

Parchedness, politics, and power: the state hydraulic in Yemen

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1. Introduction: the political ecology of a national water crisis

Water has always been central to civilization in Yemen. Around 570AD, Yemen was described in the Qur'an as the site of the Marib Great Dam, an ancient feat of engineering that sustained an entire civilization in the fierce heat of the desert (see Fig. 1). Some fifteen-hundred years later, Yemen is facing one of the world's most severe water crises, which its former water minister describes as "a collapse with social, economic and environmental aspects" (Worth 2009: A6). Yemen faces a range of contemporary challenges, including high population growth, declining revenues from oil production, and several active insurgencies. Yet even among this litany of threats to its future, water scarcity remains particularly dire, leading the former US Ambassador to Yemen to declare that it might become the world's first "ecologically failed state."

Yemen is by virtue of its geography water-scarce. Paleoclimate studies indicate that Yemen has been arid or semi-arid since at least 7500BP, and its climactic dependence on the strength of the Indian monsoon results in highly variable inter-annual rainfall (Lezine, et al. 2007: 245). Although the country's internal landscape is diverse, it is chiefly arid, and inland desert areas receive less than 100mm of precipitation annually (Harrower 2009, 62). This acute shortage of surface water is compounded by low rates of recharge to major aquifer systems (Al-Sakkaf, Zhou and Hall 1999: 351). Nonetheless, groundwater is essential for both Yemeni agriculture and urban drinking water supplies. Ground-water irrigated crops account for some two-thirds of agricultural output by volume (Ward 2000: 384). Though vital to maintaining national economic output, intensive groundwater abstraction produces a number of negative consequences, including increased infiltration of polluted water, increased and "essentially irreversible" salinization, and a continually falling water table, meaning that farmers have to drill ever deeper to access groundwater, which also tends to decrease in quality at depth (Foster and Chilton 2003: 1961).

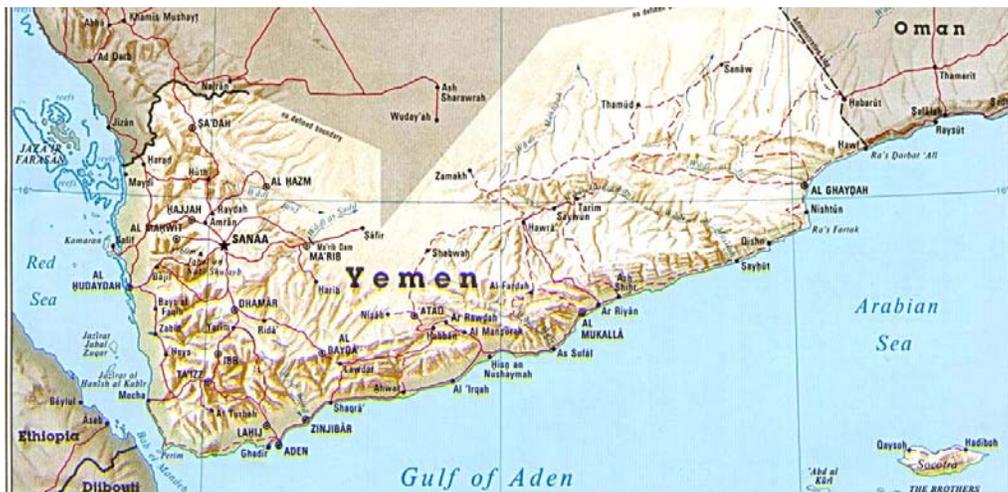


Fig. 1: Basic political and physical geography of Yemen (Scale: 1:7,000,000). Source: University of Texas at Austin Castenada Map Collection.

This dependency on groundwater reserves, coupled with high rates of population growth and low recharge rates, has produced the very real possibility that large portions of Yemen will effectively run out of water within a decade or two. In the Sana'a basin, home to the national capital, low recharge and high abstraction rates are reported to have led to measured declines in the water table of up to 4m per year (Muthanna and Amin 2005: 348). In Wadi Zabid in the western portion of the country, a decline of 40m from 1983-1992 has been reported (Al-Sakkaf, Zhou and Hall 1999: 354), far beyond what would be expected of sustainable rates of withdrawal. In consequence of such rapid rates of depletion, Sana'a is expected to run out of viable groundwater by 2015

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(Kasinof 2009: 6), and a major northern agricultural region by 2032 (Al-Sakkaf, Zhou and Hall 1999: 356). Yemen's low rates of per-capita water availability, which have not met the World Bank's standard for water-security since the 1950s, is thus threatened even further by the exhaustion of major aquifers.

How did Yemen evolve from one of the ancient world's most renowned irrigated societies to one facing collapse from a lack of water? In this article, I argue that Yemen's water crisis represents a political ecology of exploitation. In particular, the modern Yemeni state's attempts to construct a state-hydraulic apparatus in a politically and socially fragmented, ecologically fragile region have led it to rely on unsustainable exploitation of the country's effectively non-renewable groundwater reserves. At the same time, rural elites have sought to capture this new resource to enhance their own power. The inexorable developmental logic of the modern state, coupled with the process of resource capture, has supplanted the political and economic arrangements which underpinned sustainable water management for much of Yemen's history with unsustainable groundwater abstraction. Such abstraction has played an important role in Yemen's modern socioeconomic development, but is unsustainable and now threatens the country's very existence.

I develop the argument in three sections. First, I argue that prior to the advent of large-scale groundwater abstraction, Yemen had over several centuries developed a set of indigenous technologies, political and social arrangements for water management which were well-adapted to its challenging, largely arid climate. These technologies and institutions supported only limited agriculture, but were sustainable. Second, I propose that after the 1960s groundwater abstraction became the tool of a central government eager to assert its authority through developmental projects which attempted to co-opt rural elites. Third, I assert, that this Yemeni state hydraulic was enhanced by attempts by rural elites to capture new groundwater resources. These twin forces both destroyed traditional systems for water management and failed to construct a durable, equitable structure in their place, a deficiency which underpins Yemen's present water crisis.

