K4D Knowledge, evidence and learning for development

Environmental risks in Iraq

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08 June 2018

Question

What are the major internal and external environmental risks to which Iraq is exposed?

Contents

1. Overview

Iraq's environment has been subject to a number of converging pressures stemming from population growth, the impact of three wars, climate change, poor land use planning, and encroachment on fragile ecosystems (World Bank, 2017). Iraq faces serious environmental problems, ranging from poor water quality, soil salinity, air pollution, and conflict pollution to the deterioration of key ecosystems, climate change impacts and threat of water shortages.

Key findings:

Climate change

- Between 1970 and 2004, Iraq's annual mean temperature increased by 1-2^{o}C (World Bank, 2017). Precipitation in Iraq is limited and the majority of the country is arid to semi-arid. There have been variable changes in annual rainfall for the period 1951–2000, with both increases (northeast Iraq) and decreases (southeast and west Iraq).
- Future expectations, suggest that Iraq will suffer from higher temperatures, intense heat waves, a decrease in mean annual rainfall but an increase in intensity, a decrease in runoff and sea level rise in the Gulf (World Bank, n.d.). These changes are expected to have adverse impacts on the agricultural sector, water resources, human health, the energy sector and infrastructure in Iraq (USAID, 2017).
- Hameed et al (2018) found significant drought exacerbation over Iraq during the period of 1998–2009, and identified two significant drought periods of 1998–1999 and 2007–2008. Drought has become more intense at the central and southwestern parts of Iraq, and more frequent but shorter drought has been experienced. Prolonged drought has taken a toll on rain-fed crops in the north of Iraq (USAID, 2017).

Water resources

- Water demand is increasing in Iraq due to population growth, environmental considerations, and economic development (Danboos et al, 2017). Iraq is very dependent on the surface water (Tigris and Euphrates Rivers) crossing its borders from neighbouring countries. All basin countries (Iran, Iraq, Syria and Turkey) have developed large-scale projects, most often unilaterally without consultation with the other riparians.
- Iraq currently faces a significant threat of water shortages due to internal and external challenges that include poor water resource management, internal political conflicts, lack of local policies, climate change, international development laws, and unstable relationships with neighbouring countries (Al-Muqdadi et al, 2016).
- Fawzi and Mahdi (2014) found that a change in the quantity and quality of water in the Tigris, Euphrates and the Shatt Al-Arab River due to the effects of upstream damming has significantly reduced the water flow to Iraq. There has been a severe decline in water quantity and escalating levels of salinity in the Shatt al Arab River (Abdullah et al, 2015; 2016). Climate variability and continued surface water shortages are raising the importance of groundwater as a strategic water source, however, groundwater resources and use is poorly studied in Iraq.
- Al-Muqdadi et al (2016) highlight that Iraq could also fall below the water poverty line, which has been defined as less than 1000 m^3 per year per person.

Biodiversity loss

- There has been severe degradation of Iraq's biodiversity due to a number of factors, including unregulated hunting and harvesting of threatened species, trade in endangered species, high salinity and ecological pollution, uncontrolled development and a lack of protection in many of Iraq's most important biodiverse sites (Nature Iraq, n.d.).
- The Mesopotamian Marshes were greatly degraded through the drainage and diversion of water supplies for agriculture, oil exploration, and military purposes since the 1980s. International efforts were made to restore the wetlands, but restoration is patchy because of high soil and water salinities and the Marshes have become fragmented, affecting the survival of many species and the health of the Marshes (Fawzi and Mahdi, 2014).

Conflict pollution

- Previous conflicts have left Iraq with a legacy of environmental pollution and undermined the government's ability to effectively monitor and manage contaminated sites (Zwijnenburg and Postma, 2017). Iraq has experienced widespread destruction infrastructure from systematic and extensive sabotage by the Islamic State of Iraq and Syria (ISIS)[1], as well as from military operations to recapture these areas (UNEP, 2017). Key issues include: pollution problems from the Qayyarah oil fires and the Mishraq Sulphur Plant; air quality and pollution risks from oil fires and artisanal oil sector expansion; risks from damaged ISIS ammunition manufacturing plants; vast quantity of debris and waste; the weaponisation of water management infrastructure (UNEP, 2017).

