement of water.

Sea of Galilee, Lake Kinneret, Lake Tiberius: Different names for the same freshwater body in the Upper Jordan River Basin. Will be used interchangeably.

The Jordan River, once revered for its massive size and numerous civilizations it helped to supply with water, has been overexploited and polluted to the point where, by the time it reaches the Lower Jordan River Basin, it is merely a brown stream (Schwartzstein). Four countries – Israel, Jordan, Lebanon, and Syria – draw from the Upper Jordan and pollute along the full extent of their riverbanks (Comair et al, “Water Resources” 496; Elmusa 306-307; Schwartzstein). In addition to human misuse of the Basin’s resources, the natural recharge of the Jordan River system is predicted to be significantly lessened due to climate change (Comair et al, “Watershed Delineation” 4290), further endangering those who will continue to depend upon the Jordan River system in the future. The matter of apportioning the water in the Jordan River Basin is complicated beyond the usual issues over resource ownership for a river system that serves as a border between countries; the four riparian countries, along with the region of the West Bank, exist in a tense political climate (Comair et al, “Watershed Delineation” 4281-4283; Elmusa 304-310). Much of this discord is derived from the numerous conflicts between Israel and the Arab nations in the region – sometimes explicitly over water access – which leaves an atmosphere in which international compromise is a tentative possibility at best (Wolf 799, 804).

The rainfall that recharges the Jordan River, over 5,000 MCM per year across the four countries and the West Bank region, is largely lost to evapotranspiration (Gunkel & Lange 971), at a rate of 86.7% (Comair et al, “Watershed Delineation” 4285). Jordan’s national contribution is cut by a percentage higher than the 86.7% average, and Syria’s contribution is, in fact, negative – costing the Jordan River’s tributaries some 281 MCM per year as water passes through Syrian lands (Comair et al, “Watershed Delineation” 4285). Climate change is expected to exaggerate these effects yet more (Comair et al, “Watershed Delineation” 4290; Comair et al, “Water Resources” 498, 500-501), worsening the slim net contribution precipitation makes to the Jordan River system.

With the exception of Lebanon, which diverts a mere 11 MCM annually from the Jordan River, the countries of the Jordan River Basin pursue aggressive extraction regimes (Comair et al, “Water Resources” 496; Gunkel & Lange 976; Hoff et al. 720). The biggest consumer, by a large margin, is Israel, which takes 40 – 60% of the flow, depending on the year. The closest competitor in sheer usage is Jordan, at less than a quarter of the river's flow, with Syria taking 30 – 90 MCM less than Jordan annually (Comair et al, "Water Resources" 496). Part of what is driving this skewed abstraction scheme is Israel's high demand for water; Israelis use an average of 300 liters per person daily, whereas the average usage for a Palestinian, for instance, is only 72 liters per person per day, according to the Palestinian Water Authority ("Pending Water Issues"). Nationwide, including land outside of the Jordan River Basin, Israel's annual demand is estimated at just shy of 2,000 MCM (Hoff et al. 720). Despite Jordan, Syria, and Israel having similar agricultural needs for water, Israel is trending in a different direction than the other countries, with the largest source of water demand transitioning from agricultural to municipal. In 1986, Israel's agricultural water consumption was at 70% of total water consumption, with the remaining 30% being urban usage. By 2008, urban consumption had reached 55%, leaving agricultural consumption at 45% (Hadas & Gal 64-65). While Israel's current water usage rate is already unsustainable, the coming increase in demand (and subsequent heightened degree of water scarcity) as Israel and the other countries of the basin continue to industrialize and urbanize will surely be unsustainable.