2. The political ecology of water management

This argument aims to extend a general conception of the political ecology of water resources through close analysis of Yemen as a case study. Political ecology theory generally views ecological change as "the product of a structure of economic and political power" (Weisberg 1972: 274). These power structures and deleterious environmental changes are thus intimately related, as they "mediate between the pressures emanating from the larger society and the exigencies of the local ecosystem" (Wolf 1972: 202). Moreover, political ecologists suggest that, where power structures create or maintain political, social, and economic inequality, these structures drive environmental degradation (Paulson, Gezon and Watts 2003; Robbins 2004).

In recent years a number of researchers have developed a political ecology of urban water systems, arguing that in the process of mobilizing water for urban drinking and sanitation processes poorer communities are excluded and marginalized, both through inadequate service provision and regressive pricing, while the power of elites is reinforced through preferential access to the public good of clean water (Swyngedouw 1997; Bakker 2010). My analysis of the Yemen case indicates that similar processes can be identified in rural areas through the growth of groundwater-fed irrigation. The twin influences of the developmental state and resource capture can both disrupt traditional systems of water management and construct exclusionary and marginalizing institutions in their place. The Yemeni case indicates that the political ecology of water implicates both the state and socioeconomic elites, and extends far beyond the city to produce devastating ecological, as well as political, effects.

In conceptualizing water scarcity in particular as a problem with political, economic, and social dimensions, I follow in the footsteps of a number of authors who view water resources management in particular as "an inherently political process" entailing governance issues at multiple levels of society (Mollinga 2008: 9; Bryant 1998). In Yemen, these issues concern both local communities and larger political entities, including nation-states (Varisco 1983: 368). As two prominent political ecologists put it, "Diverse environmental processes interact with social processes, creating different scales of mutual relations that produce distinctive ecologies" (Zimmerer and Bassett 2003: 3). My argument centers on the tension between two of these scales, namely that of an expansionist developmental state and that of the locally-adapted, community water-management system.

This conception is in turn rooted in the political-ecologic paradigm of the hydraulic state. Hydraulic states are those which undertake monumental projects of hydraulic engineering to accomplish developmental goals, in the process of which they seek to marshal, and thereby assert authority, over a wide range of previously-unincorporated political, social, and economic resources, in turn structuring a state-dominated system of inequality. The hydraulic state paradigm was first popularized by Karl Wittfogel's study of ancient irrigated civilizations, in which he charged that "A large quantity of water can be channelled and kept within bounds only by the use of mass labor; and this mass labor must be coordinated, disciplined, and led" (Wittfogel 1957: 18). The exercise of this authority fostered inequality, because, "As manager of hydraulic and other mammoth constructions, the hydraulic state prevents the nongovernmental forces of society from crystallizing into independent bodies strong enough to counterbalance and control the political machine" (Wittfogel 1957: 49).

Though Wittfogel's hydraulic hypothesis has been much criticized (Harrower 2009), the notion that mass mobilization of water resources fosters politically-imposed inequity remains influential. In his study of water in

the American West, historian Donald Worster alleged that a "managerial elite" of private-sector agriculturalists and public-sector bureaucrats and elected officials colluded to inequitably distribute scarce water resources, with devastating ecological consequences (Worster 1985). Similarly, the geographer Karen Bakker has argued that governments, operating within a "state hydraulic paradigm," have systematically under-provided drinking water to poor urban residents (Bakker 2003, 2010).

The hydraulic state paradigm dominates the allocation of water resources around the world, yet it is a relatively recent development. As Bakker notes, "Prior to the mid-nineteenth century, state involvement in water supply was limited," but "During the past century, in many countries, water management was characterized by the dominant role of the state as owner, manager, and regulator of water supply infrastructure" (Bakker 2003: 18). In this former era, water management in most parts of the world occurred within what Worster calls a "local subsistence mode," in which "authority over water distribution and management remains completely within the local community; organization of power remains loose and uncontrolled" (Worster 1985: 31). In contrast to previous forms of management, such state control over water resources embeds its allocation in political processes and structures at a higher and more abstract level.

The involvement of the state in water resource management is largely a manifestation of the process of "territorialization," which "linked resources and people to the concept of national territory and sovereignty" (Vaccaro 2008: 226). The process of territorialization is well-illustrated in Article 8 of the Additional Acts to the Franco-Spanish Border Treaties, concluded in the mid-nineteenth century, which stipulates that "All standing and flowing waters, whether they are in the private or public domain, are subject to the sovereignty of the State in which they are located, and therefore to that State's legislation." Indeed, so absolute was the sovereignty of each state over even such a fungible resource as water that "Flowing waters change jurisdiction at the moment when they pass from one country to the other" (Food and Agriculture Organization of the United Nations 1998: 253).

Subsequent developments in international law formalized the state's role in the management of water resources. The 1921 Barcelona Convention and Statute on the Regime of Navigable Waterways of International Concern designated as "riparian states" those whose territory abutted or encompassed waterways of international concern, and conferred upon them substantial responsibilities for their management. The 1968 African Convention on the Conservation of Nature and Natural Resources provides a particularly clear assignment of new responsibilities to the state in the area of water management in demanding that contracting parties establish "policies for the conservation, utilization, and development of underground and surface water," while also ensuring "administration and control of all water utilization" (Food and Agriculture Organization of the United Nations 1998: 47).

This formalization of state authority and responsibility in water resources management was part of a marked assertion of national sovereignty over natural resources in the post-1945 period. As Nico Schrijver has documented, developing countries in particular have followed the well-established principles of state sovereignty and self-determination of peoples to "claim as many rights as possible" under a doctrine of "permanent sovereignty over natural resources," in the process "nationalizing resource management" (Schrijver 1997: 251).

