ESTABLISHING AND MAINTAINING RIPARIAN RIGHTS IN CONSTRUCTED WETLANDS IN SOUTHERN IRAQ

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EXECUTIVE SUMMARY

Since 1989, international damming and the drainage of southern Iraqi marshes have collapsed fisheries, various forms of economic activity, and livestock and dairy production—activities that underpinned local livelihoods—turning a half-million former residents into internally displaced persons in extra-urban slums. Some have clustered along two rivers: the Shatt Al-Arab and the Shatt Al-Basra, where livestock can graze. Others bring livestock into the city and feed them reeds delivered from remaining marshes, exacerbating ecosystem collapse and urban water pollution. At the same time, massive wastewater outflows are dumped untreated into rivers emptying into the Gulf, killing fish and shellfish nurseries, with regional economic consequences.

Constructed wetlands offer affordable, quickly implementable, integrated mitigation for many of these problems. They can restore services provided by pre-collapse marshes and help treat wastewater streams at a fraction of the cost of conventional treatment. A successful 2016 test case generated renewed interest in a constructed wetlands solution, which would need to be scaled up to the size of the problem. For a large-scale project to be successful, however, key stakeholders agree that establishing fair and transparent legal mechanisms for allocating grazing, harvesting, settlement, and management rights will be important.

Deficiencies in the rule of law present obstacles to such reforms. Iraq has a comprehensive legal framework for preventing, mitigating, remediating, and correcting environmental degradation, yet environmental degradation persists. Impediments to enforcement arise from problems with physical infrastructure, administrative infrastructure, and the fiscal structure of fines for violations.

Case studies of constructed wetlands from within and outside of the region—both successes and failures—provide valuable lessons for overcoming obstacles that Iraq faces within its existing regulatory structure. Such lessons may well be widely applicable world-wide, in arid delta zones threatened by water starvation and wetlands degradation.

CONTENTS

FIGURES

ACRONYMS

BOD	Biochemical (Biological) Oxygen Demand
CERP	Comprehensive Everglades Restoration Plan
DOI	(U.S.) Department of the Interior
EPA	(U.S.) Environmental Protection Agency
EPF	(Iraq) Environmental Protection Fund
FAO	(United Nations) Food and Agriculture Organization
FAOLEX	Legislative Database of the FAO Legal Office
GCI	Getty Conservation Institute
GOI	Government of Iraq
ICBA	International Center for Biosaline Agriculture
IDP	Internally Displaced Persons
IPIECA	International Petroleum Industry Environmental Conservation Assn.
LCPR	Limited Common Pool Resources
MEERM	Master of Earth and Environmental Resource Management
MoEn	(Iraq) Ministry of Environment
PDO	(Oman) Petroleum Development Organization
RAMSAR	Ramsar Convention on Wetlands
ROI	Republic of Iraq
SOC	(Iraq) South Oil Company
STP	Sewage Treatment Plant
SWIM	(E.U.) Sustainable Water Integrated Management
TDS	Total Dissolved Solids
UAE	United Arab Emirates
UNEP	United Nations Environmental Program
UNESCO	United Nations Educational, Scientific, and Cultural Organization
WHO	World Health Organization
WPCP	Water Pollution Control Plant
WMF	World Monuments Fund

GLOSSARY

Ahwar—the formerly contiguous deltaic marshes of southeastern Iraq, roughly bounded by the cities of Amarah, Nasiriyah, and Basrah.

Ahwari—A person born into a family traditionally resident in the Mesopotamian marshes.

Biochemical (Biological) Oxygen Demand (BOD)—amount of dissolved oxygen (DO) needed by aerobic biological organisms to decompose organic material present in a given water sample at a certain temperature over a specific time period. Absent sufficient DO, anaerobic decomposition proceeds, releasing hydrogen sulfide and methane gasses with a characteristic "rotten egg" odor.

Chubaya (plural *chubayish*)—human-made dwelling platform in or near a marsh, ranging from small, temporary structures to extended family compounds with livestock byres, storage buildings, work areas, and orchards/vegetable gardens.

Ecosystem Services—benefits provided at no cost by functioning ecosystems, that are impossible or prohibitively expensive to replace. Generally grouped into four categories: *provisioning*, such as the production of food, water, fuel, and materials; *regulating*, such as the control of climate and disease; *supporting*, such as nutrient cycles and crop pollination; and *cultural*, such as spiritual and recreational benefits.

Marsh—a seasonal or permanent wetland dominated by water-loving grasses, sedges, and rushes, such as reed *(Phragmites, Arundo);* cattail (*Typha*); papyrus, sawgrass *(Cyperus, Cladium*); and *Juncus.*

Primary (Sewage) Treatment—temporarily holding sewage in a basin, removing heavy solids that settle to the bottom, and skimming oil, grease and lighter solids from the surface.

Secondary (Sewage) Treatment—following primary treatment, removal of remaining dissolved and colloidal (mostly organic) compounds with aerobic microbial decomposition, in order to reduce BOD to specified levels. Usually accomplished through aeration and priming with indigenous aquatic microbial communities, which precipitate in cell clumps.

Swamp—a seasonal or permanent wetland dominated by flood-tolerant trees, such as bald cypress.

Tertiary (Sewage) Treatment—removal of biological nutrients, micropollutants, and disinfectants before discharge into watersheds.

Total Dissolved Solids (TDS)—inorganic salts (principally calcium, magnesium, potassium, sodium, bicarbonates, chlorides, and sulfates) and some small amounts of organic matter dissolved in water.

I. Introduction: Wetlands Loss

The collapse of the *Ahwar* marshes in southeastern Iraq—a result of intentional, industrial-scale drainage following the 1991 Gulf War and neighbor states' upstream damming over the past century—has led to the displacement of up to a half-million ecological and economic refugees into extra-urban slums, especially outside Baghdad, Nasiriya, and Zubayr (UNEP 2001).

This collapse has resulted in the loss of a wide variety of ecosystem service benefits—benefits provided naturally and at no cost—that are essential for the livelihoods of local populations. These wetlands provided the foundation for such occupations as fishing, animal husbandry, dairying, rice cultivation, orchard gardening, fowling, salt production, wicker production, and related boat-building and construction trades. They also regulated local temperatures, cleaned local waterways, and provided a host of other services. At the same time, greater Basrah's wastewater management systems are profoundly broken, currently in gross violation of innumerable federal and state laws (for a summary of the loss of ecosystem service benefits and the status of wastewater, see **Appendix 2: Ecosystem Services Collapse and Wastewater Status**).

Municipal and Governorate authorities throughout Basrah are all too aware of the egregious economic and social consequences resulting from loss of these ecosystem services. Environmentally insensitive practices are perceived as environmentally and economically unjust affronts to equal treatment under the law, and result in explicit social unrest. Absent productive employment or agricultural income from marshlands, disaffected youth (mostly men) turn to organized crime: kidnapping for ransom, burglary, and smuggling. Young women and children resort to rubbish-picking for recyclable scrap and street begging.

While the marshland's half-million former residents have received some international attention, including their UN classification as internally displaced persons (IDPs), there is much lower awareness of the ongoing, comprehensive impacts of these conditions on urban areas. Likewise, there is low awareness of the fact that these environmental impacts have serious social and legal consequences, which consistently erode legal and administrative credibility across multiple sectors, not just those policed by environmental ministries.

Even though educated, urban dwellers by and large pity displaced marsh residents, they do not intuitively recognize any broader relationship of ecosystem services collapse to their own administrative spheres. Under intense public and political pressure to upgrade basic services and improve quality of life, they express frustration in the face of burgeoning population, failing infrastructure, raw sewage flows, inadequate water supplies, public demonstrations, traffic obstructions, and the like.

Manmade, or "constructed," wetlands could help support livelihoods and improve living conditions for displaced marsh residents. Constructed wetlands could restore some ecosystem service benefits, clean polluted waterways, and underpin traditional marshland occupations in the absence of natural wetlands. A small-scale pilot project in Basrah has already proven successful under limited conditions (**Section II. Constructed Wetlands**).

Despite the appalling environmental conditions described in this paper, Iraq does have a comprehensive legal framework for preventing, mitigating, remediating, and correcting environmental degradation (**Section III. Legal Framework in Iraqi Law**). Enforcement, however, suffers from a complex set of challenges. Such challenges range from, on the one hand, poor physical infrastructure and the sheer scale of marshland degradation, to, on the other hand, problems of governance and the challenges of integrating the needs of vulnerable local populations into potential solutions (**Section IV. Compliance and Enforcement Obstacles**). This paper advances recommendations for reforms that could support the successful implementation of a constructed wetlands solution (**Section VIII. Recommendations**), and it examines case studies from inside and outside the region that provide insight into how a constructed wetlands solution could work in southern Iraq (**Section VI. Models and Options**).

II. Constructed Wetlands

In 2016, a University of Basrah PhD student devised a Constructed Wetlands Testbed that serves as a successful model that could be scaled and adapted for southern Iraq (**Figure 1.A**). Within the testbed's first week of operation, it transformed raw sewage into crystal clear water superior in quality to city tap water, meeting or exceeding all EPA test standards (**Figure 1.B**). It quickly generated broad consensus among key stakeholders—such as students, faculty, sewage treatment plant workers, and municipal officials—that scaling it up to treat and test re-use of campus wastewater for agriculture, husbandry, and aquaponics applications would be a cornerstone for successful implementation of constructed wetlands at larger scale. "What you have here," said one participant, "is proof that there is no reason why we cannot comply with environmental law ourselves. And why we should. This is beautiful. This gives me hope. Real hope that we can save our country. That we can do something about these problems."

Figure 1: U. Basrah Constructed Wetlands Teaching Station. (A) The six cells of the Constructed Wetlands Testbed operate along twin lines, individually, jointly, or in any combination. (B) Within three days, raw sewage flowing through the testbed becomes crystal clear water that meets all EPA test standards.

Constructed wetlands could alleviate problems presented by the loss of ecosystem services and the poor condition of wastewater management systems (see **Appendix 2: Ecosystem Services Collapse and Wastewater Status**). When successful, constructed wetlands can improve living conditions for local communities and mitigate sources of conflict. "Regulating services," such as cleaner air and a cooler microclimate, contribute to tangible, if difficult to assess, common goods. Others, especially provisioning services, restore tangible and economic goods. Those goods, if not adequately managed or regulated, under the dire economic circumstances faced by IDPs in and around the urban cores, could become sources of conflict. This section considers the services of most concern in this regard.

Cleaner Water. The first and most obvious potential benefit of constructed wetlands is cleaner water. Improving water quality at intake points, even if that water is not immediately potable, significantly reduces the load on downstream water treatment plants.

Livestock Husbandry. Constructed wetlands also offer more localized ecosystem services. In terms of immediate economic impact, the first of these is provisioning for animal husbandry. Water buffalo breeding for large-scale dairy production is extremely lucrative, while cow's milk has an enormously positive impact on infant and child development. Sheep-rearing for meat and wool is another source of dietary supplementation and direct income. Highly toxic agricultural return water, released by Ministry authorities directly into existing marshlands in order to "increase" marsh area, kills livestock that consume it.

Stock-keepers are therefore forced to purchase potable water to keep their stock alive—or relocate stock away from supplies contaminated by agricultural return water. Thus, though technically illegal, stock-keeping by impoverished families has moved into the open spaces within, and outskirts of, urban areas—where water is foul but not immediately lethal, and

more easily transported to animals. To feed these animals, reeds are harvested from anywhere available, including along sewage ditches and urban creeks, landfill pits, public parks, and storm water basins.

Figure 2: Livestock Fodder and Children's Health. One potential benefit of constructed wetlands is to relocate fodder production outside of, but nearer to, the urban cores where most IDP now reside. (A) This reed field is a private farm enterprise, which diverts agricultural wastewater from the main outfall drain into field sections for reed crop production. (B) Young reeds and cattails are harvested and fed to buffalo and cattle in nearby feedlots. (C) Feedlot dung and straw waste is collected, dried, and stored as biofuel, which also reduces organic matter runoff into waterways. (D) Children raised on high-protein, high-energy buffalo milk have measurably better health and nutritional status.

Constructed urban wastewater treatment wetlands can relocate potable water for livestock, as well as fodder production, outside of but still near to the urban cores where most IDPs now reside (**Figure 2**). The multiple social benefits include improved household diet, improved health, reduced social friction, improved quality of life, economic opportunity, and a much-reduced organic waste burden on urban waterways and sewage treatment infrastructure. Given these benefits, access to clean water and reed crops is likely to be competitive—and therefore will require clear, fair management and distribution.

Fisheries and Aquaponics. With the collapse of fisheries, fish farming startups are undergoing a new boom among agriculturalists in southern Iraq. However, water quality—

both incoming and outgoing—is a serious concern (**Figure 3.A**). The removal of biological nutrients, micropollutants, and disinfectants from wastewater ("tertiary treatment")—both as inflow for fish ponds, and re-treatment on outflow—generates clean, safe water for fish, as well as high-protein vegetal feedstock for fish food (**Figure 3.B**). Safe integration of these systems at commercial scale is now undergoing testing at the University of Basrah Marine Science Center, with recommendations for specific regulatory standards to follow.

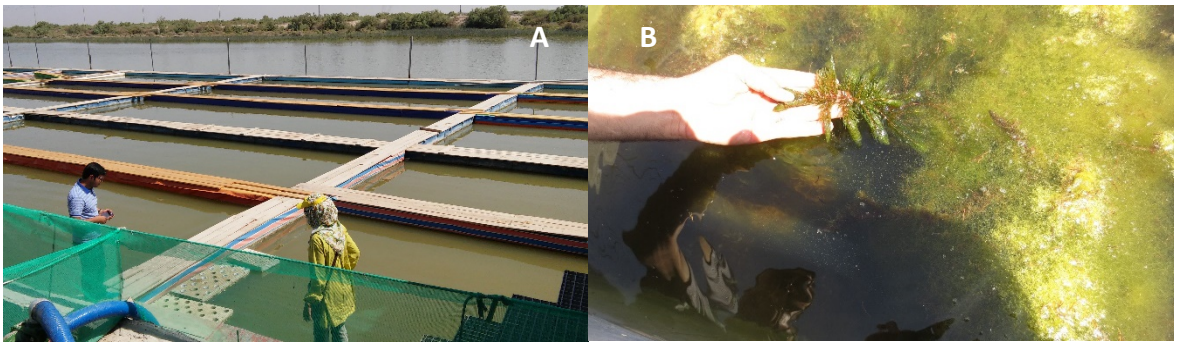

Figure 3: Fisheries and Aquaponics. (A) Al Ahwar Company experimental fish farm. Agricultural investment in fish farming is rapidly expanding. (B) U. Basrah Aquaponics Test Station. Surface-flow tertiary treatment of wastewater generates clean, safe water for fish, and high-protein vegetal feedstock for fish food.