As well as taking vast amounts of freshwater from the Jordan River, all four countries dump equally vast amounts of waste into the Jordan River and its contributing aquifers. Agricultural runoff, fish pond refuse, and municipal waste (often raw) are the most common effluents (Schwartzstein; Comair et al, "Water Resources" 496). Even when sewage is routed through wastewater treatment plants, the effluent is still quite toxic, as current wastewater treatment facilities remain ineffective (Comair et al, "Water Resources" 496). A source of indirect pollution is the effect climate change is having on the Jordan River Basin; due to higher temperatures and altered wind patterns (and thus altered stratification of surface waters), along with the increased nutrient content, diazotrophic cyanobacteria have made a comeback in the surface waters of the area, and are – simply put – disrupting ecosystems with overly-abundant nitrogen, especially the ecosystem of Lake Kinneret (Hadas et al. 1221-1224). With this water being extracted and released directly into the Jordan River on a routine basis (Comair et al, "Water Resources" 497), the problems will be spread throughout the basin and beyond to systems downstream.

A large part of the reason that Israel maintains such a dominant portion of the river's allocation is because of its past military successes over the latter half of the 19^{th} century against the nations of the Arab League (Wolf 802-805). Through aggression, Israel has taken a commanding role at the discussion table. This being said, the Arab League still has the power to refute a proposal, much like they did early on in the modern Arab-Israeli conflict with their rejection of the Johnston Plan (Elmusa 297-298, 300; Wolf 804, 821). Much of the Arab League's dissatisfaction with the Johnston Plan was due to the plan's tacit affirmation of the Israeli state as a legitimate power (Elmusa 312). With Israel's presence as a nation-state no longer an uncertainty, one would assume that the main objection the Arab League had to a formal allocation plan would be null, and discussions could begin anew, but the situation remains unsolved – the tensions in the region run much deeper (Wolf 807).

Among the most hotly-contested issues is the establishment of a Palestinian state. As it stands now, Palestinians under Israeli control receive a fraction of the water their Hebrew counterparts do – much of the water from the aquifers within the West Bank is piped out to Israel to Israeli consumers (Wolf 799). Current allocation being as inequitable as it is, it ought to be expected that an international agreement would have at least a clause ensuring increased water security for Palestinians on the West Bank and Gaza Strip. In addition to the large Palestinian population, the Israeli government (as well as those of the other Jordan River Basin nations) is facing what is turning out to be an extended period of high numbers of refugees seeking shelter in settlements around the region, creating further issues of water scarcity and sanitation (Schwartzstein).

The fact of the matter is that the resources of the Jordan River Basin are not enough; while the river itself cannot sustain the demand from the surrounding nations, no more so can the aquifers of the Jordan River Basin or any other auxiliaries (at current capacity) compensate for this discrepancy (Hoff et al. 720). There is no single solution to the water scarcity crisis in the Jordan River Basin, much less one that does not involve intensive development of water production sources.

II. POTENTIAL SOLUTIONS

The most immediate step towards thwarting the impending shortage of water in the Jordan River Basin is for all of the countries in the basin to reduce their usage, thus decreasing demand. Agricultural demand, the biggest source of water demand internationally, is currently being over-allocated in Israel, leaving over 1,000 MCM unused on crops each year (Hadas & Gal 66). Irrigation infrastructure in the area tends to be incredibly outdated and wasteful (Comair et al, "Water Resources" 502; Wolf 816). In Syria, the agricultural fields are irrigated using groundwater pumped from Jordan River Basin aquifers and spread by antiquated methods, adding to the evapotranspiration and net loss of water for the Jordan River system as it passes through (Comair et al, "Watershed Delineation" 4289). Were Syria to install even basic modern irrigation systems, it has the potential to cut its water lost by a staggering 5,800 MCM annually (Comair et al, "Water Resources" 502). With estimated reductions as large as 50% in agricultural water usage (Hoff et al. 731), countries that depend on their agricultural production may consider having their water budget slashed to such a degree would be too hampering of a blow to account for the improved irrigation technology – which is, itself, an expensive installation on the scale required – and see such an element in a proposal as stifling to their economy.