This nationalization has two, largely contradictory, implications. On the one hand, permanent sovereignty entails obligations to manage natural resources so as to avoid causing harm to other states, and also, increasingly, "for the sake of their own people, including future generations" (Trail Smelter Arbitration 1938/1941); see also United Nations General Assembly (1962). However, on the other hand, permanent sovereignty over natural resources subjects fungible resources such as water to the rigid confines of the territorial state, and as such is fraught with potential for mismanagement and inequitable allocation.

The profundity of these consequences has much to do with the characteristics of states themselves, and in particular how these characteristics shape approaches to the management of natural resources. Traditional forms of water management, which were formerly important in many parts of the world, emphasized customary norms and community-level adjudication of disputes (Ramazzotti 1996). In contrast, the state relies on a system of formal law to control, regulate, allocate and manage water resources. This reliance on formal law is in many ways intrinsic to the operation of the modern state. Indeed, "the law is the state's standard mode of expression, its very language, the essential medium of its activity" (Poggi 1978: 102).

As many observers have noted, however, the "legal-rational" mode of the state is not generally well suited to the equitable management of natural resources. Unlike traditional systems, formal state systems take little notice of complex and localized relationships between natural resources and those who depend on them. The anthropologist James Scott has insightfully characterized this process in noting that "No administrative system is capable of representing any existing social community except through a heroic and greatly schematized process of abstraction and simplification" (Scott 1998: 22). In the case of water, this process often results in a quantitatively inequitable and socially non-optimal allocation of resources.

Indeed, the ultimate significance of the state hydraulic paradigm lies in the distributional impact of mobilizing water resources for mass human use. With the exercise of political authority, water projects amount to "distributional policies," made on the basis of specialized rather than general interests (Hart 1974, 128). This political embeddedness, in the political ecology conception, unsurprisingly favors elites with disproportionate influence in the political system. If political systems are understood as "webs of social relationships, which are

interests to be satisfied" (Peluso 1993: 49), it is straightforward to explain how they "often exercised their power on behalf of narrow, special interests," which in the case of water resources often results in subsidized water prices for key political constituencies (Ingram, Whiteley and Perry 2008: 17).

Under such circumstances, it is alleged, water resource may become subject to a process of resource capture, whereby, in Thomas Homer-Dixon's phrase "powerful groups recognize that a key resource is becoming scarce, and use superior institutional resources to grab it" (Homer-Dixon 2000: 15). The scope of such claims is illustrated by one study of water management in Spain, which concluded that "In all modern urban societies, water management quickly became a national priority. Urbanely conceived and controlled water management programs, however, seldom take into account the needs of rural populations" (Vaccaro 2008: 227). This is certainly the case in Yemen, as close analysis reveals.

3. Verdant Yemen: traditional arrangements for water management

For most of Yemen's history, "Water scarcity was a perpetual threat to the sustainability of life" (Hehmeyer 2008: 92). Nonetheless, pre-modern Yemeni societies developed a variety of sustainable water management strategies. By the mid-10th century, the country was known as "Verdant Yemen" (Varisco 2009: 383). These strategies were adapted to the specific rainfall regimes of various regions; in the highlands agriculture was historically spring-fed, while foothill and coastal areas were traditionally irrigated by seasonal floods (Price 1995: 278). Moreover, these strategies were comprehensive, incorporating engineering works as well as related political and legal arrangements. The sustainability of these traditional systems is demonstrated both by their adaptation to Yemen's difficult hydrology, and their durability throughout Yemen's pre-modern history.

Yemen is home to a number of impressive works of hydraulic engineering. Of these, the most famous are those designed to capture the *sayl*, or episodic floods. Superlative among these works was the Marib Dam, which employed a system of canals and basins in addition to a large (14m) main dam to irrigate some 44,500ha of hyper-arid land. With this sophisticated system, "the huge quantity of big *sayls* could be diminished to a suitable level for irrigation," thereby supporting the ancient Sabean civilization (Brunner 2000: 170). Smaller but similar spate irrigation systems were reported by the tenth-century Arab geographer Al-Hamdani to dot the Yemeni landscape, indicating that such engineering adaptation was widespread in ancient Yemen (Varisco 2009: 391).

In addition to *sayl*-fed agriculture, pre-modern Yemen was home to other hydraulic engineering adaptations. In highland regions, terrace systems employed a combination of gravity irrigation and underground water conduits to enrich topsoil and control water flow, causing "repeated sedimentation of the suspended silt loads...onto the irrigated terraces where they are deposited because of impoundment. Hence, these terraces have the function of both retaining and conserving soil and water" (Vogel 1988: 31) (see Fig. 2). In the southern port of Aden, a complicated series of cisterns, dams, and canals dated to the first century BC were hollowed out of surrounding volcanic rock and could store 20 million gallons of freshwater (Young 1997: 30).

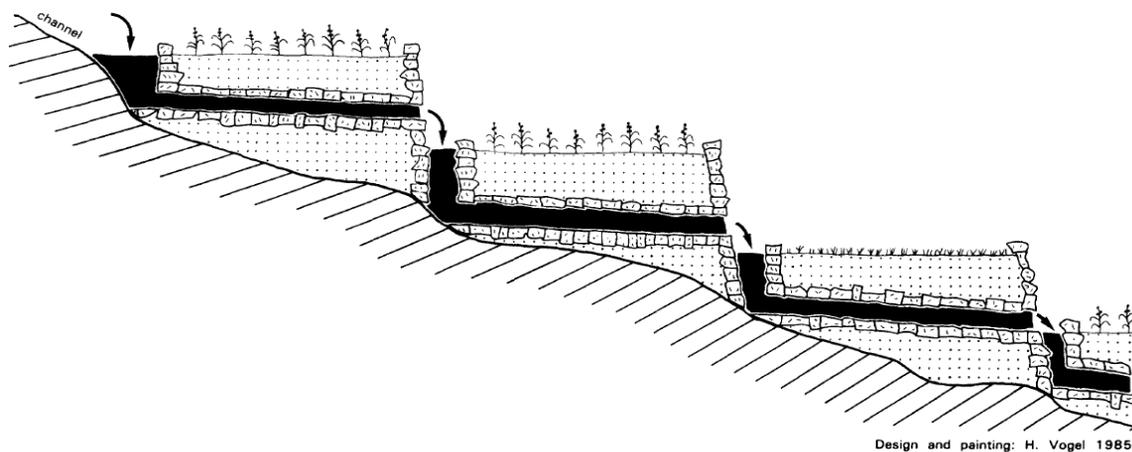


Fig. 1: Terrace agriculture system with novel underground conduits . Source: Vogel 1988: 31.