This review has used a mixture of peer reviewed and grey literature. The strength of evidence in relation to environmental risks in Iraq is mixed, as there is a lack of reliable data and some areas have been more researched than others. For example, there is significant literature on water resource use, much of which focused on large-scale water infrastructure. Whereas, less research has been done into groundwater resources. Water salinity in Iraq is a relatively under researched issue but is gaining more attention. The Mesopotamian Marshes gained a lot of attention in the 2000s, and efforts have been made to protect it, but other biodiversity loss issues (such as decreases in fauna and flora, habitat loss etc.) are not well researched. Conflict pollution (such as contaminated sites, hazardous materials, oil fires, and debris) are gaining more attention in the literature, however, this is still under researched and it is recognised that more attention is needed into the impacts of conflict on the environment as a "silent victim" of war[2].

Although it is generally recognised that women will be most impacted by the effects of climate change and environmental stresses, most of the literature explored in this review was gender-blind.[3] The literature reviewed in this report also did not reflect any issues related to people with disabilities.

[1] Also known as Islamic State in Iraq and the Levant (ISIL), the Islamic State (IS) or by its Arabic acronym, Daesh.

[2] See Erik Solheim's article on the toxic legacy of the Iraq war: https://www.theguardian.com/global-development/2017/nov/03/sheep-turn-black-mosul-iraq-war-toxic-legacy-erik-solheim-un-environment

[3] Of interest might be the launch of an electronic platform on "Women for Safe and Green Iraq" (WfSGI) in March 2018 to strengthen women's participation in national environment protection, and disaster preparedness.

2. Environmental risks

Historical environmental assessments

The United Nations Environment Programme (UNEP) Iraq performed a post-conflict assessment of Iraq in 2007, the report provides good background information on the geographical and environmental context of Iraq; the following section includes some of this key information.

Precipitation in Iraq is limited and the majority of the country is arid to semi-arid. Annual precipitation in the northern hills and mountain ranges varies from 300-1000mm, while in the extreme south and west it is in the order of 100-200mm, and highly irregular (UNEP, 2007: 11-12). The central alluvial plain relies substantially upon the flow of the Tigris and Euphrates Rivers and their tributaries. Catchments and groundwater recharge zones are concentrated in the north and east of Iraq and the neighbouring countries. Evaporation rates in the arid areas are much higher than precipitation and natural recharge rates, resulting in natural salinisation of groundwater (UNEP, 2007: 12).

Iraq's environment has been subject to a number of converging pressures stemming from population growth, the impact of three wars and their aftermath, poor land use planning, urban sprawl, and encroachment on fragile ecosystems (World Bank, 2017: 98). These negative effects on the environment in Iraq are manifested in the scarcity and pollution of the water resources, air pollution and the deterioration of air quality, a reduction in biodiversity, and the pollution of marine waters (World Bank, 2017: 98).

Climate change

Most of the countries in the Middle East suffer from aridity (Al-Ansari et al, 2014 cited in Abbas et al, 2018: 2). It is also among the most vulnerable regions to the potential impacts of climate change. Future expectations, suggest that the region will suffer from higher temperatures and intense heat waves affecting inhabitants and crop yields, and affecting marine ecosystems and fisheries. One of the expected effects is the sea level rise in the northern part of the Gulf that will affect the southern part of Iraq (Dasgupta et al., 2007 and Tolba and Saab, 2009 cited in Abbas et al, 2018: 2). Iraq is one of the countries that has been hardest hit by climate change in the Middle East. Between 1970 and 2004, Iraq's annual mean temperature increased by 1-2^{o}C (World Bank, 2017: 99).