In addition to reducing the water used for irrigation, the basin countries stand to gain a significant supply of water for irrigation by revamping their respective wastewater treatment systems and capturing other greywater. Floodwater capture, rainfall runoff capture, greywater, and treated wastewater can all be used to irrigate crops, without any additional extraction (Comair et al, "Water Resources" 502; Hoff et al. 731; Wolf 811, 815-816, 824). Given that new wastewater treatment systems would be installed and existing ones brought up to date, reinjection of water into aquifers could conceivably be safe (Comair et al, "Water Resources" 503). Currently, runoff and greywater are far too polluted with agricultural contaminants and urban waste, and are managing to mar the quality of the basin's aquifers by simple infiltration and percolation (Comair et al, "Water Resources" 496); direct reinjection would surely worsen this effect without proper treatment of water. The required systems to incorporate treated wastewater and greywater as a viable portion of water supply in the countries of the Jordan River Basin would likely be costly to install and adapt, once again putting an economic disincentive on ceasing to overexploit 'free' resources in the short term and thus complicating reuse as a part of an allocation proposal. But, with Israel reportedly recycling 87% of their water annually (Schwartzstein), there is evidence that such undertakings are possible.

Closely-knit with the scheme of reduction and reuse is the implementation of optimized distribution. The existing infrastructure that carries water around the basin to its various sites of usage is, again, outdated – it leaks and is particularly exposed to the effects of evapotranspiration

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(Wolf 816). Beyond the physical shortcomings of present systems, even Lebanon's tiny abstractions from the Jordan River have to run through a dodgy chain of communication, where each facility and domain the water passes through has a different management setup and style, and intra-facility communication is awkward and poorly conveyed (Comair et al, "GIS-Based System" 939-946). These inefficiencies lead to wasted water at each turn, and a simple standardization of Lebanon's (and those of the other countries) water distribution system could go a long way.

Something to incorporate in this renovation of internal water distribution systems should be to expand upon it to allow for the distribution of greywater from urban communities, where an excess may build up, to an agricultural area which can then use the water for irrigation. The obvious issue with this response to water scarcity is that the pipes that need to be laid or mended would require costly projects to unearth the pipes or to lay new pipes; canal-covering and above-ground leak mending should not be much cause for contention, as it is an affordable undertaking, comparatively. If expansions could be made to even include greywater and rainfall runoff from refugee locations, this would help take care not only of the available water supply, but some of the sanitation issues in refugee camps.

Perhaps the most important (and surely the most contentious) part of the redistribution of water within the Jordan River Basin countries is the allocation of more water to Palestinians, especially on the West Bank. In the 1960s, Israel first diverted salt-laden springs into the Jordan River just upstream of where Palestinian farmers grew crops. After the water became too saline to irrigate with, Palestinians were kicked out of the area and lost all access to the Jordan River (Elmusa 309). Once restricted to the West Bank, Palestinians also lost control of the aquifers under their own feet, as nearly all the water was diverted by Israel for Israeli consumption (Wolf

799). Palestinians, on the Gaza Strip and West Bank combined, are barely given enough water to live a semi-modern life, while Israel takes nine times as much water annually for its populace (Wolf 799-800). Though Israel will resist allocating more water to the Palestinians (as it will likely come from Israel's current portion), such an allotment must be made in the interest of avoiding local water crises in the future.

Importing water has been the serious consideration of many plans, with exporting countries suggested such as Turkey and Iraq (Wolf 818-819). Especially for Israel, this option is beyond unappealing; it would be extremely difficult to persuade any country in the basin to become beholden to another nation for their own water, at a fee, no less. While unsettling as a plan, the immediacy with which such a large supply can be made available through trade is undeniable, and would be especially useful for dealing with rapid influxes of refugee populations.

Groundwater, as an alternative to surface water from the Jordan River Basin, is becoming an increasingly short-term option, as it will soon cease to be a viable means of water supply. Even at current extraction rates – where groundwater is not the default source of water, as the River is still open for abstractions – on average, in the basin, there is an extraction rate that stands at 150% of the annual recharge rate (Comair et al, "Water Resources" 498). For the short term, however, groundwater is appealing; it is easily accessible, extraction technology is well understood and readily available, and upkeep is relatively low. Only these members at the discussion table with a bias towards foresight versus quick fixes would be likely to discourage using groundwater as a transitional water source.