Importantly, these engineering adaptations were specific and indigenous to Yemen. Qanats, a form of hydraulic engineering widespread in other arid regions, were in contrast comparatively rare (Lightfoot 2000: 223). As one scholar writes, "Irrigation in Yemen might have been inspired by other civilizations, but would have had to be adapted to fit very different local circumstances" (Harrower 2008: 498), and so were innovative

and highly adapted to Yemen's particular, difficult hydrology. Nonetheless, they were highly effective, and permitted pre-modern Yemen to "support a large population and to export coffee, indigo, frankincense, myrrh" (Ward 2000: 362).

Indeed, Yemeni water management was the product of a long process of adaptation to a particular climate. As one researcher notes, "Irrigation agriculture in Yemen required intimate knowledge of sporadic, unpredictable monsoon rainfall and resultant runoff as mid-Holocene climates were changing" (Harrower 2008: 497). Flood irrigation was likely stimulated by the deterioration of Yemen's climate in the fourth millennium BC (Brunner 2000: 167), but even this was only part of a long history of water management, which produced "advanced knowledge of water-flow patterns and organizational means to control them" (Harrower 2009: 61).

These organizational means were crucial to sustainable water management systems in pre-modern Yemen. Large *sayl*-fed irrigation systems such as the Marib Dam were regulated by large state structures (Harrower 2009: 62). These systems entailed "well-defined roles" for state-appointed irrigation officials (Varisco 2009: 370). Such state involvement was necessitated by the gigantic organizational challenges of *sayl* irrigation systems; the Marib system required some 20,000 individuals for major maintenance operations alone (Brunner 2000: 175). State-organized *sayl* irrigation was thus a necessary adaptation to hyper-arid regions, where only intensive irrigation could sustain agriculture (Harrower 2009: 62).

Equally important, however, was the tradition of community-level water management developed in pre-modern Yemen. Spring-fed irrigation, which employed water-collection cisterns and accounted for about one-third of pre-modern Yemeni irrigated land, placed authority in the "irrigator himself...He is not dependent on simultaneous activities by any other individual, nor is he directed by an irrigation official" (Varisco 1983: 371). In most areas, locally-employed "Water Masters" maintained irrigation works and perform basic management functions (Harrower 2009: 63), while village sheikhs typically resolved water-allocation disputes (Varisco 1983: 370).

These adaptive management arrangements were buttressed by customary and Islamic legal provisions. Customary law, influenced by Islamic tradition, dictated that in flood irrigation upstream areas are irrigated first, but that ultimately downstream users are guaranteed a certain amount of runoff flow (Kohler 2000: 173). Additional provisions indicated that this "right to runoff" took precedence over land ownership, which in many outlying areas was considered to be owned by the tribe in any case (Lichtenthaler 2003: 147). This traditional legal system remained in place in many parts of Yemen for some 500 years (Viziterv-Vituki 1971: vii), and required little intervention by national authorities to arbitrate disputes (Ward 2000: 382).

This traditional system was judged by modern experts to be remarkably effective. A UN study from the early 1970s concluded that "the existing system of water rights is logical and may be kept unchanged" (Viziterv-Vituki 1971: vii) while a prominent scholar assesses the Yemeni community-management system as "the most efficient method for flood irrigation" (Varisco 1983: 369). Traditional systems had one further distinctive and sustainable characteristic: groundwater abstraction was undertaken only in "exceptional circumstances," and at rates which permitted natural recharge (Al-Sakkaf, Zhou and Hall 1999: 350). After the 1960s, however, the sustainable engineering, political, and legal systems which characterized traditional Yemeni water management began to unravel in the face of political and economic modernization.

4. Power and patronage: groundwater and the growth of the State

Crucial to this disruption were the political and economic interests of an expanding Yemeni state after the 1960s. The modern Yemeni state came into being with independence from the Ottoman Empire in 1918, after which the British effectively held sway in the south while the Zaidi Imamate ruled the northern portions of the country. In 1962, however, the Imamate was overthrown by radicals influenced by Egyptian President Gamal Nasser's vision of pan-Arabism, and the Yemen Arab Republic was proclaimed in its place. Following a British withdrawal from southern Yemen, Marxist guerrillas proclaimed a People's Democratic Republic of Yemen in 1970 (Halliday 1990). This history of division continued until 1990, when Yemen was formally re-unified, but insurgencies have persisted in both the northern and southern portions of the country.

This political discord between north and south has only exacerbated the long-standing difficulties of the state in both north and south in controlling outlying tribal areas, which traditionally had been hesitant to recognize its sovereignty (Dresch 1993: 334). Tribal authorities traditionally maintained *de facto* autonomy, and exercised core functions of sovereignty including the provision of security and the administration of justice. Little in the way of public works was undertaken in either the northern or southern portions of the country, with the exception of water supply and sanitation systems in the British colony of Aden. As a result, Yemen's government in subsequent decades "focused on three key development objectives: legitimizing itself with citizens...through visible development projects; enriching as many families as possible; [and] consolidating power by ensuring influential groups have wealth and prestige" (Ward 2000: 388). This quest for legitimacy extended to attempts to assert authority over rural areas by using infrastructure projects to co-opt local elites, including through financing the expansion of groundwater-fed irrigation.