Key climate changes noted in Iraq include (USAID, 2017: 2; World Bank, n.d.):

- Increases in mean annual temperature since 1950 at a rate of approximately 0.7°C per century.
- Variable changes in annual rainfall for the period 1951 to 2000:
    - In the northeast (a moist Mediterranean climate), annual rainfall has increased at a rate of 2.4 mm/month per century.
    - In the southeast (a semi-arid steppe climate), annual rainfall has decreased at a rate of 0.88 mm/month per century.
    - In the west (an arid climate), annual rainfall has decreased at a rate of 5.93 mm/month per century.

Projected future changes in Iraq include (USAID, 2017: 2; World Bank, n.d.):

- Increase in mean annual temperature by 2°C by 2050.
- More frequent heat waves and fewer frost days.
- Decrease in mean annual average rainfall by 9% by 2050, with the greatest reduction (-17%) expected during December, January, and February.
- Decrease in the maximum amount of rain that falls in any 5-day period, but overall increase in rainfall intensity.
- Decrease in runoff of 22% (countrywide average).

Increased temperatures, greater frequency and intensity of drought, and increased intensity of rainfall events are expected to have adverse impacts on the agricultural sector, water resources, human health, the energy sector and infrastructure in Iraq (see USAID, 2017 for more detail). Some of the potential impacts include (World Bank, n.d.):

- Increased river fluctuations expected to intensify flood occurrences.
- Decreased precipitation rates might lead to longer and severe droughts.
- Increase in water pollution and contamination is likely to intensify epidemics, particularly cholera.
- Increase in drought periods is likely to decrease agricultural production with significant impacts on livestock production.
- Increase in floods expected to aggravate damage to infrastructure.
- Increase in droughts might increase rural-urban migration, increasing pressure on the already strained urban social and economic infrastructure.

Drought

Drought has been a characteristic of the Middle Eastern climate. Drought is an extreme event that happens periodically mostly because of precipitation deficit, but other climatic variables may also contribute such as temperature, wind, relative humidity and precipitation timing (Hameed et al, 2018: 1). It is thought that global warming and climate change will aggravate the consequences of drought (see Hameed et al, 2018 for full references); however, assessment of drought is a complex process and there are a number of different indices and methodologies available that deliver different results.

Several researchers have studied drought in Iraq (see Hameed et al, 2018 for full references). Amini et al (2016: 97) reviewed drought analyses using the standard precipitation drought index (SPI) to inspect the Euphrates-Tigris basin. They found that among the four riparian countries (Iran, Turkey, Iraq and Syria), Turkey has less severity and frequency of drought than the other three, and Syria has the most (Amini et al, 2016: 108). Hameed et al (2018: 1) investigated meteorological drought[4] across Iraq from 1948 to 2009. Their results revealed a significant drought exacerbation over Iraq during the period of 1998–2009, and identified two significant drought periods of 1998–1999 and 2007–2008 during which severe to extreme droughts covered about 87% and 82% of Iraq, respectively. Their results also showed that drought has become more intense at the central and southwestern parts of Iraq compared to the northern and

[4] Drought is generally characterised into four types: meteorological; agricultural; hydrological; socioeconomic. Meteorological drought is primarily related to precipitation deficit (see Hameed et al, 2018: 1).

southeastern parts. Meanwhile, more frequent but shorter drought has been experienced at the western, central and southeastern parts of Iraq (Hameed et al, 2018: 1, 13). Several other studies over Iraq and the Middle East region have also found similar results (see Hameed et al, 2018 for further information). Prolonged drought has taken a toll on rain-fed crops in the north of Iraq, damaging approximately 50% of northern agricultural lands and devastating livestock in 2008 and 2009. Drought is expected to significantly affect future livestock production, which is already limited by feed shortages (USAID, 2017: 3).