The auxiliary water source most costly, yet most dependable (in the long term) is desalination. With an abundance of inputs available – saltwater abounding and plenty of solar energy – desalination offers an appealing component for each nation's scheme of overall water independence. Indeed, many of the parties involved are considering pursuing desalination proliferation (Hoff et al. 731); Israel has already developed facilities that can produce up to 250 MCM annually (Hoff et al. 720). Israel's desalination regime, currently reportedly supplying for 50% of the drinking water consumed in the country, is projected to reach 700 MCM per year by 2020, satisfying 70% percent of drinking water demands (Schwartzstein). While these numbers are promising, it is only through great expense and rigorous construction schedules that Israel has achieved this standard, and the other nations in the basin are not as rich as Israel. To progress from having next to no desalination capabilities to an ability to account for a significant portion of a nation's supply is an undertaking that will require time and (potentially outside) money, especially in the case of Palestine. Being the most costly water production option presented thus far, both in terms of installation and upkeep, as well as one of the models with the longest delays before producing a significant supply, it would be a tough sell to convince leaders outside of Israel that desalination should be selected as the primary source of water supply in the near future, and sought after aggressively, as the Israelis have done.

III. EVALUATION

To start at the most basic point, the Jordan River needs to be allowed to restore itself, to some degree, to its former state. This would mean a significant reduction in the total water extracted from the river, and thus every country's allocation would be smaller. With the smaller allocation will come a number of issues, most principally the irrigation supply for each country. As the restoration of the Jordan River is essential to its continued availability as a resource at all, the issues that will become apparent must be dealt with, as not reducing the Jordan's flow is not an option.

To help ensure that each country remains honest in their allocation, setting up a system of cooperative distribution and monitoring would be pertinent. Pieces of such a system have come together before, as with Israel's private "Picnic Table Talks" with Jordan in which the two parties settled on water distribution and daily usage (Wolf 804). Even now, Israel and Jordan have an exchange agreement, in which Israel pumps water into the King Abdullah Canal to make up for a similar amount that Israel pulls from the Yarmouk River in the wet season (Comair et al, "Water Resources" 497-498). Cooperation such as this is becoming more appealing to the parties involved, as evidenced by discussions that lead to third party proposals for a canal from the Red Sea to the Dead Sea, with the goal of supplying Jordan, the West Bank, and Israel with some 600 MCM of desalinated water from the canal annually (Hoff et al. 731). By setting up shared systems (to cut costs) from which all or multiple parties get their water would help to create common ground and habits of collaboration between the countries out of necessity; it could lead not only to water security for each country (and Palestine), but to better international relations overall, facilitating international discussion – perhaps discussion of a Palestinian state.

Desalination needs to be an integral part of any plan put forward for the countries of the Jordan River Basin, just as the proposed "Red Sea—Dead Sea Conduit" incorporated desalination facilities (Hoff et al. 731). With the reactants readily available, as well as an over-abundance of solar power – the basin routinely sees 300 days without clouds annually (Wolf 833) – the ongoing utilization of desalination is far and away the most viable means of large-scale production of water, especially for production of potable water. Of course, the cost in building up the appropriate infrastructure will be immense, particularly so if a development schedule such as Israel's is pursued. With the burden of upfront cost for installation and maintenance, comes the potential benefit of the region becoming the standing authority on desalination technology (Wolf 816-817). As nations of less arid regions become dependent upon desalination with the onset of accelerated climate change, they would turn to the Jordan River Basin for information, which would give each nation in the region joint bargaining power in the international theater. At the least, foreign investment may help to stem the high cost of desalination, as nations such as the United States are aware of the benefit that would come from developing desalination technology, in light of the increasing water shortage in the American Southwest (Wolf 816-817). Another benefit specific to the Jordan River Basin is what the region can do with the pollution from desalination plants; the brine from the completed desalination process can be used directly, as is, in local industry as an input. Jordan and Israel have salt works and potash works already operating, and the industry could grow as desalination grew to meet demand, taking care of much, if not all, of the by-products of desalination (Wolf 833).