Yemen's water scarcity meant that launching large, "visible" development projects entailed resorting to

groundwater abstraction. As one author describes it,

"Groundwater was viewed as the natural exploitable resource to induce socioeconomic development. The aridity of the region did not support other options. Groundwater resources development has the advantage of scale over surface-water development...giving the government a good opportunity to reach out to remote communities with 'tangible' development" (Al-Sakkaf, Zhou and Hall 1999: 356).

Indeed, groundwater-fed development has aided rural communities in several ways: "Intensive aquifer use...has boosted crop production and improved access to relatively clean drinking water" (Steenbergen 2006: 381). Such benefits clearly served the state's interest in promoting tangible development.

The efforts of Yemen's government to pursue such tangible development efforts in the water sector increased particularly after unification in the early 1990s.² The unified government's first policy address, in 1990, pledged to rapidly expand water supplies to "meet citizen's needs," in particular "giving priority to distant areas suffering from water shortages" (Republic of Yemen Radio 1990). Yemeni President Ali Abdullah Saleh continued to emphasize water supply as a key objective of his government, including in his 2002 Unity Day statement, in which he pledged to devote attention to "preserving water supply and replenishing underground water" (Yemen News Agency 2002). In a 2006 interview, Saleh further emphasized his government's developmental ambitions, stating that "After the uni[fication], the leadership and government were of the view that instead of putting the totalitarian regime which led the secession on trial, we should carry out developmental projects like roads, schools, universities, water, electricity, and communications" (Sharbil 2006).

Such projects also aided the government in serving the interests of important agricultural constituencies. The Yemeni government's "Policies helped foster the rapid development of Yemen's water resources, enabling the government to raise farmer incomes and consolidate its alliances with many important interest groups" (Ward 2000: 381). Until 1995, for example, diesel fuel, which powers most tube wells, was priced at USD\$0.02/L, though the market price was between USD\$0.15-0.2/L. Pump prices for diesel fuel remain some of the very lowest in the world, at US\$0.23/L in 2010 (World Bank 2011). Another governmental scheme offered agricultural credit, used to buy pumps and drill wells, to Yemeni farmers at interest rates of 9-11%, substantially lower than the commercial rates of 50-60% (Ward 2000: 383). Consequently, the private costs of groundwater abstraction were vastly and artificially lower than its benefits, which were further maximized by bringing more and more land under irrigation (Riaz 2002: 92).

Rampant, groundwater-fed irrigation also played a role in integrating tribal elites into the government's "formal ruling establishment," another key state objective (Stookey 1974: 252). In many tribal areas, tube wells came to be seen as a sign of wealth and prestige. In the northern Sadah region, for example, saying that someone has "four wells on his farm" came to denote wealth (Lichtenthaler 2003: 165). Accordingly, financing groundwater abstraction among tribal elites became an effective patronage mechanism. Wells, in particular, "signalled important political gifts through which shaykhs were co-opted into power." In Sadah, "One influential tribal leader established a 25-hectare citrus farm with about 10,000 trees...with support from the government, who drilled a number of holes for him" (Lichtenthaler 2000: 160).

Many such groundwater-fed irrigation projects were financed by multilateral development institutions, including the World Bank, which found such schemes more attractive than traditional irrigation technologies. As a World Bank official put it, "The neglect of traditional water control systems can be traced to one key constraint: the lack of easy technical packages that can readily lead to new productivity and attract private or public investment." The attractions of groundwater-fed irrigation projects in the eyes of international lenders further encouraged the Yemeni government to adopt groundwater abstraction as a key development strategy. International lending institutions, according to the official, "supported these developments" by funding an agricultural credit bank which in turn helped to finance groundwater-fed irrigation projects (Ward 2000: 388).

A US\$70 million dollar agricultural assistance project, implemented in the 1970s and financed almost entirely by the World Bank in Yemen's Tihama coastal plain, provides a good indication of this usage of groundwater irrigation as a patronage mechanism. Despite the project's intent to equitably allocate irrigation water to all users in the project area, the Yemeni government implementing authority colluded with the Ministry of Agriculture and the provincial governor to sign a separate agreement with a small group of farmers to receive six times their allocated share of irrigated water. A World Bank report later implicated this "political consideration given to some of the [locally] influential beneficiaries" in the project not having achieved its stated goal of equitably improving smallholder irrigation water availability (World Bank 1991: 3).

Largely because of such patronage, the exploitation of subsurface water came to be identified in many areas with the growth of the state. This association, in turn, had the consequence of further promoting groundwater abstraction as some tribal areas sought autonomy from the state. As one scholar wrote of the 1970s, "Tribal perceptions vis-a-vis government politics triggered the acceleration of groundwater-irrigated agriculture" (Lichtenthaler 2000: 144). This process took several forms; for example, in the early 1980s and in

² This paragraph is drawn from an unpublished manuscript, Scott Moore, "Catalyst for conflict or incubator of instability? Renewable resource scarcity, violence, and state fragility in Yemen," p. 26.

the midst of the Civil War, the South Yemen government built a series of dams in an attempt to control water flow, prompting downstream users to dig wells (Kohler 2000: 174). Similarly, a desire to maintain food self-sufficiency drove some tribal agriculturalists to dig wells. As one Yemeni author remarked, "the political history of our country provides sufficient evidence to all our generations that we must remain food self-sufficient" (Lichtenthaler 2000: 172).

More typical, however, was the belief that the government might seize upon the existence of groundwater as a pretext to seize and irrigate land that had previously belonged to tribes. In the Sadah basin in northern Yemen, for example, a team of government hydrologists was "seen as the first advance of the government into certain areas" (Lichtenthaler 2000: 155). This belief was strengthened by the state-held notion that uncultivated, "white" lands, common property resources often used for grazing, were not owned and therefore open to exploitation (Lichtenthaler 2003: 146). If the government could make it arable through the use of groundwater-fed irrigation, it might cease to belong to the tribe. Thus, government-sponsored irrigation projects were generally viewed with suspicion in rural areas (Kohler 2000: 174). The solution of many tribes was to dig their own wells, ensuring that their land could not be seized by the government.