Water resources

According to the Food and Agricultural Organisation of the United Nations' AQAUSTAT database, the total renewable freshwater resources available in Iraq in 2014 was estimated at approximately 2467 m^3 per inhabitant per year (FAO, 2016a). The same database estimates that in 2014, Turkey had 2690 m^3 per inhabitant per year, and Iran had 1732 m^3 per inhabitant per year (FAO, 2016a). In comparison, in 2014 theoretically available total renewable freshwater resources globally were estimated at approximately 5800 m3 per person per year. Although it is important to remember that this is only theoretical and that freshwater is unevenly distributed geographically and a large part of it is not easily accessible (FAO, 2016b). Iran, Iraq and Turkey cover the highest withdrawals in the Middle East region, accounting for 34%, 24% and 15% respectively of total annual water withdrawal for the Middle East (FAO, 2016b).

Water demand is increasing in Iraq due to population growth, environmental considerations, and economic development (Danboos et al, 2017: 7540). The Iraq water demand and supply are predicted to be approximately 66.8 and 43 billion cubic metres in 2015, respectively, and are expected to reach 77 and 17.6 billion cubic metres in 2025, respectively (Al-Ansari et al., 2015 cited in Danboos et al, 2017: 7537). Despite significant supply vulnerability and existing scarcity, Iraq has a water withdrawal rate that is almost double the world average, due to a lack of adequate national water management policies (USAID, 2017: 3-4).

Iraq is very dependent on the surface water crossing its borders from neighbouring countries, in particular, it relies heavily on the water resources of the Tigris and Euphrates Rivers, which supply more than half of Iraq's freshwater resources. More than 90% of the Euphrates originates within the highlands of Turkey; it acquires very little water in Syria and none in Iraq. While almost 50% of the headwaters of the Tigris originate in Iraq and the rest are spread across Iran and Turkey. Both rivers follow a south eastern route across arid land of Syria and Iraq. The Euphrates and Tigris merge in southern Iraq to form the Shatt Al-Arab, which in turn flows into the Arabian Gulf (Fawzi and Mahdi, 2014: 2). There is a lack of formal agreement among the countries regarding riparian rights (USAID, 2017: 3-4). Iraq depends on exports from nearby countries for more than half of its water needs (Danboos et al, 2017: 7536).

Threat of water shortages

Al-Muqdadi et al (2016) highlights that Iraq currently faces a significant threat of water shortages due to internal and external challenges that include poor water resource management, internal political conflicts, lack of local policies, and an insufficient legal framework, climate change, international development laws, and unstable relationships with neighbouring countries, namely Turkey, Iran and Syria. The external factors include climate change and the water resources policies of neighbouring countries, whereas the internal factors include the mismanagement of water resources.

A study by Abdullah et al (2015: 226) provides a broad description of the current state of hydrological and geographical characteristics of the Shatt al Arab River, and analyses the severe decline in water quantity and escalating levels of salinity. They conclude that the Shatt al Arab River system is under increasing pressure due to reduction in water quality and inflow quantities coming from the Euphrates, Tigris, Karkheh and Karun Rivers. Additionally, degradation of the Mesopotamian Marshlands also results in reduced flows to the river. Abdullah et al (2015: 226) identified the major causes of decreasing water quantity and quality of the Shatt al Arab River system as:

- changes in the flow regime and reduced inflows from upstream rivers due to increased regulations and water uses
- decrease in water quality along the major rivers due to polluted return flows from irrigation and wastewater inflows
- reduced inflows with increased salinity levels due to high evaporation from the marshes
- discharge of high salinity water into the Shatt al Arab River upstream and around Basra city
- the effect of increased tidal influence.

Al-Furaiji et al (2016: 214) focus on water resources availability and demand in the four oil-rich provinces of southern Iraq. They conclude that water shortage in the south of Iraq is a serious issue that is only expected to worsen in the future because of population growth, increased abstractions upstream, poor management of the available water resources and climate change. They calculate a total water deficit of 430 mm^3/year for the four southern provinces of Iraq in 2010. Irrigation claims about 81% of the consumed water in the south of Iraq. The worst water situation was reported in Al Muthanna and Al Basrah, while the other two provinces of the southern region (Maysan and Dhi Qar) suffer from poor quality water rather than insufficient water quantity (Al-Furaiji et al, 2016: 224).