However, care is required in aquaponics administration. Constructed wetlands provide a fish nursery habitat, but care is required in reconciling overarching needs for re-growth of commercial fisheries stocks against needs for commercial fish cultivation. The two are not irreconcilable, but are a potential source of legal conflict.

Agriculture, Horticulture, and Landscaping. The most immediate and highest demand—and highest level of competition—for wastewater re-use is likely to come from the arable agricultural sector. Large landholders are wealthy and well-connected, allowing them to make investments in infrastructure and agricultural land, as well as provide employment, but also oppose establishment of wetland crops that they view as competitors for arable land area. However, most formerly arable soils are now too salinized for any commercial crop production. Therefore, research to identify salt-tolerant strains of key crops amenable to drip irrigation—often funded in joint ventures with local agricultural business—has become a high research priority for agricultural colleges, as is low-water-intensity commercial greenhouse gardening (**Figure 4.A**). The landscape gardening industry is another agronomic activity geographically well-placed for integration with ecosystem services-based wastewater cleanup. Despite current poor water quality, urban plant nurseries already cluster along Basrah's creeks, in order to meet high demand from the DIY home garden trade (**Figure 4.B**). All of these activities—rather than competing with farming of wetland crops, would be beneficiaries of constructed wetland wastewater treatment systems.

Figure 4: Agriculture and Horticulture. (A) Research to identify salt-tolerant strains of key crops (like these dates) amenable to wastewater irrigation is a high priority. (B) Urban plant nurseries cluster along Basrah's creeks.

Urban Cooling, Storm Water Control, and Development. Salt- and drought-tolerant plants irrigated with recycled wastewater prove remarkably adaptable to urban greenways, which are essential components for attenuating brutal, potentially life-threatening summer temperatures that routinely top 120ºF (49ºC) for days on end.[1]

Urban trees and vegetation also improve air quality and attenuate storm water runoff. With no or inadequate storm water drainage systems, rains are inevitably accompanied by flash flooding that ties up city traffic for hours after every storm. Worse, the sudden flush of water and surface contaminants dumps raw storm sewage directly into the Shatt Al-Arab and other drinking water sources. Diverting storm water into constructed wetland treatment systems, then using treated water for irrigation, is an obvious virtuous circle.

However, creek banks and orchard enclaves are displaced by massive infrastructure development at an alarming rate (**Figure 5.B**). The increase in such development is a major contributor to the degradation of urban creeks, rendering them useless for any purpose beyond pollutant transport. In turn, they are left seemingly unworthy of protection, and thus open to further development. Their reengineering and restoration as constructed wetland wastewater treatment systems would serve the public good, but could be opposed by developers, requiring legal intervention.

[1] In the summer of 2016, Basrah officially earned the dubious honor of becoming the hottest city in the world, with city-center temperatures exceeding 129°F (54°C in the shade). With temperatures that high, the heat index was not even calculable, as the combined effect of temperature and humidity exceeded all charts. All public facilities and most businesses were forced to close.

Figure 5: Urban Cooling, Stormwater Control, and Development. (A) The Basrah Corniche along the Shatt Al Arab. (B) Mnawi Basha Hotel tea garden. Salt- and drought-tolerant plants irrigated with recycled wastewater prove remarkably adaptable to urban greenways and courtyard gardens. Traditional green spaces are essential for improving air quality, attenuating brutal "heat island" temperatures, and slowing storm water runoff. (C) New hospital construction replaces the palm gardens that once surrounded the University Guest House. (D) Increasing hardscape runoff amplifies flash flooding that ties up city traffic for hours after every storm.

Biomass: Construction Material. If large enough, constructed wetlands could be a major source of biomass production not only for animal fodder, but for construction materials, especially materials readily useable by marshland IDPs. Throughout all wetlands of southern Iraq, the woody stems of mature reed were once the foundation of farm and residential construction, and split-cane reed mats underpinned *Ahwar* economic activity (**Figure 6.A and Figure 6.B**). Absent reeds, IDP houses and home-businesses are constructed from the next-cheapest materials, such as cinderblocks and corrugated metal sheeting—leading to higher electricity demand for light and cooling (**Figure 6.D**). An increase in local reed supply could diminish demand on distant, protected marsh areas, but it could also result in competition for a saleable resource and raw material. Anticipation, prevention, and mediation of disputes over collection and sale territories, as well as profit ownership, requires prior coordination and allocation by community councils.

Figure 6: Construction Material. (A) Woody stems of mature reed were once the foundation of all manner of farm and residential construction, including fences, palisades, livestock byres, storage sheds, family homes, and (B) classic marshland coffee houses (mudhif). (C) No longer ubiquitous, reeds still provide split-cane mats and cheap building material for scaffolding, floors, walls, and roofing; temporary shelters, storage sheds, and roadside market stalls. (D) Absent reeds, IDP houses and home-businesses are constructed from cheap materials such as cinderblocks—adding to the urban "heat island" effect.

Biomass: Fuel. To reduce indoor cooling needs, most traditional foods are cooked outdoors (**Figure 7.A**). The preferred fuel is charcoal made from brushwood that grows along wetland margins, as well as mature reed canes and scraps. Without brushwood, ovens and grills are converted to higher-cost propane (**Figure 7.B**). For limited household use, firewood-gathering is generally children's activity, and not particularly contested. Any increase in local supply would be a convenience for IDPs, freeing up children's labor for school or other productive pursuits. However, as for construction material, collection for resale to restaurants and street vendors could become economically competitive, requiring access regulation.

At industrial scales, reed cane burns at extremely high temperatures, and when abundant, is the preferred fuel for commercial brick and pottery kilns. In the 1980s, Basrah's brick-making industry was largely abandoned (**Figure 7.C and Figure** 7.**D**). Infamously, and primarily employing impoverished, displaced former marsh dwellers, Baghdad brickworks

continue operating by burning fuel oil—releasing pungent clouds of toxic fumes and soot in flagrant violation of environmental standards. Scaled to be sufficiently biomass-productive, constructed wetlands might prove an alternative model, providing local employment and a cleaner working environment. However, if commercialized, this scale of fuel usage could prove directly competitive with other local needs as described above, again requiring legal regulation of harvesting and leasing rights.

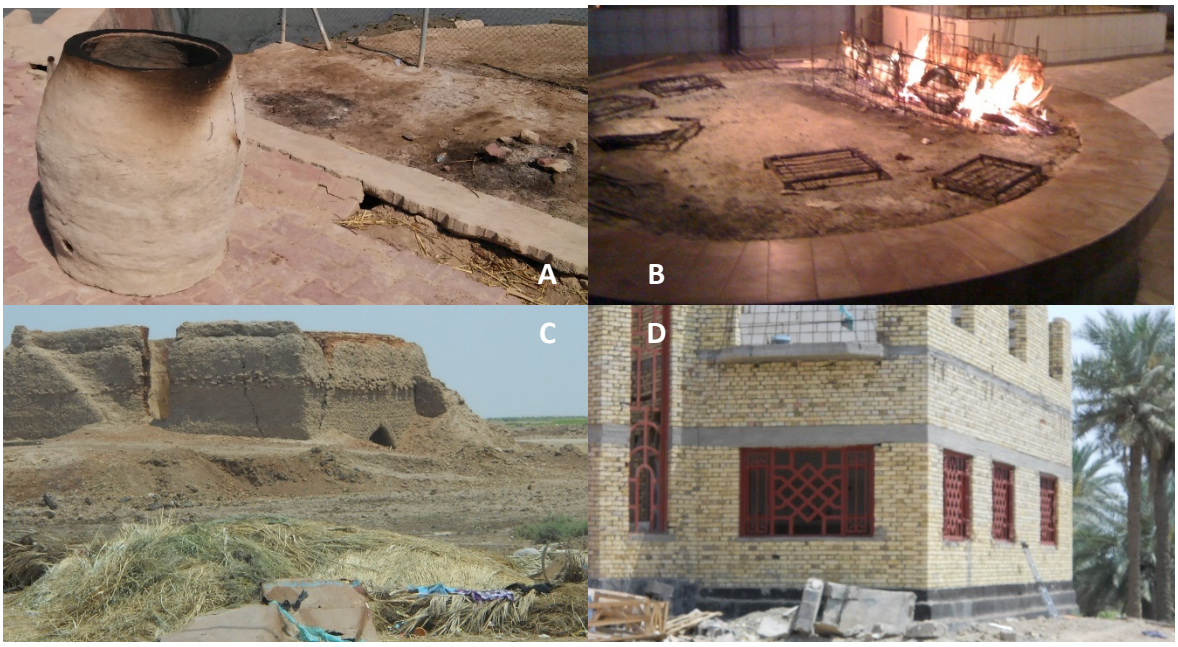

Figure 7: Biomass for Cooking, Heating, and Kiln Fuel. Traditional foods are (A) baked in earthen tannūr ovens, or (B) grilled over fire pits. The preferred fuel is charcoal, made from dense, aromatic brushwood that grows along wetland margins. Without brushwood, ovens and grills are converted to higher-cost propane. (C, D) The Basrah brick-making industry once depended on mature, dried reed cane which burns at extremely high temperatures. Without cane, kilns are abandoned or converted to highly toxic fuel oil.

Wastewater Management. Along Basrah's creeks, officials are loathe to pursue hundreds of individual cases of point-source pollution violation, no single one of which is a substantial contributor, because they know they would make enemies and achieve no solution. When presented with the idea of diverting other wastewater streams *into* one of the creeks, in order to provide sufficient water volume to support the use of living plants to remediate contaminants, officials were initially skeptical. But on further reflection, they became excited by the possibility of addressing the problem one pollution point at a time, using progressive fine abatements for violators who took corrective measures ("fix or fine" options), especially if the fixes could provide even minimal demonstration of additional ecosystem services benefits. This would make it possible, they pointed out, to proceed neighborhood by neighborhood, diverting wastewater to wherever constructed wetlands would be preferable to the current situation. The aim would be to first work with government lands and offices where compliance could simply be agreed and directed, then with amenable neighborhood associations, village councils, and tribal authorities. Indeed,

they anticipated that the biggest problem might rapidly become disputes over order of precedence, given the extensive dissatisfaction with the problem.

With regard to pre-injection petroleum produced water, since the Iraq South Oil Company (SOC) owns and controls all of the relevant inputs, were a constructed wetland to prove a viable treatment option, ultimate distribution of any marketable benefits would fall to SOC's discretion, under their existing social responsibility directives and agreements. Surprisingly, post-injection water can support some life, and combined with oil recovery technologies, constructed wetlands for such produced water can be self-sustaining, as at Nimr Field in Oman. With regard to produced water from degassing facilities, opportunities and constraints are similar to those for post-injection recovery, and the produced quantity is not high.

Agricultural wastewater may prove the most difficult for a constructed wetlands solution. On arrival in Basrah, the water does not "belong" to provincial authorities. Legally, it is still state property, and any diversion, for any purpose, including for a constructed treatment wetland, must be permitted by at least three Ministries (Water, Irrigation, and Agriculture), while flow management must be coordinated with both upstream Governorates and the national authority.

III. Legal Framework in Iraqi Law

Despite the appalling, highly visible environmental conditions described above, Iraq does not lack a legal framework for preventing, mitigating, remediating, or correcting environmental degradation.

Law relevant to constructed wetlands falls into three broad categories: General Administrative, Environmental Protection, and Agriculture and Animal Wealth. General Administrative refers to law governing relevant ministry organization, authority, budgeting, and pay schedules. Environmental Protection refers to law governing pollution prohibitions and wildlife protection. Finally, Agriculture and Animal Wealth is an overarching category covering agricultural land tenure, animal husbandry, aquaculture and fisheries, forestry and woodlots, as well as the huge body of water and irrigation law (**APPENDICES: Appendix 1: Relevant Iraqi Laws and Regulations).**

A. General Administrative

Ministerial administrative structures and levels of responsibility were established by Iraqi Civil Code No. 40 (GOI 1951) and subsequent amendments. Also of note is the Government and Public Sector Employees Salaries Act (Law No. 22 of 2008) (GOI 2008), which specifies

salary scales for all public employees by rank and education level, providing incentives for any government worker to continue education and skills upgrades to maintain technical competencies. Fines and punishments for violations of law are iterated in Penal Code 111 of 1969 and its Amendments (GOI 2003).

Of particular concern to implementers of ecosystems services remediation projects is the Basrah Local Powers Act (Law 1 of 2010) (GOI 2010) and its equivalent in other regions, which devolves jurisdiction for, among other things, land, water, and environmental rights management to local Governorate authority. Governorate councils:

> *"are authorized to protect and improve the environment through coordination with local peoples' councils as well as making plans for each governorate to protect public water from pollution and improve its quality according to timetables. These plans are to be presented to the Council of Environmental Protection and Improvement. Furthermore, the…councils' plans for the protection of public water from pollution must identify the sources of pollution in public water and indicate the proposed treatment method. The plans must also account for future projects, the funds to be reserved for the implementation of these projects, and the timetables for the projects to be implemented in order to treat sources of pollution." (Ahmmad 2012, p. 9; emphasis added)*

B. Environmental Protection

In the context of water rights and water pollution prevention, Iraqi environmental protection law is thoroughly reviewed by Ahmmad (2012). As he notes, the primary legal resources are the Environmental Protection Act (Law No. 27 of 2009) (GOI 2009), which protects lands, waterways, and territorial waters from pollution, and reduces pollution effects on health, the environment and natural resources; and the Wildlife Protection Act (Law No. 17 of 2010) (GOI 2010), enacted to specifically address the dismal consequences of massive habitat loss, especially among species attracted to and supported by constructed wetlands.

Article 18 of the Environmental Protection Act identifies prohibited pollutants and harmful acts, and specifies penalties for violation. This includes prohibition of discharge into national waters by any entity, public or private, of any waste, without prior treatment to meet standards set forth in domestic environmental legislation and international conventions ratified by Iraq.[2] Article 33 establishes MoEn authority to issue violation warnings, and in cases of non-compliance, suspend the activity or order temporary closure, extendable in 30-day increments, along with monthly fines. Powers of enforcement—but not powers of collection—are vested in the Minister and the authorized Governorate

[2] Based on recommendations by a number of international advisory bodies, these standards are comparable to those set out by EPA and the Ramsar Convention on Wetlands.