The development of groundwater resources was central to the Yemeni state's developmental mission after the 1960s. It sought in particular to strengthen its power and legitimacy by co-opting rural elites through preferential access to irrigated water, and succeeded in that groundwater abstraction came to be increasingly identified with the growth of the state in many regions, which in turn had the effect of encouraging rural Yemenis to seek independence from the government by digging their own wells. The expansion of groundwater-fed irrigation was thus not only the result of an expansionist, developmental state, but also an attempt by rural elites to capture a new resource to enhance their power *vis a vis* others. This attempt to enhance relative power, however, like that of the state, ultimately produced deleterious ecological consequences.

5. Mining the Subterranean Sea: groundwater and resource capture in Yemen

The growth of groundwater-fed irrigation throughout much of rural Yemen was the result of macroeconomic pressures combined with state subsidies for crucial inputs such as diesel fuel. Large new reserves of groundwater quickly became subject to resource capture by elites and pawns in tribal conflicts, with the result both that traditional systems for water management were disrupted and that no durable system could be erected in their place. Such is the predicament in which Yemen presently finds itself.

Throughout most of pre-modern Yemen, groundwater abstraction was a foreign concept. After the 1960s, however, a series of events both raised awareness in rural areas about the presence of groundwater, and also promoted its use. In one northern area in the 1970s, for example, an Italian road-building crew dug a well to supply its own water needs, with revolutionary effect: "Before this event," one farmer remarked, "many were unaware of the water resources resting undisturbed in the ground. This [event] gave people the idea to drill for water and to develop the land" (Lichtenthaler 2000: 152). In still more areas, Yemenis returning from Saudi Arabia, which in the 1970s launched a large campaign to achieve food self-sufficiency with the aid of groundwater, began to dig their own wells (Lichtenthaler 2003: 15).

A number of macroeconomic pressures coincided with growing realization of groundwater resources to promote abstraction. A ban on imported fruit, instituted in the 1980s by Yemen's government, persuaded many farmers to switch to citrus cultivation, whose large water demands were met by groundwater. Economic uncertainty and the devaluation of Yemen's currency during the 1980s also made it "better to have land than money," which incentivized many rural residents to invest in improving their land through digging wells and installing diesel pumps (Lichtenthaler 2000: 162). At the same time, the growth of the oil industry in neighbouring Saudi Arabia supported a large Yemeni diaspora whose remittances provided ready capital for investments in groundwater-fed irrigation (McGowan and Cassam 1985).

This new resource promised great economic opportunity. Groundwater was perceived as virtually inexhaustible; it was often referred to as *bahr* (the sea), "indicating the perception that it was limitless, like the sea" (Lichtenthaler 2003: 161). Indeed, there was a widespread belief that "God had provided them with the 'gift' of water as he had blessed the Saudis with the 'gift' of oil" (Lichtenthaler 2000: 151). Groundwater, then, had the crucial and unique quality of being perceived as plentiful, and even divinely bequeathed.

Subsurface water was also free once accessed. According to Islamic tradition, groundwater could be owned only when it was "contained," for example in a well or pipe (Kohler 2000: 174). Water in the ground, however, was free to all. Under traditional water management systems, this acted to constrain groundwater abstraction because it meant that land and water rights could only be bought or sold together. But in 1976, an Islamic jurist determined that land and water rights could be traded separately, which changed the political and economic calculus in rural areas to favour the development of irrigation sources including groundwater (Lichtenthaler 2000: 147).

Despite the perception that groundwater irrigation promised liberation from traditional, restrictive land-use norms and offered economic opportunity, groundwater abstraction was quickly harnessed to strengthen rural elites. Under the post-1976 legal regime, well-owners could extract high fees from well-users, thereby strengthening rural elites. Traditionally, "Water use [was] restricted to those who have paid for the equipment of the well" (Kohler 2000: 176). "With the advent of pump irrigation," a UN study found, "a new system of

land tenure is emerging. Under this system, the landlord bears the full cost of pumping and provides the sharecropper with the seed and animal power; the share cropper retains only 25% of the product" (Viziter-Vituki 1971: 26). As a result, well-owners could charge tenant farmers for the abstraction of groundwater. This change in rural political economy had the general effect of "shift[ing] income from the poor to the rich" (Ward 2000: 385), which encouraged those with available capital to invest in groundwater abstraction.

The use of groundwater resources to strengthen the control of rural elites is further illustrated in the production of the narcotic *qat* (*Catha edulis*). Usage of *qat* plays a major role in Yemeni society, and consumption is regarded as an almost universal, daily activity by men (Kennedy 1987). *Qat* cultivation has been practiced for centuries in Yemen, but expanded after the 1970s, when large amounts of food aid reduced profit margins for other cash crops, pushing Yemeni farmers into *qat* cultivation (Lichtenthaler 2003, 12). *Qat* is estimated to account for up to one-third of Yemen's total water consumption, and because of its high profitability, it contributes much of the capital required for large-scale expansion of groundwater-fed irrigation. Though no surveys of the *qat* industry in Yemen have been undertaken, it appears that much of the trade is controlled by cartel-like organizations. A World Bank report concluded that "it is clear that *qat* creates fortunes, and with it vested interests." These interests, while nebulous, were implicated in the report in blocking several crop-substitution and *qat* regulation efforts, while maintaining a "laissez-faire" policy toward *qat* use (Ward 2000: 13). As with other uses of Yemen's groundwater reserves, *qat* cultivation appears ultimately to strengthen elites to the detriment of the national economy and environment.