Reverting to groundwater as a primary source of water after each country has weaned itself off of the Jordan River is the default choice, but ever the risky one. The increased extraction rate would worsen the already-unsustainable extraction rate. To ensure that the Jordan River is not turned to again once groundwater is exhausted, the countries in the basin must not form a dependence upon groundwater greater than the amount that can be safely recharged. It is likely, though, that groundwater will need to be exploited in the short term as a transitional water source, as the establishment of desalination plants, an overhauled distribution system, and a comprehensive wastewater treatment system (among other solutions) is a time-consuming process.

Along with the potential temporary overexploitation of groundwater comes the likelihood of artificial recharge. Unless the changes made to the current water systems in the Jordan River Basin include extensive wastewater treatment, such reinjection of runoff and “grey” water – at present, chock full of urban and agricultural contaminants (Comair et al, "Water Resources" 496) – would weaken aquifer viability by increasing the rate at which they are polluted, running the risk of rendering aquifers unusable in future. If the water was properly treated prior to reinjection, then there is nothing wrong with initiating artificial recharge programs. The trouble lies in monitoring such practices, as people in charge of treating and re-injecting water could easily skimp on treatment processes and get away with pumping contaminated water into an aquifer for some time before it would be detected. For this reason, any treatment of water to be re-injected would benefit from a monitoring process, including separate facilities for treatment and pumping, with a quality inspection point between the two.

Reduction of water usage, especially for irrigation, is paramount to the success of any plan, perhaps more so than desalination. If existing irrigation allocations were to remain the same in future years, desalination (pursued at the current rate) and reused wastewater together would still not provide a large enough supply to cover urban and agricultural usage in Israel (Hadas & Gal 69). With water consumed through irrigation standing to be reduced by as much as 50% by some models through updating existing systems (Hoff et al. 731), reduction of usage is the key to closing the gap between demand and supply.

In addition to the irrigation systems, the distribution and wastewater treatment networks must be overhauled and expanded upon to include greywater capture. Reusing water collected in this way, as well as reducing loss to leakage and evapotranspiration, will help cut the amount of freshwater needed for irrigation further yet, freeing up more water to be used in the quickly-growing urban sectors of the basin (Hadas & Gal 69). Covering canals to prevent evapotranspiration and mass collection of rainwater, floodwater, and other greywater (from urban centers) are among the cheapest means by which more of the water supply can be secured, and all forms of reuse discussed are cost-effective in the long run; to ignore them would be to spend more money on less water elsewhere in the hydrological system of the Jordan River Basin.

The option of importing water is discussed in a number of plans for water supply and usage in the Jordan River Basin. To depend upon imported water would be to depend utterly on nations outside the basin, putting each country within the basin in quite a precarious situation, as they will have developed no systems of their own to compensate for any potential withholding of water by the exporting party. Short of using imported water to supply suddenly-formed refugee camps, importing water should not be seen as a viable option in any plan.

The final tenet that must be upheld in any proposal to grapple with the growing water scarcity in the Jordan River Basin is that of guaranteeing reasonable allocation (not based on imported water – such an allocation treats Palestinians, permanent residents, as refugees) for Palestinian settlements. The allocation would work best if paired with establishment of water rights for Palestinians, to ensure that the overall allocation is enough for each individual. Though the Palestinian people are without a centralized leadership or their own consolidated funding, there is enough foreign interest and funding to allow for the pursuit of the installation of water production systems. For instance, in 2012, the Union for the Mediterranean provided funding for a desalination plant to be built on the Gaza Strip to help ease the intense water scarcity in that area (Comair et al, “Water Resources” 502). Given similar foreign interest, paired with Israeli assistance, Palestinians within the basin could seek out similar means of water production and become self-sufficient. Only once an egalitarian allocation scheme is achieved can the crisis of water scarcity in the Jordan River Basin be resolved.

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