Directors General. Fines are collected through environmental courts and paid to the general treasury in Baghdad. The original intent of this provision may have been to assuage fears that corrupt officials would impose environmental strictures in order to pocket collected funds. But the maximum level of fines is so low—the equivalent of no more than $2500 per month—and the need for public services and industrial economic activities so high, that the result of this provision is to weaken enforcement capacity, as discussed below (**Section IV.C.: Fiscal Structure**).

Other laws mandate the same surface water, ground water, and soil pollution prevention mandated by Article 18 for public works projects and operations such as roads and bridges (Public Roads Law No. 35, GOI 2002), ports and harbors (Chapter IX of Instructions No. 1 of 1998, GOI 1998), riverbanks and beaches (Beaches Utilization Law No. 59, GOI 1987), and petroleum extraction (Hydrocarbon Resources Preservation Law No. 84, GOI 1985). In keeping with the MoEn's public health origins, water contamination is also prohibited within Public Health Law No. 89 (GOI 1981).

Following enactment in 1997 of the Environment Protection and Improvement Law, two additional measures were passed to provide teeth to provincial enforcement: Protecting Departmental Functions to Improve the Environment in the Provinces (Regulation No. 1 of 1998), and Pay Incentives for Provincial Environmental Protection Services (Regulation No. 2 of 1998) (GOI 1998).

Responding largely to oilfield operator attention to gross violation of even rudimentary pollution control standards (aimed largely at employee environmental health compliance), as well as international attention to marshland ecosystem and biodiversity collapse along international flyways, Resolution No.1 of 2015 on Rules of Procedure of the Department of Environmental Police establishes Environmental Protection Police centers in the various provinces. Their powers derive administratively from the General Directorate of Civil Defense in the Ministry of Interior, and at the technical level from the Ministry of Environment.

While broadly charged with environmental planning, monitoring, analysis, pollution control, and follow-up, their primary foci notably include "protecting natural reserves and habitats; providing protection for the teams of the Ministry of Environment during [fieldwork]; investigating environmental…crimes; and supervising the trading of dual-use chemicals." The latter explicitly refers to agricultural fertilizers and pesticides that can be employed, not just in stove-top manufacture of explosives, but in "toxic fishing" used by poachers to quickly move into an excluded zone, poison the water, harvest all, and flee. Thus, "environmental police" are less a response to innumerable studies that have consistently indicated the comprehensiveness of environmental law violation, the scale of environmental degradation, and demonstrated dissatisfaction with consequent

environmental injustice, and more a reinforcement of "fortress conservation" at the expense of local population provisioning needs.

What *does* recognize and respond to those needs—comprehensively so—is the 2013–2017 National Environmental Strategy and Action Plan for Iraq, published by the MoEn. Its explicit aim is "to improve the quality of life and livelihood of the population through the protection of natural resources and support to sustainable practices." Of its ten strategic objectives, improving air and water quality are the top two. These were developed "as a result of the active participation of all stakeholders, governmental and non-governmental, and intensive consultations…" Relevant to this study, it explicitly promotes—

> 1. *Engagement of different social categories, whether institutions or individuals, in decision making and implementation;*
> 2. *Concepts of voluntary work among individuals, groups and institutions …;*
> 3. *Optimal use of natural resources without loss or damage to the natural environment or prejudice to the ecological balance or biodiversity;*
> 4. *Adoption of policies and principles based on modern environmental concepts;*
> 5. *Encouragement of methods of irrigation and cultivation with the highest efficiency and the least rate of loss, in particular focusing on using untraditional water, such as greywater, rainwater harvesting, industrial wastewater, wastewater, and treated water;*
> 6. *Environmental monitoring and early warning…*

—all of which are reflected in the recommendations.

C. Agriculture and Animal Wealth

It is instructive that "Agriculture and Animal Wealth" is the inclusive category ascribed by the Iraqi Local Governance Law Library for all legal documents even remotely related to agronomic production, ranging from agrarian rights and land reform to all aspects of water and irrigation. This points to the fundamental legal conception of land, animal and plant life, and water as economic engines—and that these areas are a source of conflict sufficient to require legal mediation.

1. Agrarian Rights and Land Reform

There is a long history of state land grants being used to buy political support and spur both agronomic development and social mobility. Major land reform was undertaken in the 1970s under the Agrarian Reform Act (Law No. 117 of 1970) and State Lands Unification Act (Law No. 53 of 1976), with local stakeholder authority invested by the Provincial Agricultural Association Councils Act (Resolution No. 980 of 1979). 1980s-era regulatory measures issued by the Ministries of Agriculture and Irrigation—Resolution of Abandoned

Farmland (Regulation No. 9 of 1988), Resolution of Neglected Orchards (Regulation No. 10 of 1988), and Land Lease Reform for Nursery Purposes (Regulation No. 7 of 1989)—remain relevant to granting access rights to benefits generated by constructed wetlands on land now made barren by massive hydrological disruption. More recent legislation helps mediate such disputes, while recognizing the importance of land access to stabilizing IDP populations: the Agricultural Concessional Lending Fund Act (Law No. 28 of 2009), and the Agricultural Land Rents and Leases Act (Law No. 24 of 2013).

2. Livestock Husbandry

The surge of IDPs and their livestock from marshlands into urban zones has led to effective suspension of enforcement of the Animal Shelters and Animal Husbandry in Residential Neighborhoods Act (Law No. 33 of 1983) (GOI, 1983). Police both sympathize with poor populations who engage in animal husbandry to make a living and fear public outrage and violence were they to attempt enforcement within the sprawling extra-urban slums. The Natural Pastures Act (Law No. 2 of 1983) (GOI 1983) specifically governs the carrot offered by grazing commons, while the Livestock Confiscation Act (Law No. 1045 of 1980) (GOI 1980) provides the countervailing stick for abuses. Were there viable alternatives to rearing livestock in public parks and squatters camps, these measures could be productively re-invoked to encourage reverse migration to created grazing areas.

3. Fisheries and Aquaculture

The Fishing Act (Law No. 57 of 1938) (GOI 1938) governs fisheries, while the Fishing and Aquatic Life Exploitation and Protection Act (Law No. 48 of 1976) extends regulation to other marine life and includes limited powers for protection of some nursery habitat. The implementation Instructions for Resolution No. 30 of 2000 on Fishing (Regulation No. 10 of 2000) govern fishing practices, outlawing destructive harvesting by explosives, electric shock, and toxins. Especially relevant to constructed wetland habitat management, Regulation No. 30 of 2000 (GOI 2000) grants the Livestock Services Division of the Ministry of Agriculture authority to limit fishing seasons, in order to protect spawning grounds and runs. Thirty years ago, fish farming became regulated under the Fish Breeding Farms Act (Regulation No. 100 of 1985), including environmental protections related thereto. However, the more important regulation is the Ministry of Agriculture and Agrarian Reform Act for leasing state-owned, non-arable lands for fish farming (Resolution No. 995 of 1985). The latter explicitly authorizes state-owned land leases for fish farming, providing direct, high-value opportunity for economic development as a spinoff of constructed wetland development.

4. Forestry

Forestry regulation is relevant to management of constructed wetland conservation easements and windbreaks, including collection of brushwood and tree branches for fuel and construction material. The Forests and Woodlots Act (Law No. 30 of 2009) prohibits clear-cutting along watersheds or around water sources, and Planting and Care of Trees and Windbreaks for Industrial Purposes (Regulation No. 8 of 1995) regulates easements, rights of way, and harvest rights for protective green strips.

5. Water and Irrigation

Especially since construction of the Basrah River, Main Outfall Drain, and Third River drainage systems in the 1970s and 1980s, mediation of downstream control and authority between the Ministries of Water and Irrigation has become increasingly contentious. It is at this point unclear whether wastewater streams diverted into constructed wetlands would be classified as "irrigation works" or "waterways." If the former, they would be subject to governance under Irrigation Law No. 6 of 1962 and Maintenance of Irrigation and Drainage Networks Act (Law No. 12 of 1995), as outlined by Irrigation Ministry Companies and Bodies Law No. 44 of 1987, with authorization for the Minister of Irrigation to assess fines for violations (GOI 1984). Were this the case, its implications are discussed below (**Section IV.C.: Fiscal Structure**).

Hazardous waste discharge into waterways is prohibited by the Protection of Rivers and Public Water from Pollution Act (Law No. 25 of 1967). Prior to the 21st century, however, the primary concern regarding water management was flood control and prevention. With the advent of events described above (**Section I. Introduction: Wetlands Loss**), concern shifted to water scarcity.

Reinforcing protections under environmental statutes, The Preservation of Water Resources Act (Law No. 2 of 2001) was the most effective water regulation in the country prior to 2003. It specifically empowered the Environment Protection and Improvement Directorate (EPID) to establish specifications for wastewater recycling for any entity, public or private. Thereafter, the Ministry of Water Resources Act (Law No. 50 of 2008) created a legal and technical framework for regulating national water resources, under the authority of the Ministry of Water Resources. Whereas the environmental ministry is charged with protecting watersheds and water bodies, the water ministry is charged with investment, development, distribution, and maximum utilization of water resources. The potential for inter-ministerial conflict is explicitly addressed in Article 2. On the one hand, the Ministry of Water is granted the lead for international water-sharing and information exchange with its riparian basin neighbors, i.e., Turkey, Syria, and Iran, in order to obtain maximum inflow. On the other, it is charged to "preserve ground and surface water from pollution, giving

priority to the environmental aspect, and revive and maintain marshlands and other water surfaces" (Ahmmad 2012, p. 7) in accordance with Ministry of Environment mandates. In practice, in inter-agency disputes between them, the younger, more poorly-funded MoEn holds the losing hand. At the municipal level, powers devolve to the Governorate and municipal authorities, as set out in the General Authority for Water and Sewer Act of 1999.

D. Compliance Assessment

As discussed above (**Sections B. Environmental Protection, C.5. Water and Irrigation**), jurisdiction for implementation and compliance monitoring of environmental protection and anti-pollution law is invested in the MoEn. In terms of technical competence and capacity, despite chronic understaffing, for MoEn-Basrah this process is actually functioning well. The General Director and his staff are well and appropriately educated, maintain open communications with counterparts in other agencies, have sufficient laboratory and monitoring equipment to make essential measurements, have strong GIS support and acumen, and show clear understanding of municipal needs and priorities, backed by objective data (**Figure 15**).

The Ministries of Agriculture, Irrigation, and Water also conduct testing programs within their respective spheres, generally for soils and agricultural runoff (Agriculture), water suitability for agriculture (Irrigation), and water potability (Water), with some overlap. At the working level, testers frequently coordinate geographic lines of responsibility and share transportation, test equipment, and data to avoid redundancies. To monitor their own operational compliance, other major governmental operational units maintain internal environmental divisions certified to operate their own test equipment and laboratories, SOC being paramount in this regard. Funded by the Ministry of Oil, and required by law to meet International Organization for Standardization and other international testing certification standards, SOC's capacity for petroleum and other industrial contamination assessment is superior to that of the MoEn itself. Its capacity to *meet* those standards is a separate issue.

Similarly, at the municipal level, Hamdan STP maintains an on-site, ISO certifiable water testing laboratory staffed with a team of highly trained, skilled chemists and technicians, tasked with providing certified water quality analysis for every operation stage. Additional testing capacity of varying quality is available in departmental laboratories at the University of Basrah's Garmat Ali Campus, including those of the Marine Science Centre, College of Agriculture, College of Science, College of Engineering, and Date Palm Research Centre, all of whom maintain collegial relations with their Ministry counterparts, most of whom are their graduates.

IV. Compliance and Enforcement Obstacles

Iraq's 2005 constitution requires that the federal and regional governments ensure the "just distribution" of water. However, under that constitution, power over water is shared between Iraq's federal and regional governments, not directly with governorates themselves (Murthy 2010, p. 765). Since 2005, lack of efficient inter-governorate regulatory mechanisms has resulted in considerable friction between downstream governorates and their upstream neighbors. This is especially the case between Basrah and Thi Qar, not primarily due to issues related to water discharge volume, but rather to water discharge location, timing, and quality.

Because this issue remains seemingly intractable, village, municipal, and Governorate authorities have moved their focus to issues more firmly under their own control. What follows is a summary of impediments to effective implementation of relevant environmental law at the intra-Governorate level.

A. Physical Infrastructure

Two of the biggest sources of sewage pollution—the University of Basrah and Hamdan STP—currently fail to meet standards because they are physically incapable of doing so (**Appendix 2: Ecosystem Services Collapse and Wastewater Status**). One-off interventions to remedy glaring deficiencies can correct neither the lack of a supply chain for spare parts, nor the administrative and fiscal impediments to successful operation.

A 2010 retrofit of Hamdan's water testing laboratory is illustrative. Lab equipment, testing procedures, and working conditions were upgraded to meet ISO standards. Lab personnel underwent intensive training, re-training, and certification. Hamdan was certified as compliance-testing ready. Four years later, the lab was all but idle. No budget or supply chain was established for certain key components. Intermittent electricity outages stop ventilation hoods and fans, so even in mid-day heat, all windows must remain wide open to prevent inhalation of toxic fumes. And with secondary treatment systems down, water quality is so bad that it could not be introduced into the lab equipment without damaging it. "We are set up to test *drinking* water, not raw sewage," explained the director. Such conditions force personnel to resort to less sophisticated testing procedures, and each sample requires hours or days to process.

Publicly funded university labs suffer the same constraints and resort to the same workarounds. Businesses and industries boast little or no self-testing capacity. Hoping to capture an emerging market for certified, calibrated testing required to fulfill any number of medical and industrial needs, two commercial labs lasted less than one year: the 2015 economic crisis following the oil price bust left them with no customers. They relocated to

Jordan, but the high costs of HAZMAT customs clearance and DHL shipping makes mail-order lab work infeasible. Relatively cheap, off-the-shelf well test kits (**Figure 9.C**) might provide quick "meet or fail EPA standards" results, but are not certified for proof-of-compliance.

B. Administrative Infrastructure

Recognizing the dire water situation in Iraq, despite millions spent by international aid organizations on emergency relief and infrastructure upgrades, in 2006 WHO and UNICEF commissioned an external water quality management review. The study documented all-too-familiar administrative difficulties encountered by contractors in every sector:

- *Delays by the Authorities in formulating their needs and articulating their requirements in terms of type, parameters, layout and frequency of reports;*
- *Frequent changes in the Authorities' requirements leading to repeated re-work [and] protracted review and provision of comments by the Authorities…;*
- *Varying levels of staff skills and differing needs for [management] structure among the three Authorities;*
- *The Contractor's inability to manage multiple Authorities with their differing needs simultaneously and a number of holidays during the last two months of the year also severely affected the implementation.*
- *Lengthy procurement procedures. (Stars Orbit 2010, p. 4)*

Much of this administrative background noise remains, and need not be reiterated here. If anything, it attests to the inevitable ineffectiveness of "build it and leave it" projects encouraged under multinational contracting rules. At the working level, focused on the national Ministries in Baghdad, implementation of the report's specific recommendations resulted in laudable upgrades to MoEn's regional capacity.