Groundwater irrigation projects moreover became tools of conflict between tribes seeking to enhance their own power over those of neighboring tribes. A US\$16.5 million irrigation project in Wadi al-Jawf, northeast Yemen, provides an example of this phenomenon. The project was jointly funded by the World Bank, which intended to provide US\$2.51 million, the Arab Fund for Economic and Social Development US\$4.85 million, and the Yemeni government the remainder of approximately US\$9.1 million. The irrigation project was intended to benefit 1,700 farming families and to extend the government's "influence in tribal administration." However, the project's final report, compiled in 1994, found that "The irrigation component was never completed" because "Each of the schemes ran into conflicts between tribal interests," some of which were so intense that "On one scheme a contractor was driven off by bazooka fire" (World Bank 1994, iii). Tribal rivalries thus became another component of the political ecology of status and control over groundwater resources.

The very economic opportunity promised by groundwater abstraction attracted new irrigators whose methods and origins placed them outside traditional management structures. Partly through the expansionist policies of a developmental state, and partly through the use of groundwater to strengthen rural elites, institutions for water management in Yemen evaporated, laying the foundations for a water crisis. As one farmer remarked, "We don't know each other and we don't trust each other; there is hardly any cooperation between us, and it will be difficult to achieve a consensus to reduce groundwater abstraction" (Lichtenthaler 2003: 186). Another scholar reached similar conclusions: "The perception of many farmers is that as groundwater levels drop further, there will be less and less co-operation among stakeholders. Even now, everyone tries to minimize his personal loss at the expense of the common resource" (Kohler 2000: 177).

This lack of trust and of the institutional mechanisms to control groundwater abstraction are reflected in the government's failure to redress Yemen's water crisis. A series of institutional reforms, including the 2002 Water Law, which asserted state ownership of Yemen's water resources (Richards 2002: 9), have notably failed to establish effective legal mechanisms for water resource governance. The ineffectiveness of governmental regulation is indicated by a World Bank review of water management in the Sana'a basin, which found that despite 141 citations being issued in 2007 for illegal drilling, only two were prosecuted, and "so far no action has resulted" (World Bank 2010: 46). Both Yemeni and foreign sources view the central government as both unwilling and unable to back enforcement of water-use regulations, as well as to prevent bureaucratic infighting among Yemeni government agencies as well as multilateral donors. Despite legal directives to centralize authority for water management in NWRA, for example, the Ministry of Agriculture remains responsible for all irrigation matters, and its interests tend to favor the continuous expansion of groundwater-fed irrigation (Al-Asbahi 2005: 5).

The convergence of rural interests which promoted groundwater use after the 1960s supports Grey and Sadoff's assertion that

the rapid technological advances of the 20th century have often outpaced institutional capacities. The case of groundwater is illustrative, where the cultural practice and customary law of groundwater development was well-adapted to technologies which did not allow substantial groundwater abstraction from any but very shallow depths (Grey and Sadoff 2007: 560).

As groundwater abstraction in Yemen became very substantial indeed, traditional management unravelled, and a water crisis resulted. As one observer put it, "The persistence of century-old Islamic and customary rights coupled with technological and economic progress introduced from outside over the past thirty years have led to the present water problems" (Kohler 2000: 177). With this conclusion in mind, the implications for Yemen's future can now be considered.

6. Conclusions: political ecology and ecological failure

This article has argued that Yemen's present water crisis is a manifestation of patterns of exclusion and control that disrupted traditional, largely sustainable, systems of water management in favour of groundwater abstraction. In contrast to the political ecology of urban water supply, the rise of groundwater-fed irrigation in Yemen was characterized both by the expansion of a developmental state and resource capture on the part of rural elites. These two forces together constitute what I have called the *Yemeni state hydraulic*—an ambitious attempt to assert control over the groundwater reserves that are vital to Yemen's politics and economy.

Ultimately, however, the Yemeni state hydraulic has foundered on a set of deeply-rooted issues. These include the power struggles between center and periphery, the effects of economic instability in the 1980s and 1990s, and the wrenching changes wrought by modern technology in a deeply conservative, traditional tribal culture. Though the state has increased its ability to control water resources and certain tribal elites, it has failed to secure and stabilize the country. Rural elites, similarly, have succeeded in enhancing their power in relative terms by dominating usage of scarce water resources, but in the medium and long-term they too face the prospect of acute water scarcity. In the wake of these processes, traditional technologies and institutions for water management have broken down, and there exists neither the social trust nor the institutional capacity to erect new systems in their place. In this institutional vacuum, Yemen's water crisis festers.

This vacuum is of crucial importance, for it threatens Yemen's future. Grey and Sadoff write that "With the continued mining of groundwater in all regions of Yemen, some areas will almost certainly lose their economic viability" (Grey and Sadoff 2007: 559). Al-Sakkaf *et al.* similarly warn that "Groundwater is being depleted to such an extent that socioeconomic development is threatened by the cessation of irrigated agriculture" (Al-Sakkaf, Zhou and Hall 1999: 351). Overall water shortages have also led to growing discord; in the Abyan region, hundreds of people rioted after being left without state-supplied water for over two months (Al-Shabibi 2010). In other areas, reports suggest that the government's legitimacy is continually undermined by its inability to provide basic, critical services, including supplies of water.

Some commentators suggest that the solution to Yemen's water crisis is to return to traditional strategies. As one prominent commentator writes, "A new orientation towards the traditional agricultural irrigation techniques is necessary for the purpose of sustainability" (Rappold 2005: 2437). Yet the political ecology outlined in this article suggests that returning to the past is too narrow a solution. It is not simply that Yemen's water use has grown unsustainable, but that the fundamental political and economic interests which underpin water management systems have unravelled. A poignant illustration of this shift is provided by the government's attempt to reconstruct the famous Marib Dam during the 1980s. Despite spending millions of US dollars to reconstruct the dam and its attendant Sabeen irrigation system, its irrigation system was never replicated, and local farmers have preferred to rely on groundwater abstraction (Lichtenthaler 2003: 180).