What the report does not address are barriers *within* provincial administration. Law No. 27 of 2009, enacted to "improve and to protect the environment," established a Council referring to the MoEn and cooperating with other Ministries, with Small Councils to be established in the provinces. In practice, the disconnection between these laudable structures and infrastructure management is similar to the situation in the 1990s, at a number of sewage treatment plants struggling to comply with U.S. Environmental Protection Agency (EPA) wastewater discharge standards.

The first of these is sustainably *maintaining* managerial expertise. There exists tremendous "internal brain drain" throughout Iraq, but especially in Basrah, where competent, energetic managers and engineers are snapped up by oilfield operators, leaving a dearth of appropriately qualified personnel to serve the public sector. At Hamdan STP, managers and operators are smart, dedicated, and well-educated, with degrees in mechanical, chemical,

and electrical engineering. However, none have the civil, environmental, or biological engineering qualifications essential for effectively understanding and managing the aerobic and anaerobic microbial activity that pumps the heart of effective secondary treatment. This shortfall is compounded by the complete dearth of ecosystems services engineering in any engineering curricula in the country: "hardscape" water treatments are the only processes taught.[3]

The second of these is the delegation of responsibility with little or no discretionary authority. STP managers report to the Basrah Sewage Directorate, whose head reports to the Basrah Water Resources Directorate, who reports to the Municipal Public Works Council (where real decision authority resides), which reports to the Basrah Governorate Council. So, when the STPs are allocated funds, these are often earmarked for designated (contracted) projects, which there may or may not actually be capacity to execute. This places working-level managers in an impossible position. Though obligated to provide water quality data to MoEn, if they do so, their *agencies* are subject to fines for violations they have the responsibility to, but cannot, fix. Aware of this dilemma, environmental authorities do not *want* to officially receive that data, because if they did, they would be required by law to shut them down, eliminating what treatment is accomplished. High frustration all around is palpable. As a way forward from this impasse, the low-cost option of constructed wetlands, executable with in-house land and labor, was greeted with universal enthusiasm.

For the half of urban wastewater *not* piped to Hamdan STP, this gap between needs and manageable options is replicated across every suburb. Household wastewater is evacuated into sewage cisterns serviced by honey trucks or, in poorer neighborhoods, self-serve open sewage channels that ultimately drain into the rivers. Nominally, responsibility for waste management coordination to bring these streams into environmental compliance rests with community councils and homeowners, while sewer hookups are a municipal responsibility. None are adequately funded.

C. Fiscal Structure

The single greatest barrier to effective implementation and enforcement of environmental protections and standards in Iraq's southern delta is monetary. When confronted with the prevailing centralized, hardscape engineering model, neither the municipalities, nor the Governorate, nor the federal authorities have any reliable financial stream sufficient to address the grand scale of their own violations, let alone those of the civil and industrial sectors. Scrapping and replacing urban wastewater handling infrastructure with new, state-

[3] A shortfall currently being addressed by engineering curricular review, revision, and implementation under IREX University Linkages Program Subgrant Award No. FY16-IULP-USC-01 (final report due 17 January 2017).

of-the-art facilities would require budgetary commitments beyond the capacity of most U.S. cities, let alone cities burdened with swelling IDP communities and contributions to ongoing military crises. Compounding this is the extreme volatility of the national budget itself: pegged to and dependent upon national petroleum income, any international manipulation of crude oil prices can collapse national capacity to meet its budget obligations overnight, as happened during the ongoing economic crisis.

This gap between aspiration and fiscal capacity would at first glance seem to be recognized by Law No. 27 of 2009, enacted to "improve and to protect the environment" by "protecting public health and natural resources" and "handling damages." However "handling damages" refers, in this instance, not to imposition and management of violations fines, but rather to environmental disaster response. With no direct budgetary authority, MoEn was even in these cases forced to bootstrap environmental impact assessments, and then request and negotiate (future) budget appropriations sufficient to respond to the unfolding environmental threat. The inevitable result: too little, too late, and further erosion of MoEn's limited authority.

Recognizing MoEn's untenable position as evaluator and enforcer under these conditions, Instructions No. 1 of 2013, as amended by Instructions No. 4 of 2015, organized an Environmental Protection Fund (EPF), managed and administered by a Board of Directors, which in turn is established by a resolution of, and chaired by, the Minister of the Environment. The Board's functions are to establish the conditions for access to the fund; provide technical and economic assessment of projects for which funds are required; and follow reports of work in progress.

The laudable, overarching national activities sustained by the fund include environmental protection, establishing and managing nature reserves, increasing green areas, combating desertification, managing environmental disasters, supplying tools and equipment to combat pollution, financing studies to prepare environmental projects, supporting natural resources protection projects, creating networks of environmental control, and increasing environmental awareness among the population. This secure budgetary availability has certainly served to improve and sustain technical competence in regional offices (as in Basrah), and has sponsored excellent Governorate-level technical studies such as that of Basrah Creeks discussed in **Appendix 2: Basrah Creeks and Suburbs** (see also **Figure 10).** However, *quantifying* such problems is a far cry from *fixing* them, and the primary impediment to reducing or mitigating such impacts is the cost of implementation. Thus, while inexpensive projects with primarily aesthetic impact have been undertaken, the appalling governmental violations remain intractable.

To maintain the Fund, the EPF charges fees for services performed by its regional offices technical divisions, outlined in Annex I of Instructions No. 1. This casts MoEn officers as

internal consultants and consulting laboratories for other agencies (such as the Ministries of Public Works), funded by inter-agency recharge. In good times, this generates "income" that can be dedicated to otherwise unfunded environmental efforts. But in the face of extraordinary, unpredictable, and externally-driven budget volatility, impact assessments and lab work are among the first to fall to budget cuts in other agencies.

There are no revenue-generating income taxes or property taxes in Iraq; nor are there mechanisms for issuing municipal bonds to fund infrastructure improvement. Therefore, the only remaining potential revenue stream for effecting local fixes to prevent or mitigate violations is from fines assessed by the federal environmental courts. In both the United States and European Community, placing fines assessed by environmental authorities into escrow accounts, which are then used to incentivize or directly fund fixes, has proven effective in moving both municipal and corporate actors into compliance with clean water and air standards. In some cases, funds are rebated to the violator when standards are met; in others, they are applied directly to repairs, maintenance, or upgrades necessary to bring an activity into compliance; finally, they may be applied to mitigation efforts elsewhere in the enterprise, where greater environmental goods can be achieved at lower cost, to offset the harm caused by a technically or financially intractable violation.[4]

But a similar structure is not available to regional MoEn authorities. Fines assessed as a result of their environmental enforcement do not remain within Governorate control. Rather, they are paid by the courts into the general treasury in Baghdad, whence it is not guaranteed that they will be used even to support the national EPF, let alone return them to their locale of origin. The net result is that, as currently implemented, the fine payment structure serves as a *disincentive* to enforcement. Not only does it firmly place local environmental authorities in the position of making innumerable community and political enemies, it actually strips local communities of even more resources that might be used to effect improvements, and it opens everyone concerned to retaliatory charges of political favoritism and corruption.

V. International Donor and NGO Programs and Standards

As discussed throughout this paper, a range of obstacles stands in the way of providing adequate ecosystem services and sustaining livelihoods for the people of southern Iraq. Such obstacles include, for example, weak infrastructure, problems of governance, and the challenges of accounting for the needs of IDPs.

[4] Probably the best-known and most dramatic success in this regard is the long-term cleanup of the Cuyahoga River in Cleveland, Ohio—a river so polluted by industrial waste that in caught fire *13 times* between 1869 and 1970, triggering passage of the Clean Water Act and establishment of the Environmental Protection Agency (EPA). Now, the Cuyahoga boasts trout fishing and a National Park.

Successful constructed wetlands projects, particularly if implemented on a large scale, must anticipate and balance these various factors. In recent years, a range of international donors and NGOs have supported environmental, rule of law, and capacity building programs that plan for these factors in different ways. This section offers an overview of selected environmental projects in Iraq that have focused not only on scientific factors, but also the governance and human needs dimensions of the issue—as well as relevant environmental standards, as a reference for practitioners engaged in this area.

A. USAID

USAID has been involved in efforts to collect information on conditions for Iraq's marshlands. Drawing on data collected in 2003, USAID in 2004 formulated an Action Plan for the Iraq Marshlands Restoration Project (IMRP). A 2008 issue of the National Wetlands Newsletter, published by the Environmental Law Institute, details some of the findings of USAID's data collection efforts in 2003 and subsequent years (Richardson 2008). The IMRP development team was international and cross-sectoral, comprising Iraq's Ministries of Water Resources, Agriculture, and Environment; local officials from Maysan, Nasiriyah, and Basra; the University of Basrah College of Agriculture and Marine Science Center; representatives of the Iraq Foundation and AMAR International Charitable Foundation; and other advisors from Iraq, the United States, the United Kingdom, Jordan, Australia, and the Czech Republic. (USAID 2004, p. viii)

The IMRP Action Plan included a focus on social and economic assistance to local communities, as well as capacity building in marshland management, in addition to scientific assessment of marshland restoration (USAID 2004). The three-year plan included both national-level and marshland/local-level operations. National-level activities included strategic and comprehensive marshlands planning, hydrologic and hydraulic modeling, and capacity-building in marshland management and restoration. Marshland/local-level activities included integrated marshland management, agricultural production and agribusiness, livestock and dairy production, capture fishing and fish farming, public health, and constructed wetlands. The Action Plan had a proposed budget of $11,100,000 for the first year and $13,879,000 for the second and third years.

Additionally, USAID provided funds for the Strategy for Water and Land Resources in Iraq (SWLRI) project, a component of their Agriculture Reconstruction and Development in Iraq Program (ARDI). The project was initiated in May 2005, again in collaboration with the Ministry of Water Resources (MoWR). The long-term goal of the project was to "provide a sound and comprehensive basis for Iraq's management and development of its water and land resources over the next few decades, together with a framework and methodology for ongoing updating of plans" (USAID 2006, p. 1-1). The project was intended to provide

support to MoWR, which maintains primary responsibility for water and land resources planning. The project's intended activities included "assisting with the establishment of a new unit at the ministry's Sader Al Qanat complex; delivering data sets; handing over models and other tools, and providing capacity building in modern techniques for planning" (USAID 2006, p. 1-1).

More recent USAID projects in Iraq have focused on stabilization and economic reform. Specific projects include the USAID/Iraq Community Action Plan, which aimed to increase Iraqi citizens' ability to effectively address community concerns—including access to clean water—through organized democratic processes; the USAID-*Inma* Agribusiness Program, which aims to promote economic diversification and job generation by providing agricultural and business development services; the Iraq Governance Strengthening Project, which aimed to improve provincial financial management systems; the USAID/Iraq Broadening Participation Through Civil Society Project, which aimed to strengthen civic participation in Iraqi democracy by advancing professional, interactive, and collaborative civil society organizations; and the Iraq Access to Justice Program, designed to advance access to justice among vulnerable and disadvantaged populations in Iraq.

B. World Bank

The World Bank's Country Partnership Strategy (CPS), which covers the period July 1, 2012 to June 30, 2016, outlines its framework for engagement in Iraq on a variety of issues, including environmental issues (World Bank Group 2012). The CPS followed the conclusion of a series of Interim Strategy Notes, which previously guided the World Bank's engagement with Iraq, and it represents a shift from a transitional strategy to a deeper, more comprehensive partnership with Iraq.

The CPS outlines plans for addressing problems with water quality, sanitation, and delivery of drinking water in the context of various social and governance factors. For example, it notes that insecurity in rural areas has contributed to the movement of internally displaced persons into urban areas, which puts pressure on water and sanitation services. It also notes that the number of widows and young people in Iraq is high, making them and their households particularly vulnerable. In addition, Iraq faces challenges in providing an adequate social safety net for its people, particularly the most vulnerable sections of the population. The CPS notes a range of areas in which governance and institutional capacity is poor, such as the prevalence of corruption, weakness of transparency and accountability, ineffective public service delivery (including water), and weak citizen engagement in oversight of the public sector. In addition, the CPS notes that Iraq's top-down, centralized agricultural planning style has hampered the ability of farmers to identify ways in which to help improve conditions for the agricultural sector.

C. UNEP

From August 2004 to December 2009, the United Nations Environment Programme (UNEP) implemented the "Support for Environmental Management of the Iraqi Marshlands" project, with financial support from the Government of Japan and the Government of Italy (UNEP 2009). The project aimed to facilitate the management and restoration of marshlands by focusing on a broad variety of factors: monitoring marshland conditions, capacity building among Iraqi decision-makers and community representatives, identifying environmentally sound technology (EST) options for drinking water and sanitation, and developing a longer-term plan for the management of marshlands.

The project yielded lessons about the importance of maintaining a focus on the human dimensions of a complex problem. As Suzuki and Nakayama argue, the project focused disproportionately on the technical aspects of managing the marshlands and less on the basic human needs that motivated the project in the first place (Suzuki and Nakayama 2010, p. 126). For example, the project monitored changes in vegetation and re-flooding of the marshlands on a regular basis, but it only surveyed socioeconomic factors during one three-month period. UNEP acknowledges lessons learned in this regard, as well (UNEP 2009). For example, when the project began, UNEP discovered that local communities were wary of data collection and assessments that occurred before drinking water facilities were put in place, as the provision of clean drinking water was their primary concern. They also acknowledge the importance of involving multiple Iraqi stakeholders in the project, including local communities, Governorates, and national ministries. In conducting capacity building initiatives, they discovered that they had to be careful in selecting personnel for training activities, because selections were sometimes perceived as rewards for loyalty. They also learned that investing time and effort in community-level initiatives yielded significant results. For example, such initiatives helped generate support for larger components of the project and allowed implementers to address gender concerns within marshland communities.

D. CIDA

The Canadian International Development Agency (CIDA) has provided technical assistance to the restoration of the Iraq marshes through the Canada-Iraq Marshlands Initiative (CIMI). CIMI began in 2005 as a partnership between the Canadian and Iraqi governments and universities in both countries, as well as various NGOs, with a goal to "contribute to the development of a stable and prosperous southern Iraq and to support the social, economic, institutional and environmental sustainability of the Iraqi Marshlands" (CIMI 2010). The project components that focused on capacity building and training to enhance the skills and knowledge of scientists at universities in southern Iraq. The project identified the key

factors crucial for the sustainability of the marshes and developed objectives and recommendations to address each factor. The objectives included, among others, reducing wastewater and pollution; reducing the extent and nature of water-management conflicts; reducing the negative impacts of drought in the marshes; incorporating new and effective resource management methods to improve traditional methods of dealing with resources and the environment; establishing sustainable livelihoods based on a healthy population and a healthy marsh ecosystem; and developing a comprehensive land use plan that identifies protected areas in the marshes.

E. UNDP Social and Environmental Standards

The UNDP Social and Environmental Standards (SES) offer guidelines for programming that addresses environmental sustainability in conjunction with issues such as poverty, inequality, and other challenges faced by vulnerable populations. In particular, the SES provide a framework intended to help practitioners avoid aggravating existing social and economic issues already faced by vulnerable local populations when pursuing environmental sustainability.

Many Iraqi citizens, particularly vulnerable rural populations, depend on ecosystem services for their livelihoods, as discussed in this paper. SES Standard 1: Biodiversity Conservation and Sustainable Natural Resource Management, seeks to "maintain and enhance the goods and services provided by biodiversity and ecosystems in order to secure livelihoods, food, water and health…." (UNDP 2014, p. 13). UNDP argues that effective governance can help strengthen rights protections for affected populations, including women and others in local communities. UNDP employs such measures as assessments, experts, siting preferences, mitigation methods, use of offsets, and protected habitats to achieve sustainable biodiversity.

In order to mitigate or avoid adverse effects to the health and safety of impacted communities, UNDP employs SES Standard 3: Community Health, Safety and Working Conditions. Recognizing that "project activities, equipment, and infrastructure can increase community exposure to risks and impacts" (UNDP 2014, p. 23), UNDP establishes guidelines for protecting against community exposure to disease—with emphasis on marginalized groups—critically important in situations where water-borne diseases threaten IDP populations.

SES Standard 5: Displacement and Resettlement calls for practitioners to "enhance or at least restore the livelihoods of all displaced persons and to improve the standards of living of the displaced poor and other displaced groups and to support efforts to progressively realize the rights to adequate housing and adequate standards of living for displaced

populations" (UNDP 2014, p. 30). Projects that follow such guidelines are crucial for mitigating the impact on Iraqis displaced by marshland degradation.

F. International Union for Conservation of Nature

The International Union for Conservation of Nature (IUCN) provides public, private, and non-governmental organizations with resources related to economic development and environmental conservation. In 2012, the IUCN published a set of principles, guidelines, and best practices, along with illustrative case studies. One case study, "Restoring the Marshlands of Iraq," analyzed a number of international and domestic initiatives that took place from 2003 to 2008 to illustrate practical experience with implementing IUCN principles during ecological restoration. Efforts to restore these marshlands provided important benefits, argued IUCN, such as recovering unique ecosystems and building cultural heritage (IUCN 2012, p. 93). One of the biggest challenges that IUCN noted, however, was coordinating development policies and programming among national and international agencies in the region. Another was capacity, as there is a lack of prior experience and knowledge of planning and managing protected areas. Several projects at the local level focused on building long-term relationships with the communities based on planning and capacity building. Other elements of the projects were effective communication, research and monitoring, and the design of governance mechanisms to secure restoration investments (IUCN 2012, p. 93).

IUCN concluded its case study with a number of observations (IUCN 2012, p. 95):

- Donors and technical support staff need to consider traditional ecological knowledge of local communities when developing restoration projects.
- Marshlands management and governance regimes need to be clearly documented and respected.
- Restoration projects must consider the roles of civil society, the private sector, and the international community in marsh development.
- Environmental protection must be balanced with socioeconomic development.
- Many community leaders see the benefits of restoration but feel action is beyond their capacity. International donors and the Iraqi government need to recognize the importance of partnerships with local communities and capacity building.

VI. Models and Options

At face value, restoring ecosystem services by constructing wetlands presents a problem of administering a "commons" or "common pool resources"—a fraught endeavor under legal systems that prioritize individual rights-holders and private landholdings, e.g., that of the United States. However, in Iraq, where the state nominally has sole authority over allocating and leasing land, water, and related access, usage, and control, so long as placed on state land—and virtually all undeveloped land in southern Iraq *is* state-owned—in strict legal terms no "common pool resources" exist. They are state-owned.

Despite agreement over the scope of state land ownership, land disputes in Iraq are often heated and violent. Environmental inspectors fear violent reprisal if they attempt to enter a peripheral, solidly-built neighborhood, erected by former *Ahwari* on what everyone agrees to be government land, in order to test effluent quality and, if necessary, issue violator citations. The underlying reason for this problem is not a failure of rule of law. Rather, it is a deep, longstanding, fierce disagreement regarding *which* law.

Communities that depend on provisioning services for daily sustenance and survival cannot own and manage those services as individuals, nor can they risk degradation of those services by allowing outsiders free access to them. Formally or informally, these communities develop practices for sustainable management and institutions for mediating management disputes with neighboring communities. These systems include agreed mechanisms of authority for granting rights of access, formalized penalties for violations and collection of damages, and procedures for appeal. These systems are, in fact, a system of property law particularly suited to governing "limited common pool resources" (LCPRs), that is, ecosystem provisioning services situated within defined territorial boundaries controlled by self-identifiable communities. This was especially true of the *Ahwar* until its extra-judicial destruction.

Such alternative legal systems may appear "traditional" or "backward" to urban eyes, but they are vested with legitimate authority, and not only by those who live within them. They are explicitly recognized in Iraqi law by environmental jurisdictions granted to agricultural associations, tribal councils, and community councils in 1979 and 2010. As a model for legal practice, LCPRs are gaining Western recognition (Saunders 2011), and for professional jurists can serve as an intellectual bridge for understanding successful and failed relationships between these long-competitive legal systems is Iraq.

To be successful in providing a sustainable ecosystem that will mitigate civil tensions and prevent violence, constructed wetlands must accomplish three legal missions: technical success, governmental compliance, and negotiated managerial devolution.

Technical success refers to the capacity to function as intended in mitigating environmental pollution violations. Technical success alone, however, may deepen, rather than attenuate, conflict. For example, creating migratory bird habitat in a fashion that worsens groundwater pollution simply transfers environmental costs from one community to others, generating genuine and intractable conflicts of interest. Governmental compliance refers to the ability of public services to meet minimum environmental standards. If they do not, they not only engender public contempt for environmental law, but also push communities to invoke the legitimacy of their local LCPR legal systems over those of the central government. Negotiated managerial devolution prevents competitive rupture between these legal systems. Successful models for long-term ecosystem services maintenance integrate community, commercial, public, and private interests to sustainably restore, manage, and regulate provisioning services.

The following are examples of models (both successes and failures) for using constructed wetlands to clean wastewater and sustainably generate ecosystem services that accomplish all three missions.

A. United States: Phinizy Swamp: Mixed-System Tertiary Treatment

Figure 8: Phinizy Swamp Nature Park Constructed Wastewater Treatment Wetland. Three centuries ago, this area was a patchwork of tree-dominated swamps and reed-dominated marshes. Cleared and drained for agriculture, until 1973 it was still operating as a beef farm. Since 1993, when it was re-engineered for urban wastewater treatment, it has returned to swamp and marsh, with water quality and biodiversity equal to or better than that of surrounding wetland reserves.

The Phinizy Swamp, outside Augusta, Georgia, provides a model for a sustainable, flexible, adaptable sewage treatment system. It delivers effluent from the J.B. Messerly Water Pollution Control Plant (WPCP) to constructed wetlands, both to achieve EPA discharge water quality standards and to restore wetland habitat. With an operating capacity fifty times that of Basrah's Hamdan plant, it presents a scalable model, adjustable through time, to accommodate urban growth (**Figure 8**).

Even though newer technology now allows the plant to meet nitrogen standards without the wetland, its manifold ecosystem services benefits—recreation space, storm water overflow safety catchment, biodiversity habitat, cooling effects, carbon sequestration, and groundwater recharge—more than compensate for its low maintenance cost.

Of special note is Messerly WPCP's role in violation management. In 1999, in the wake of an order by the Georgia Environmental Protection Division for Augusta to correct many deficiencies, the municipality hired the firm Operations Management International (OMI) to operate and maintain the plant. Of particular concern was the city's failure to punish industrial customers that inadequately pre-treated their wastewater. OMI monitored collection intake points, and issued hundreds of notices to industries for wastewater infractions, then levied stiff fines against non-compliant violators. Fines were then used to offset plant maintenance costs.

For a number of reasons, Phinizy Swamp provides a readily comparable, feasible model for what could be accomplished with effluent from Hamdan STP (and comparable plants elsewhere in Iraq).

First, it was constructed on government land, owned by the public works department, as is the land within Hamdan and along the entirety of its effluent channel.

Second, decisions were made with the clear intention of resolving defined problems. Messerly WPCP—originally built in 1976—was simply unable to meet EPA requirements using its existing treatment methods. Further, post-storm storm water surges swamped the unit's retention capacity. The wetland cells were constructed to provide a low-energy, low-cost area for storm water drainage, as well as receive post-secondary wastewater, where natural bioactive processes removed excess nutrients and water treatment chemicals, such as nitrogen and chlorine.

Third, construction required permitting in accordance with federal laws as outlined in the Clean Water Act and implementing regulations, and construction was performed by private contractors, using local labor, with public funding. Phinizy's construction was not complex, requiring only equipment and methods identical to those used on a daily basis throughout Iraq for agricultural irrigation.

Fourth, Phinizy has utterly revitalized Butler Creek and its ecosystem, holding promise for Basrah's now-dead urban creeks. A waterway once classified, after years of raw sewage and industrial pollutant dumping, as a dead zone, was quickly colonized by a broad range of native species. Only native sawgrass was initially planted. Other plants and animals moved in from surrounding areas.

Fifth, Phinizy is large enough to sustain some harvesting of natural resources, livestock, and agriculture. No hunting or fishing is allowed within the parkland, which serves as a breeding and nesting refuge. However, a state-owned Wildlife Management Area (WMA) abuts it—a public sporting reserve managed by the Georgia Department of Natural Resources Wildlife Resources Division. Financed by public membership and hunting, fishing, and gun licensing fees, WMAs are locally managed to maximize sustainable fish and game harvests.

Finally, a research and education center was included as mitigation for alterations to the existing watershed. This center has proven enormously popular as a base for ongoing public research, education, and training, as well as for its role in transitioning the revitalized areas to highly popular greenspace.

B. Region

In terms of environmental conditions, wastewater input quality, and technical capacity, a project in Egypt supported by the European Commission-funded Sustainable Water Integrated Management program is particularly relevant to southern Iraq (El Gohary 2013: 19–53). This project used urban sewage to support afforestation and agriculture in environmental settings comparable to those in various locations throughout southern Iraq.

The Egyptian Ministries of Agriculture and Land Reclamation and Environmental Affairs established 24 projects along the upper and lower Nile and in the Sinai desert, growing trees, shrubs, flowers, ornamentals, and fodder crops. These plantations were thoroughly monitored over a two-year period, showing no adverse impacts on soil, plants, groundwater or health, even with only minimal primary treatment. Key components in all cases including training to sensitize farm workers on protection measures and water re-use hazards, vaccination of farm workers in compliance with STP work standards, and halting irrigation two weeks prior to harvest to minimize contaminant exposure.

Best practices findings were so positive and so directly applicable both to Iraqi legal structure and the human conditions in the IDP slums of Zubayr, that they are here quoted at length (with minor abridgements; emphasis added):

"3.3.1.1 Technical Criteria (Terms of Reference)

1. The treated wastewater *is up to standard*. The used wastewater is *compliant to standards*.

2. Reuse of wastewater is *integrated in the national plans for wastewater treatment and stems from the willingness of the government to increase the reuse of treated wastewater*.
3. Is effective in the reuse of treated wastewater. Using treated wastewater in reforestation and agriculture does not require advanced treatment systems. Reuse is simple through drip irrigation requiring little operation and maintenance with low human contact. The practice is efficient; it is simple in terms of installation and operation and has *very low environmental and health risks*.

"3.3.1.2 Impact

1. Has led to an increase in the use of wastewater for irrigation in agriculture and reforestation.
2. Is integrated in the national plans for wastewater treatment and reuse.
3. Can lead to a cost reduction in the treatment of wastewater...
4. The practice can lead to the prevention of pollution through the treatment of wastewater. It can lead to the greening of deserts, the improvement of biodiversity, carbon sequestration, the production of timber, biofuels (reduction of carbon emissions), silk and other byproducts. It can generate income and improve livelihoods. It has a potential for private sector involvement through a public-private partnership (PPP).

"3.3.1.3 Technical Feasibility

1. The developed system for treatment and reuse is simple and reliable. The selected plants used in agriculture and reforestation do not require intensive management and the irrigation system, if installed and operated as recommended, is almost hassle free.
2. The need for technical expertise is low.
3. The prospects of success of this practice are good due to its low requirements for technical expertise, low environmental and health risks and positive economic and financial feasibility.

"3.3.1.4 Financial Feasibility

The practice has been proven to be financially and economically feasible in the Egyptian context as detailed in the feasibility analysis undertaken by USAID and included in the references of this best practice.

"3.3.1.5 Affordability

Resources can be easily mobilized for this practice. Simple low cost wastewater treatment technology can be used. Operation and maintenance requirements are low; it is mainly the running of the irrigation pumps and maintenance of the network and plantations. There is potential for PPPs since the practice is economically and financially feasible." (El Gohary: 24–26)

The Egyptian case is notable for its reliance on local law, labor, expertise, and equipment, but equally so for its lack of direct community engagement and private participation. Given the potential health risks, these were operated as closed research stations, well outside their cities. The Gulf provides closer-to-home models.

1. Gulf Cities: Urban Wastewater Re-use

Gulf cities share with Basrah heat, humidity, aridity, and the problem of urban wastewater management. Being situated on rocky desert coasts, however, rather than within an ancient, silty delta, presents different technical challenges for wetlands construction. However, they do offer near-to-hand instruction and aspirational vision for water conservation and urban wastewater recycling, and valuable lessons learned from their successes and failures. Successful, sustainable projects with enforceable outcomes all included local training,

operations, and management plans. "Build it and leave it" projects let to international civil engineering contracts did not do this and uniformly failed. Examples follow.