The fundamental shifts in political and economic interests shaping water management in Yemen frame the difficulty of charting a path out of the current crisis. They help to explain, why, for example, one author writes that "Allegiance of the local inhabitants to the tribal system is so strong that...even if [comprehensive, national water] legislation exists, it will take a long time to overcome the adherence of the local inhabitants to the customary law" (Al-Sakkaf, Zhou and Hall 1999: 358). They also help contextualize the continual failures of centralized administration, including the new National Water Resources Authority, to arrest groundwater depletion (Gerhager and Sahooly 2009: 29). These failures indicate the need for Yemen to develop a new set of political and economic arrangements that will lead to sustainable management of water resources at all levels, from local to national.

Among water management specialists, the consensus seems to favour decentralization as a means of addressing groundwater depletion problems by building on social capacity at the community level. As a UN report concluded, "[local] communities have the advantage that they can better monitor compliance with the law and bring social pressures to bear on [water law] violators" (UN Development Program 2003, 25). Others advocate the use of "Local Councils for Cooperative Development," which would employ a number of locally-adapted water demand management strategies (Al-Sakkaf, Zhou and Hall 1999: 364). Two aid workers likewise offer a set of principles to encourage "increased independence and local ownership" for water management institutions in Yemen (Gerhager and Sahooly 2009: 31).

However, Yemen faces a number of other systemic challenges to water security that communities are unlikely to be able to meet on their own. The first of these is an extremely fragile economy. As a recent assessment notes, "Already the poorest country in the Arab world, Yemen is rapidly depleting its oil reserves and lacks any options for creating a sustainable post-oil economy" (Boucek and Donadio 2010). The second is lack of indigenous capacity to effectively address water management issues (Gerhager and Sahooly 2009: 42). Third is the prohibitive cost of exploiting alternative sources of water, particularly from desalination of seawater. Although many of its richer arid neighbours have turned to desalination, the economics of such systems make it unlikely that Yemen can afford to do the same (Al-Sakkaf, Zhou and Hall 1999: 151). Yemen, more so than perhaps any other country, appears to vindicate Grey and Sadoff's assertion that "Countries with difficult hydrologies often get in a 'deep hole' that is difficult and expensive to climb out of" (2007: 559).

If Yemen is to achieve water security and realize a sustainable future, it will have to overcome the deep social cleavages and conflict between state and tribe which has underpinned much of its water crisis.

Encouragingly, recent protests in the wake of the so-called Arab Spring against President Ali Abdullah Saleh appear to have fostered a remarkable surge in dialogue between Yemen's educated urban elite and the conservative tribesmen who rule large swaths of the country (New York Times 2011). However, as of September 2011 these putative dialogues have produced no concrete results, and the legacy of exploitation, marginalization, and exclusion in Yemen's water sector continues to haunt the country's prospects. Largely as a result, Yemen, despite its proud history of traditional and sustainable water management, stands the risk of political, economic, and ecological failure.

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Abstract

Historically, Yemen was noted for its sustainable, locally-adapted system of water management. Today, however, it faces one of the world's most acute shortages of water, driven chiefly by unsustainable rates of groundwater depletion. This article seeks to explain Yemen's present water crisis as the result of a political ecology dominated both by an expansionist Yemeni state and rural elites. By adopting intensive groundwater abstraction as a key development strategy, Yemen has produced an unsustainable basis for future economic and social development. The Yemeni case confirms both the importance of states and elites in the political ecology of water systems, and indicates that rural as well as urban water systems are characterized by patterns of exclusion and marginalization. As Yemen attempts to reap the fruits of the Arab Spring, it must adopt reform of its broken system of water management as one of its most pressing national objectives.

Key Words: Yemen, groundwater depletion, developmental state, hydraulic civilization, water scarcity

Résumé

Historiquement, le Yémen a été notée pour son système de gestion de l'eau, qui a été durable et gérés localement. Aujourd'hui, il fait face à une pénurie de l'eau, tiré principalement par des taux insoutenables de l'épuisement des eaux souterraines. Cet article cherche à expliquer la crise de l'eau du Yémen, et à la suite démontrer 'une écologie politique dominé à la fois par un état expansionniste yéménite et les élites rurales. En adoptant captages d'eau souterraine intensive comme une stratégie de développement clés, le Yémen a produit une base non-viable pour le développement économique et social. Le cas du Yémen confirme à la fois l'importance des Etats et des élites dans l'écologie politique des systèmes d'eau, et indique que les régions rurales ainsi que les systèmes d'eau urbains sont caractérisés par des schémas d'exclusion et de marginalisation. Comme le Yémen tente de récolter les fruits de la «printemps arabe», il doit adopter un réforme de son système de gestion de l'eau comme l'un de ses plus importants objectifs nationaux.

Mots clés: Yémen, épuisement des eaux souterraines, «developmental state», la civilisation hydraulique, la pénurie d'eau

Resumen

Históricamente, Yemen se caracteriza por su sistema sostenible, adaptadas localmente de la gestión del agua. Hoy, sin embargo, se enfrenta a una escasez de más agudos del mundo de agua, impulsada principalmente por las tasas insostenibles de agotamiento del agua subterránea. Este artículo trata de explicar la crisis del agua presente en Yemen como resultado de una ecología política dominada tanto por un Estado expansionista de Yemen y de las élites rurales. Mediante la adopción de extracción de aguas subterráneas intensiva como una estrategia clave para el desarrollo, Yemen ha elaborado una base sostenible para el futuro desarrollo económico y social. El caso de Yemen confirma tanto la importancia de los estados y las élites en la ecología política de los sistemas de agua, e indica que las zonas rurales, así como los sistemas urbanos de agua se caracterizan por patrones de exclusión y marginación. Yemen como los intentos de recoger los frutos de la primavera árabe, que debe adoptar la reforma de su sistema que no funciona de la gestión del agua como uno de sus objetivos nacionales más urgentes.

Palabras clave: Yemen, agotamiento del agua subterránea, «developmental state», civilización hidráulica, la escasez de agua