Model for Failure: Doha. Doha is typical of Gulf cities rapidly transformed by oil wealth from small, pearl-trading ports into massive metropolitan areas. None of these have southern Iraq's jaded, outdated sewage system infrastructure—because none have in-ground sewage systems at all. As in Basrah's newer suburbs, there are no municipal sewer hookups: instead, all buildings, from skyscraper hotels to luxury homes, maintain sewage cisterns serviced by "honey trucks." The trucks suck up the raw sewage, then (if operating legally) transport it to sewage treatment facilities and pump it out again. Rapid urban growth has rendered this system unsustainable. Trucks line up for hours or days outside overtaxed facilities. Many simply do not bother, and dump the raw sewage out in the desert. Spills are common.

Laudably, Doha was one of the first to attempt a constructed wetlands solution to this ongoing problem. In 1982, Abu Nakhla Wetland was built by international contractors, as a centralized facility to receive and polish outflow from two conventional sewage treatment plants. Over four decades, it became a climax wetland ecosystem. But almost from the day it opened, Abu Nakhla was overwhelmed by the sheer volume of effluent influx. Operators were neither trained to comply with operations specifications, nor given the simple power to close the gate after X number of trucks rolled in. The net results were, on the one hand, a thriving fenced refuge for flamingos, migratory flocks, and other rare species; on the other, groundwater contamination with feces-borne human pathogens, resulting in pump-irrigated agriculture contamination, food recalls, permanent loss of agricultural production, public health hazards, and abandonment of constructed wetlands in favor of new, extremely expensive, conventional STPs (as yet not constructed). Al Nakhla is an illustrative, common failure of the "build it and leave it" model observable throughout the region.

Model for Wastewater Irrigation Research Stations: Dubai. Informed by these "intellectual capital" failures, under the Ministry of the Environment and Water (MoEW)'s 1992 "Water Resources Law for Exploitation, Protection and Development of the Living Aquatic Resources in the Waters of the United Arab Emirates," the International Center for Biosaline Agriculture (ICBA) conducts experiments to assist the MoEW in creating policy and regulations for the safe use of treated waste water in landscaping and agriculture, using tertiary-treated municipal wastewater from Dubai Municipality's Al Aweer STP. This NGO-Public-University partnership affords an excellent capacity-building model for Basrah (and other metropolitan areas) that have the distinct advantages afforded by a research university, engineering colleges responsible for training present and future managers and agency employees, with on-site capacity, commitment, and existing expertise germane to localized solution-testing.

2. Kuwait, Bahrain, and Saudi Arabia: Coastal Mitigation

Gulf coastal areas illustrate what can be accomplished to remediate massive petrochemical contamination and restore fisheries. Salty agricultural return and produced water streams may be mixed to restore and expand ecosystem services provided by salt marshes, adding shellfishing to the list. Funded by Iraqi war reparations in the wake of wartime oil spills, RPI has executed comprehensive coastal environmental mitigation contracts that successfully emphasize community engagement in ongoing, sustainable maintenance and management.

3. Oman: Produced Water

Constructed and operated by Bauer Nimr LLC on behalf of Oman's Petroleum Development Organization (PDO), Nimr Field offers *the* successful model for public-private partnership (PPP) driven produced water re-use research and operational training. Bauer operates state-of-the art laboratories, field test sites, training programs, and a kilometer-square constructed wetland, self-funded by oil recovery from the wastewater stream, successfully demonstrating sustained production of all the ecosystem services described herein. Direct conversations between Bauer and SOC were opened during this research.

VII. Conclusions

If overarching goals of increasing respect for and compliance with law include reducing social unrest and recruitment of IDP youth to violent crime, improving environmental justice by re-creating and providing access to common goods provided by ecosystem services is crucial to the task. Confronted daily with the abject failure of environmental law, citizens call into question their governments' fundamental commitment to meeting even their most basic needs and rights.

Basrah Governorate's wastewater management systems are profoundly broken, currently in gross violation of innumerable federal and state laws, and everyone knows this. However, public perception notwithstanding, the primary reasons are not criminal corruption, legal ignorance, or contempt for environmental law; rather the combination of fiscal unpredictability, administrative stovepipes, and ignorance of effective, low-cost, "non-hardscape" ecosystem services restoration options. Under these conditions paranoia, finger-pointing, and conspiracy theories prevail over effective action.

Restoring ecosystem services with constructed wetlands provides occupational training, economic opportunity, and direct support to "just living" by provisioning husbandry, agriculture, fisheries, and construction materials. For the growing educated classes, it also provides entry into commons management, monitoring, and enforcement career paths.

To improve respect for and adherence to environmental law, such law must be made enforceable in practice by amending penalty structures away from criminalization, and toward incentives for prevention and mitigation. In particular, to achieve these aims, locally assessed fines must be locally directed.

To avoid ecosystem services access becoming a new source of local conflict, stakeholder engagement through existing governing councils is essential. In order to enable effective municipal outreach into IDP communities, those communities themselves must be hired into the local management process. Successful ecosystems services regeneration projects, such as constructed wetlands, include local training, local operations, and workable local management plans. Failed projects do not.

Basrah, as most cities in Iraq, has the advantage of a research university and technical college responsible for training managers and MoEn employees, as well as the MoEn and STP labs they staff. Collectively, these entities already possess on-site capacity, commitment, and expertise necessary for effective, sustainable PPP partnerships and are ideally suited to house permanent lab-based operations.

VIII. Recommendations

A. Incentivize Reporting and Compliance for High-Priority Violations

1. **Fix-or-Fine.** Amend existing MoEn and MOW code to set progressive fine abatements for environmental violators, for corrective actions taken directly by the violator that (a) measurably improve combined ecosystem services, even if short of standards and (b) decrease future unmitigated violations.
2. **Fine-to-Fund.** Re-configure federal fine structure away from payment to General Fund (in Baghdad), and into municipal- and governorate-level escrow accounts for receipt and disbursal of environmental violation fines and mitigation assessments.
3. **Fund-to-Fix.** Prioritize direct application of escrow funds to concrete, corrective actions that will diminish or prevent future violation; thereafter to mitigation and remediation of the existing violation.
4. **Fix Local.** Promote resilience and sustainable operations by granting first precedence to projects that can be completed by violator or state employees with existing equipment, and/or by public-private training consortia.

B. Rights Designation and Management

1. Place primary responsibility and authority for wastewater management in suburbs, along creeks, and in extra-urban areas with local governing councils.
2. STPs and MoEn establish effluent "no entry" areas for public health and safety.
3. Establish no-entry/stream bank conservation easements, with harvest commons delineation and management delegated to specific communities.
4. Establish constructed wetlands treatment before distribution to and after recovery from agricultural operations, with priority to metropolitan mixed community garden-orchards in built-up areas, and PPPs in open areas.
5. Prohibit road traffic (except for official vehicles) except at engineered crossing points. Allow light boats for fishing and reed harvesting in designated areas.
6. Establish fish-farming PPP leases that include education regarding the need for protected zones and constructed wetlands for pre- and post-treatment of aquaculture water to prevent disease and organic waste pollution.

C. Continuing Education and Certification

1. Support existing major entities (Ministries; University, Technical College, and agricultural investors) in joint training and research to ensure common training and testing standards.
2. Require environmental operators and laboratories to complete a minimum number of annual continuing education hours in ecosystem services engineering and management.
3. Emphasize "continuous process improvement" rather than ISO Certification per se, which is at this point irrelevant unless funds are locked in for test equipment supplies and calibration.

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X. Interviews

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AL-MUKHTAR, Dr. Riyadh Sadeq M. Salih, Asst. Professor, Dept. of Chemical Engineering, Baghdad University of Technology.

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ABDULSADA, Khalel Fahad, Chairman, Planning and Implementation, Basrah Water Resources Directorate.

ADJI, Ahmed, Director, Wastewater Management, Basrah Water Resources Directorate.

AJRASH, Ahmed Hanoon Jassim, Director-General, Office of Environment Protection and Improvement, Southern Iraq, ROI Iraq Ministry of Environment.

AL-ASADI, Salih, Abu Ramadan, Head, Al Hiadrah Village.

AL FARTUSI, Dr. Mohsin, World Health Organization, Basrah Office.

ALABEED, Mr. Qahtan, Director of Antiquities and Cultural Heritage, Basrah Governorate.

ALBACHARY, Mr. Hatem, Head, Iraqi/ British Chamber of Commerce, Basrah.

AL-KANAANI, Adil Abdullah Jolan, Head, Environment Division, South Oil Co.

AL-KAWAZ, Shaima Ibrahim Abdul-Rasool, Journalist and Environmental Activist.

AL-MALIKY, Jassim Hussein Abdullah, former Manager, Dept. of Marshland Development, Iraq Ministry of Agriculture and present PhD. Candidate, Agricultural Engineering, College of Science, University of Basrah.

AL-MASHAD, Mohammed Abu Nadir, Buffalo Farmer, Hareer Khaber.

ALMUSAWI, Dheyaa J., Director–Manager, South Oil Company.

ALSAWAD, Hayn A. Abdul Zahra, Director-General, South Oil Company.

ANONYMOUS, Fishermen, East Hammar (Bani Malik Al-Shamaylia, Hareer Marine Field Station, Hareer Sugher, Abu Salabikh); Shatt Al Basrah, and Shatt Al Arab (Al-Haritah, Ad Dayr, Shafi, Al-Bubsairy, Duwa, Al-Sharish).

BADRAN, Alaa Hashem Salem, Basrah Governorate Council.

CAMPBELL, Piper Anne Wind, Consul General, U.S. Consulate General, Basrah.

FAKHER, Naser Hashem, Director, Dept. of Environment, South Oil Company.

HALIM, Abdel Basset Abdel, Basrah Water Resources Directorate.

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D. Region

AL AMRI, Mundher Khamis Matar, Wetland Manager, Al Ansab Wetland, Haya Water, Muscat, Sultanate of Oman.

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E. USA

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APPENDICES

A. Appendix 1: Relevant Iraqi Laws and Regulations

Comprehensive databases of English-language abstracts (FAO) and full Arabic-language texts (in some cases translated to English) are listed below.

The following list includes major regulations and laws, currently in force, that are directly relevant to establishment, management, and enforcement of environmental standards, water and irrigation rights, and other rights impacted by or arising from constructed wetlands ecosystem services benefits. This list is not exhaustive, and should always be supplemented by local Region and Governorate acts, as well as ongoing updates to the databases above.

FAO, 2016. FAOLEX-Iraq. Legislative Database of the FAO Legal Office. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=000101&database=valid&search_type=link&lang=eng&format_name=@ESPRF . Accessed 18 September 2016.

FAO, 2016. WaterLex-Iraq. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=000101&database=valid&search_type=link&lang=eng&format_name=@ESWAT. Accessed 18 September 2016.

Iraqi Local Governance Law Library, 2016.http://www.iraq-lg-law.org/en. Accessed 17 September 2016.

State of Qatar. 2016. Qatar Legal Portal (Al Meezan). Doha: Ministry of Justice. http://www.almeezan.qa. Accessed 23 September 2016.

US Library of Congress. Legislation on use of water in agriculture in Lebanon, Yemen, Saudi Arabia, and Iraq. http://www.loc.gov/law/help/water-law/middle-east.php. Accessed 23 September 2016.

A-I. General Administrative

GOI 1951. Iraqi Civil Code No. 40, Iraqi Official Gazette, No. 3015 on 08 September 1951, p. 243. TidesCenter Resource Equity. http://landwise.resourceequity.org/record/750. Accessed 23 September 2016.

GOI, 2003. Penal Code 111 of 1969 and its Amendments, Iraqi Official Gazette, No. 3980 on 10 September 2003, p. 31. http://www.iraq-lg-law.org/en/content/penal-code-no-111-1969-amended. Accessed 23 September 2016.

GOI, 2008. Government and Public Sector Employees Salaries Act (Law No.22 of 2008). http://www.iraq-lg-law.org/en/node/359. Accessed 17 September 2016.

GOI, 2010. Basrah Local Powers Act (Law 1 of 2010). العدد البصرة لمحافظة الرسمية الجريدة 1. http://www.iraq-lg-law.org/en/node/199. Accessed 17 September 2016.

A-II. Environmental Protection

GOI, 1981. Public Health Law No 89, Iraqi Official Gazette, No. 2848 on 17 August 1981, p. 759, Vol. 2. قانون الصحة العامة رقم 89 لسنة 1981 المعدل. http://www.iraq-lg-law.org/en/node/635. Accessed 23 September 2016.

GOI, 1985. Hydrocarbon Resources Preservation Law No. 84, Iraqi Official Gazette, No. 3061 on 21 October 1985, p. 734, Vol. 2.

GOI, 1987. Beaches Utilization Law No. 59, Iraqi Official Gazette, No. 3157 on 06 July1987, p. 390, Vol. 2. قانون استغلال الشواطئ رقم 59 لسنة 1987 المعدل. http://www.iraq-lg-law.org/en/node/747. Accessed 23 September 2016.

GOI, 1998. Chapter IX of Instructions No. 1 of 1998 on the Iraqi Ports and Harbors, Iraqi Official Gazette, No. 3731 on 20 July 1998, Inst No.1.

GOI, 1998. Pay incentives for Provincial Environmental Protection Services (Regulation No. 2 of 1998). المحافظات في البيئة وتحسين حماية لدائرة والاجور الحوافز 1998 لسنة (2) رقم نظام. http://www.iraq-lg-law.org/en/node/1286. Accessed 17 September 2016.

GOI, 1998. Protecting departmental functions to improve the environment in the provinces (Regulation No. 1 of 1998). المحافظات في البيئة وتحسين حماية اقسام مهام 1998 لسنة (1) رقم تعليمات وتشكيلاتها. http://www.iraq-lg-law.org/en/node/1288. Accessed 17 September 2016.

GOI, 2002. Public Roads Law No. 35, Iraqi Official Gazette, No. 3947 on 09 September 2002, p. 450, Vol. قانون الطرق العامة رقم (35) لسنة 2002 المعدل. http://www.iraq-lg-law.org/en/node/115. Accessed 23 September 2016.

GOI, 2009. Environmental Protection Act (Law No. 27 of 2009). قانون حماية وتحسين البيئة رقم 27 لسنة 2009. http://www.iraq-lg-law.org/en/node/773. Accessed 17 September 2016.

GOI, 2010. Wildlife Protection Act (Law No. 17 of 2010) قانون حماية الحيوانات البرية رقم 17 لسنة. Iraqi Local Governance Law Library. http://www.iraq-lg-law.org/en/node/1268. Accessed 17 September 2016.

GOI, 2013. Instructions No.1 for the year 2013 the Environmental Protection Fund. رقم (1) لسنة 2013 – تعليمات صندوق حماية البيئة. FAOLEX No: LEX-FAOC147978. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=147978&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

GOI, 2013. The National Environmental Strategy and Action Plan for Iraq. FAOLEX No: LEX-FAOC155814. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=155814&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

GOI, 2015. Instructions No. 4 of 2015 - First Amendment of Instructions No.1 of 2013 for the Environmental Protection Fund. صندوق لتعليمات الاول التعديل - 2015 لسنة (4) رقم تعليمات رقم البيئة حماية (1) لسنة 2013. FAOLEX No: LEX-FAOC149752. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=149752&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

GOI, 2015. Iraq: Resolution No.1 of 2015 on Rules of Procedure of the Department of Environmental Police. النظام الداخلي لقسم الشرطة البيئية رقم 1 لسنة 2015. FAOLEX No: LEX-FAOC153322. http://faolex.fao.org/cgi-

bin/faolex.exe?rec_id=153322&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

A-III. Agriculture and Animal Wealth

"Agriculture and Animal Wealth" is the inclusive category ascribed by the Iraqi Local Governance Law Library for all legal documents listed below, including those covering water and irrigation. Subcategory groupings are provided for ease of reference.

A. Agrarian Rights and Land Reform

GOI, 1970. Agrarian Reform Act (Law No. 117 of 1970) (amended). قانون الاصلاح الزراعي رقم 117 لسنة 1970 المعدل. http://www.iraq-lg-law.org/en/node/447. Accessed 17 September 2016.

GOI, 1976. State Lands Unification Act (Law No. 53 of 1976). قانون توحيد أصناف أراضي الدولة رقم 53 لسنة 1976. http://www.iraq-lg-law.org/en/search_by_jurisdiction. Accessed 17 September 2016.

GOI, 1979. Provincial Agricultural Association Councils Act (Resolution No. 980 of 1979). قرار مجلس قيادة الثورة (المنحل) رقم 980 لسنة 1979 حول ارتباط المجالس الزراعية في المحافظات. http://www.iraq-lg-law.org/en/node/1130. Accessed 17 September 2016.

GOI, 1988. Resolution of Abandoned Farmland (Regulation No. 9 of 1988) issued by the Ministries of Agriculture and Irrigation. تعليمات رقم (9) لسنة 1988 صادرة عن وزير الزراعة والري بشان حل الاراضي الزراعية المتروكة. http://www.iraq-lg-law.org/en/node/1811. Accessed 17 September 2016.

GOI, 1988. Resolution of Neglected Orchards (Regulation No. 10 of 1988) issued by the Minister of Agriculture and Irrigation. تعليمات رقم (10) لسنة 1988 صادرة عن وزير الزراعة والري بشان حل البساتين المهملة. http://www.iraq-lg-law.org/en/node/1801. Accessed 17 September 2016.

GOI, 1989. Land Lease Reform for Nursery Purposes (Regulation No. 7 of 1989). تعليمات رقم (7) لسنة 1989 بشأن تأجير اراضي الاصلاح الزراعي لاغراض المشاتل. http://www.iraq-lg-law.org/en/node/1578. Accessed 17 September 2016.

GOI, 2009. Agricultural Concessional Lending Fund Act (Law No. 28 of 2009) (as amended). قانون الاقراض الزراعي الميسر رقم 28 لسنة 2009 (المعدل). http://www.iraq-lg-law.org/en/node/539. Accessed 17 September 2016.

GOI, 2013. Agricultural Land Ownership, Rents, and Leases Act (Law No. 24 of 2013). قانون تنظيم إيجار الأراضي الزراعية وتمليك حق التصرف فيها للخريجين الزراعيين والبيطريين رقم (24) لسنة 2013. http://www.iraq-lg-law.org/en/node/2505. Accessed 17 September 2016.

B. Livestock Husbandry

GOI, 1980. Livestock Confiscation Act for livestock that graze in agricultural and fenced areas or at forbidden grazing rates (Law No. 1045 of 1980). قرار مجلس قيادة الثورة (المنحل)

المعدل فيها الرعي المحرم او والمسيجة الزراعية المناطق في ترعى التي المواشي مصادرة 1980 لسنة 1045 رقم. http://www.iraq-lg-law.org/en/node/1956. Accessed 17 September 2016.

GOI, 1983. Animal Shelters and Animal Husbandry in Residential Neighborhoods (Law No. 33 of 1983). السكنية الاحياء في الحيوانات وتربية ايواء بشأن 1983 لسنة (33) رقم يان. http://www.iraq-lg-law.org/en/node/1959. Accessed 17 September 2016.

GOI, 1983. Natural Pastures Act (Law No. 2 of 1983). قانون رقم الطبيعية المراعي (2) لسنة 1983. http://www.iraq-lg-law.org/en/node/940. Accessed 17 September 2016.

C. Fisheries and Aquaculture

GOI, 1938. Fishing Act (Law No. 57 of 1938). قانون رقم الصيد (57) لسنة 1938 المعدل. Iraqi Local Governance Law Library. http://www.iraq-lg-law.org/en/node/1195. Accessed 17 September 2016.

GOI, 1976. Fishing and Aquatic Life Exploitation and Protection Act (Law No. 48 of 1976). تنظيم صيد واستغلال الاحياء المائية وحمايتها رقم (48) لسنة 1976. Iraqi Local Governance Law Library. http://www.iraq-lg-law.org/en/node/861. Accessed 17 September 2016.

GOI, 1985. Ministry of Agriculture and Agrarian Reform Act for leasing state-owned, non-arable lands for fish farming (Resolution No. 995 of 1985). قرار مجلس قيادة الثورة (المنحل) بحق المنتقلة غير للدولة المملوكة الاراضي تاجير الزراعي والاصلاح الزراعة وزارة تخويل 1985 لسنة 995 رقم عليه الاسماك لتربية مزارع لانشاء للزراعة الصالحة وغير التصرف. http://www.iraq-lg-law.org/en/node/1955. Accessed 17 September 2016.

GOI, 1985. Fish Breeding Farms Act (Regulation No. 100 of 1985) (amended). رقم تعليمات (100) لسنة 1985 بشأن تربية مزارع الاسماك (المعدلة). http://www.iraq-lg-law.org/en/node/1953. Accessed 17 September 2016.

GOI, 2000. Implementation Instructions for Resolution No. 30 of 2000 on Fishing (Regulation No. 10 of 2000). رقم تعليمات (10) لسنة 2000 تسهيل تنفيذ قرار رقم 30 لسنة 2000 حول الاسماك صيد. http://www.iraq-lg-law.org/en/node/1184. Accessed 17 September 2016.

GOI, 2010. Granting the General Company for Livestock Services power to determine the period during which fishing is forbidden (Regulation No. 30 of 2000). قرار رقم 30 لسنة 2000 منح صلاحية تحديد المدة التي يمنع فيها صيد الاسماك للشركة العامة لخدمات الثروة الحيوانية. http://www.iraq-lg-law.org/en/node/849. Accessed 17 September 2016.

D. Forestry

GOI, 1995. Planting and Care of Trees and Windbreaks for Industrial Purposes (Regulation No. 8 of 1995). رقم تعليمات (8) لسنة 1995 غرس رعاية وشجار مصدات الرياح للاغراض الصناعية. Accessed 17 September 2016.

GOI, 2009. Forests and Woodlots Act (Law No. 30 of 2009). قانون الغابات والمشاجر رقم 30 لسنة 2009. http://www.iraq-lg-law.org/en/node/1301. Accessed 17 September 2016.

E. Water and Irrigation

GOI, 1962. Irrigation Law No. 6, Iraqi Official Gazette, No. 645 on 20 January 1962, p. 25. FAOLEX No: LEX-FAOC147232. قانون الري رقم (6) لسنة 1962. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=147232&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

GOI, 1967. Protection of Rivers and Public Water from Pollution No. 25 of 1967, Iraqi Official Gazette, No. 1446 on 16 July 1967, p. 108, Vol. 2. بشأن (25) رقم التنظيمية اللائحة التلوث ضد العامة والمياه الأنهر على المحافظة. FAOLEX No: LEX-FAOC038268 http://faolex.fao.org/docs/pdf/irq38268E.pdf Accessed 21 September 2016.

GOI, 1984. Authorization for the Minister of Irrigation to assess fines specified in paragraph (iii) of the Revolution Command Council Resolution No. (622) at the 05/06/1984 (Resolution No. 826 of 1984). وزير تخويل 1984 لسنة 826 رقم (المنحل) الثورة قيادة مجلس قرار في (622) المرقم الثورة قيادة مجلس قرار من (ثالثا) الفقرة في عليها المنصوص الغرامة قرض صلاحية الري 1984/6/5. http://www.iraq-lg-law.org/en/node/1177. Accessed 17 September 2016.

GOI, 1987. Irrigation Ministry Companies and Bodies Law No. 44, Iraqi Official Gazette, No. 3153 on 08 June 1987, p. 360, Vol. 1

GOI, 1995. Maintenance of Irrigation and Drainage Networks Act (Law No. 12 of 1995). قانون صيانة شبكات الري والبزل رقم (12) 1995 المعد. http://www.iraq-lg-law.org/en/node/715. Accessed 17 September 2016.

GOI, 1999. Law of the General Authority for Water and Sewage No: 27, Iraqi Official Gazette, No. 3788 on 23 August 1999, p. 495. Food and Agriculture Organization of the United Nations FAOLEX No: LEX-FAOC 145550. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=145550&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 17 September 2016.

GOI, 2001. Iraq: Abstract: Law No. 2 of 2001 on Preservation of Water Resources. Food and Agriculture Organization of the United Nations FAOLEX No: LEX-FAOC146993. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=146993&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 13 September 2016.

GOI, 2008. Ministry of Water Resources Law No. 50, Iraqi Official Gazette, No. 4098 on 24 November 2008, p. 8. Food and Agriculture Organization of the United Nations FAOLEX No: LEX-FAOC147092. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=147092&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 17 September 2016.

GOI, 2010. General Authority for Water and Sewer Act. 2010. قانون الهيئة العامة للماء والمجاري. http://www.iraq-lg-law.org/en/node/231. Accessed 17 September 2016.

GOI, 2012. Act on National Determinants for the use of Treated Wastewater in Agriculture Irrigation No.3 of 2012. نظام المحددات الوطنية لاستخدام مياه الصرف الصحي في المعالجة الري الزراعي رقم (3) لسنة 2012. LEX-FAOC149859. http://faolex.fao.org/cgi-bin/faolex.exe?rec_id=149859&database=faolex&search_type=link&table=result&lang=eng&format_name=@ERALL. Accessed 23 September 2016.

B. Appendix 2: Ecosystem Services Collapse and Wastewater Status

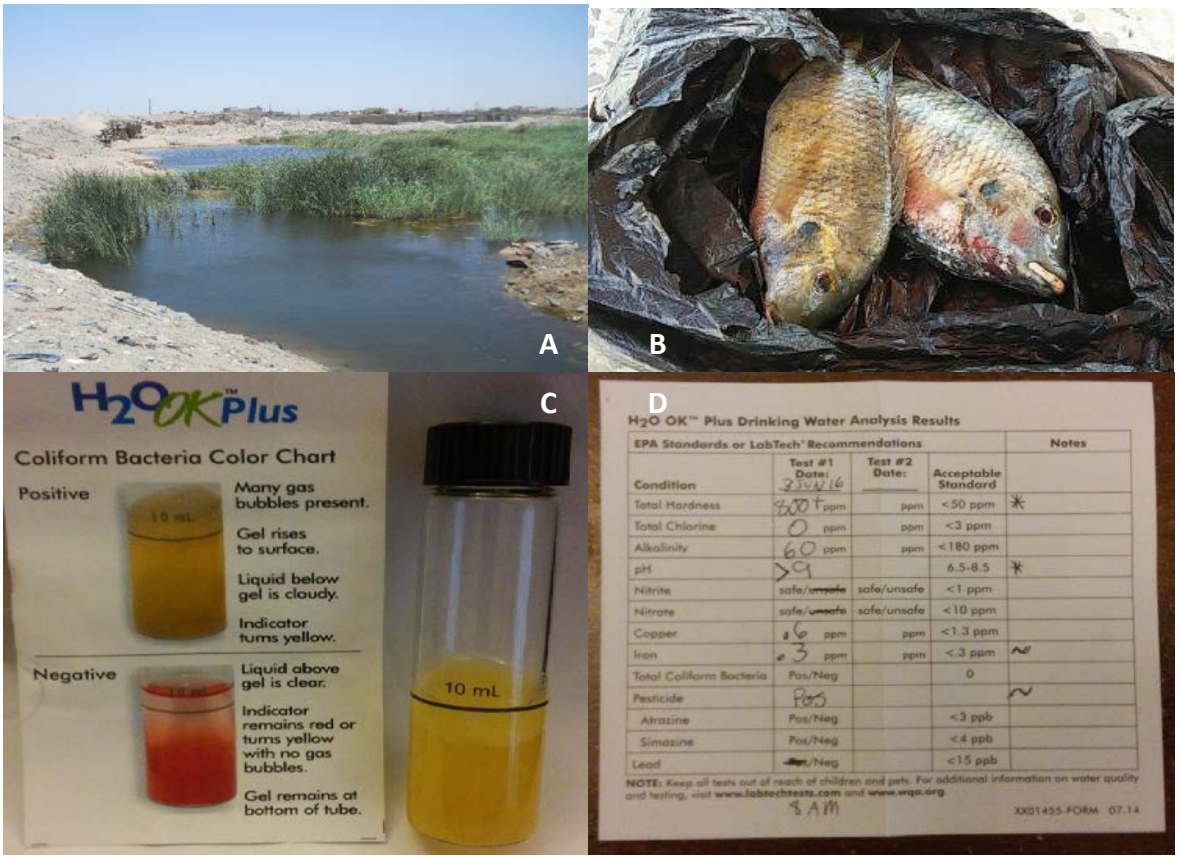

Figure 9: Public Health Impacts: Fecal-Oral Disease Transmission. (A) Zubayr Landfill, where impoverished IDP harvest reeds. Sites like these do not efficiently remove contaminants. (B) Cholera bacterium have been found colonizing fish mucous, especially in pollution-distressed fish populations. WHO-Basrah fears that cholera is being spread by improper disinfection after handling raw fish prior to cooking. (C) Coliform bacteria—the key "indicator species" for fecal contamination—is present in tap water even after harsh chemical treatment. (D) Even after boiling, tap water is unsafe for cooking due to high pH and total hardness.

Since their collapse, southern Iraq's wetlands have lost the ability to provide the full variety of essential ecosystem services that benefited local populations and underpinned their livelihoods. At the same time, greater Basrah's wastewater management systems are profoundly broken, currently in gross violation of innumerable federal and state laws.[5] This section provides an overview of how the loss of various ecosystem services and the problems with Basrah's wastewater management systems have affected environmental and living conditions.

[5] The current state of Basrah City and Basrah Governorate waste water streams was assessed by direct inspection, technical expert consultation, review of university research and test results, review of municipal and Iraq Ministry laboratory test results, through individual and collective interviews (**Section X: Interviews**), and literature review (**Section IX: References**). All interviews were conducted under Chatham House Rules.

B-I. Ecosystem Services Collapse

Clean Water. Previously, the *Ahwar* stopped suspended sediments and neutralized pollutants. Now, burdened by a ten- to hundred-fold decrease in incoming water quality, Basrah Governorate's water treatment plants are operating far beyond capacity. Tap water is potentially unsafe even for hand, face, and dish-washing, and water hardness sixteen times above EPA's maximum safe standards contributes to extremely high rates of kidney, bladder, and gall bladder stones (**Figure 9.D**).

Figure 10: Urban Surface Wastewater. (A) Basrah Creeks. Only half of the greater metropolitan area is connected to municipal storm- and sewage-collection systems. (B) Livestock markets and unpermitted IDP housing cluster along urban watersheds, adding to the organic waste load. (C) Waste load fouls the waterline along the Corniche. (D) Wind-blown trash aggregates hazards and pollutants in what have become open sewers of water unfit for any purpose.

Sediment Entrapment. Dust laced with industrial pollutants, trash, and other debris is washed into urban watersheds, contributing to high loads of suspended sediment in Basrah's waterways (**Figure 10.C** and **Figure 10.D**).

Tidal Flushing. Historically, rising sea tides allowed the entire canal-and-creek system in Basrah to be flushed with fresh water. Currently, only half of Basrah's greater metropolitan area is connected to municipal storm- and sewage-collection systems, and unpermitted IDP housing and livestock markets add to the organic waste load (**Figure 10.A and Figure 10.B**). Tidal push no longer reaches the creeks, and Basrah is now in effect criss-crossed by open sewers, whose waters are deemed "unfit for any purpose" by the Ministries of Environment and Public Health (**Figure 10.C and Figure 10.D**).

Figure 11: Fisheries Impacts. *(A) Decomposition of organic waste and dying algae depletes dissolved oxygen, resulting in mass fish kills. High temperatures exacerbate the problem. (B) Loss of breeding habitat has virtually eliminated annual migratory fish runs. Gill nets strung across the Shatt Al Arab every 100m obstruct upstream navigation. (C) Net impact is a rapid reduction in average sizes for fish populations, as well as near-collapse of overall catch. This fingerling is the total result of one entire day of effort. (D) As recently as 1990, river-spawned fish were both a dietary staple and a major export. Basrah grocers now sell frozen fish, imported from Myanmar.*

Microclimate Mediation. Decomposition of organic waste and dying algae results in mass fish kills, and high temperatures exacerbate the problem (**Figure 11.A)**. Diminished marsh surface area has accelerated local temperature rise and lowered local humidity (UNEP 2001, p.5). These factors in turn accelerate surface water evaporation, increasing water salinity.

Provisioning Services: Fish Populations and Biomass. The *Ahwar* collapse has also resulted in the loss of various "provisioning services"—material benefits that can be extracted from the ecosystem. For example, fresh- and salt-water fisheries stocks have collapsed, and annual migratory fish runs from and to the Gulf have been virtually eliminated (**Figure 11.B**) (UNEP 2001, p. 35). The loss of biomass seriously threatens local livelihoods, as such biomass previously provided over 60% of livestock fodder, nearly 100% of construction material, pottery- and brick-kiln fuel, and substantial income from the production of reed matting and packing basketry sold nation-wide. Moreover, the combination of water pollution, agricultural waste, and collapse of reed beds has all but collapsed livestock husbandry and dairy production.

In order to purchase potable water, a small percentage of IDPs harvest reed for sale to consolidators who supply urban markets. The net result of this effort is overharvesting, leading to further collapse of marsh ecosystems, as well as water fouling along roadways (**Figure 12.F**).

Figure 12: Urban Husbandry Impacts—Reed Bed Overexploitation. (A) In traditional within-marsh husbandry, most livestock were protected and reared in cattle sheds situated on man-made dwelling platforms in or on the margins of marshes. Here, weanlings feast on hay made from cattail and reed shoots. (B-E) A small percentage of IDP now cluster along roadways through remaining wetlands, in order to harvest reed for sale to urban livestock markets. (F) This results in overharvesting and water fouling along roadways.

B-II. Wastewater Status

A. University Wastewater

Figure 13: University of Basrah Wastewater Effluent. (A) Under-road culvert for creek drainage into the Shatt Al-Arab. The old, higher shoreline—which used to submerge the pipes, allowing for tidal back-flush—is clear along the bank. (B) Discharge water, murky brown with suspended organic waste, contrasts with the clearer, bluer water of the river.

The University of Basrah's Garmat Ali campus collects and directs its wastewater streams to its sewage treatment plant (STP). The plant currently stands idle, as funds for ongoing operating fuel were stripped by national authorities during the 2015 economic crisis. The required amount is small, but the legal impediments to moving funds between categories are perceived to be huge. Even were it operating, the plant would offer only partial treatment. With the plant idle, 100% of campus wastewater flows untreated directly into an urban creek, eventually leading the wastewater just upstream from the city's water treatment and distribution facility intake pipes. Raw sewage is being fed directly into the city's water intake system.

B. Urban Wastewater: Storm Water and Sewage

Figure 14: Hamdan Sewage Treatment Plant Effluent. (A) Effluent discharge gate. (B) Effluent discharge canal. Reeds (*Phragmites*) volunteer along the narrow banks, but cannot root in the center of the 3m-deep channel. Dredged sludge accumulates along the right bank, reinforcing canalization. (C) Channel junction regulator, choked with suspended solids. Even here, in open air hundreds of meters downstream, hydrogen sulfide gas emissions exceed health and safety standards. (D) Effluent discharge into the Basrah River. By law, effluent should meet tertiary treatment standards before discharge. Even to untrained eyes, this is not remotely close.

Hamdan Sewage Treatment Plant. Built in the early 1990s by a now-defunct contractor registered in India, the Hamdan STP handles 55% of urban wastewater from Basrah's incorporated areas. The plant suffers from a chronic lack of repair parts and repair expertise. As of 2014, portions of the treatment process were under contract with a Chinese firm, but construction stopped during the 2015 economic crisis.

After treatment, two channels discharge effluent into a canal that empties into the Basrah River (**Figure 14**). By law, the plant is required to meet tertiary treatment water quality standards before discharge into any waterway. However, after Coalition forces incorrectly identified the original tertiary plant as a bunker and destroyed it, the Hamdan STP was granted a ten-year waiver for reduced standards. Since the budget collapse, it has technically been operating outside permitted standards, but *de facto* under a tacit extension waiving tertiary treatment. Thus, water discharged into a major waterway is essentially still raw sewage.[6]

[6] For example, post-treatment biochemical oxygen demand—the amount of dissolved oxygen needed by aerobic biological organisms to break down organic material in water—is 2 ½ times recommended post-secondary levels in the water upstream from the container port at Umm Qasr.

Basrah Creeks and Suburbs. Historically, Basrah grew up around six tidal creeks, integral to date orchard farming, that drained into the Shatt Al-Arab and provided tidal flushing (**Figure 15**). However, upriver damming has now so reduced river volume and depth that Basrah's creeks are no longer naturally flushed. In addition, pollution occurs at hundreds of individual points along the creeks. The result is that the creeks now act as nothing more than open sewers, and their water has been officially designated as "unfit for any purpose" by every agency that has tested it.

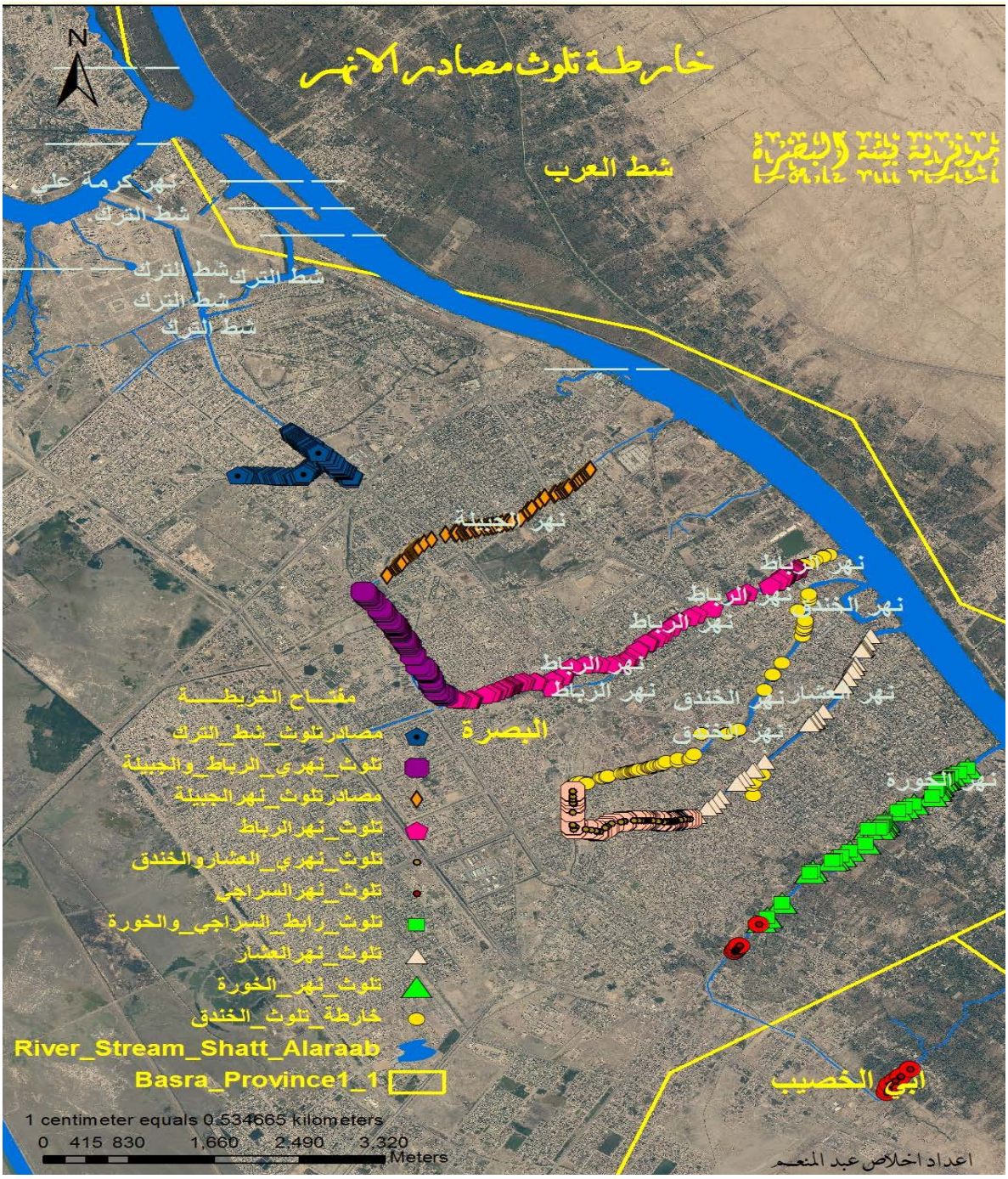

Figure 15: Effluent Discharge Points Along Basrah's Creeks. Burdened by hundreds of point-source pollution outlets along their lengths, water "unfit for any purpose" flows through the tidal creeks for which Basrah was once known as "Venice of the East." Upstream damming reduced river volume by 90%, so tidal push no longer performs the twice-daily service of flushing contaminants. Image courtesy Ministry of Environment, Basrah.

C. Petroleum Produced Water

Figure 16: SOC Well Injection Water Filtration Plant. (A) Water intake from Garmat Ali River (upstream from Basrah). (B) "Million Lake," where approximately one million m^3 post-filtration wastewater is discharged per year. (C) Dense tamarisk and camelthorn "volunteers" at the margins of million lake provide wildlife habitat. (D) Reeds even struggle to grow on the margins of the other "million lake," black with oil, at the DS5 water injection facility in the British Petroleum concession of Rumaila oilfield.

In Basrah Governorate, oil drilling operations require injecting water down drilling lines, in order to force more oil upward for extraction. These operations generate three streams of "produced water"—wastewater that is the byproduct of petroleum drilling and refining operations: pre-injection, post-recovery, and degassing.

Pre-injection, to avoid clogging pressurized pumps and equipment, water is mixed with alum—highly poisonous to livestock—to remove suspended sediments, filtered, then piped onward. With no remedy to render the alum-contaminated wastewater safe for return to waterways, it is currently sequestered by the state-owned South Oil Company (SOC) in a retention lake and allowed to evaporate, and SOC's environmental division would welcome options for the wastewater's re-use (**Figure 16.B**).

Post-injection wastewater recovery and remediation, which falls under the authority of oilfield operators, is far more problematic. Oilfield operators differ markedly in their attitudes toward cultural heritage, environmental justice, and social responsibility mandates, both inside and adjacent to the sites of their operations. Most recovered injection water is re-injected wherever possible, to help maintain overall oilfield pressure. The remaining water is a highly saline soup mixed with crude oil, radionucleotides, and heavy metals.

The third produced water source is from degassing facilities—the part of the refining operation that separates crude oil into various components and removes any water remaining from the extraction process.

B-III. Agricultural Return Water: Main Outfall Drain and Basrah River

Of the three available wastewater streams—urban, produced, and agricultural—urban water is technically easiest, but involves the greatest number and most disparate mix of stakeholders. Produced water is the most impaired and presents the highest technical challenge, but involves only one concerned party—SOC—which has already expressed enthusiastic regard for moving forward. Agricultural water—the largest wastewater source flowing through the governorate—may prove to be the most intractable.

The Basrah River is the final drain bearing every agricultural contaminant flushed from every agricultural operation south of Baghdad. At every lock, dam, conduit and juncture, that water is sent on by the Ministries of Water and Irrigation in gross violation of federal and local water quality standards. Salinized and polluted with excess fertilizers, pesticides, herbicides, and heavy metals, having passed through some of the Hammar marsh zone on its way downstream, it is nevertheless the highest-quality water source available, and prized for its irrigation, fishing, and navigation potential (**Figure 2**).