Water management in Iraq

Issues exacerbating Iraq's water crisis stem from inside Iraq. These include lack of domestic water usage regulations and enforcement; leaky pipes; weak regulation around the dumping of toxins; and lack of proper water and sewage treatment facilities (Levkowitz, 2018; Nature Iraq, n.d.). Additionally, Iraqi farmers have had a longstanding reliance on flood irrigation, using techniques that are water intensive but also enable salt in the soil to rise to the surface and enter rivers, leading to higher rates of salinity downstream (Levkowitz, 2018; Nature Iraq, n.d.). Much water is wasted either directly to the Gulf or through evaporation due to a lack of irrigation planning and water harvesting (Al-Muqdadi et al, 2016: 1099). Al-Muqdadi et al (2016: 1099) also argue that complex political conditions have led to uncertainty surrounding water policies. They give the examples of Article 110, Paragraph 8 of Iraq's constitution and Article 114, Paragraph 7 as contradictory policies. The former grants the federal government responsibility over handling water resources coming from outside Iraqi borders, while the latter gives local, provincial governments the authority to formulate internal water resource policies and to regulate usage of water resources. They suggest that this clear contradiction could lead to internal disputes in the near future in Iraq.

Water management in Turkey and Iran

Extensive large-scale dam projects since 1950 in Iraq, Iran and Turkey have resulted in a significant reduction in annual flows of the Tigris and Euphrates Rivers, permanently changing the riverine and wetland ecology. Excessive river water abstraction and several millennia of irrigation have resulted in chronic salinity problems for much of the alluvial plain (UNEP, 2007: 12). All basin countries (Turkey, Syria, Iran and Iraq) have developed large-scale projects, most often unilaterally without consultation with the other riparians. The total storage capacity behind the existing dams is larger than the average annual flow of Euphrates, Tigris, Karkheh and Karun Rivers. Earlier studies have indicated that the demands for Euphrates water in Turkey and Syria can be met, but with serious impacts for Iraq, which will be confronted with significant water shortages (Kliot 1994, Kolars 1994 cited in Abdullah et al, 2015: 223). The situation on the Tigris is better, since water availability is reported to be sufficient to meet the demands, with some "surplus" water left in the system. Moreover, similar trends are anticipated as the result of current and ongoing water resources developments in the Karkheh and Karun rivers in Iran, as well as the tributaries of the Tigris River shared between Iran and Iraq (Abdullah et al, 2015: 223).

Iran and Iraq share a number of rivers, most of which run through the Kurdistan Region of Iraq before they join the Tigris River in Iraq. The three main rivers are Alwand, Sirwan and Lower Zab (Abdulrahman, 2018). Abdulrahman (2018: 28) explores the drying up of the Lower Zab River and its impact on the Kurdistan Region. According to Abdulrahman (2018: 30), the Alwand and Lower Zab have completely dried up and Sirwan is under the threat of drying up as many water projects in Iran, mainly dams, built on these rivers have been completed or are near completion and some have started operation. The legal status of Kurdistan Region is that it is a federal region in Iraq, but the Iraqi constitution, approved in a national referendum in 2005, allows the Kurdistan Region to manage its own resources. The Kurdistan Region now possesses two hydroelectric dams, which partly control the flow of water to Iraq (Abdulrahman, 2018: 42).

Turkey's Southeastern Anatolia Project (GAP) consists of 22 dams and 19 hydraulic power plants. The Ilisu Dam has just recently begun to fill the reservoir and has displaced the residents of Hasankeyf [5] (Levkowitz, 2018). It is estimated that the Euphrates will lose 70% of its water at the conclusion of the GAP project. Iraq could also fall below the water poverty line, which has been defined as less than 1000 m³ per year per person (Al-Muqdadi et al, 2016: 1099). Of the 45 tributaries once shared by Iran and Iraq, only three have not been dammed, diverted or blocked. For example, Iran's Daryan Dam, expected to be completed later this year, will reduce the water flow of the Sirwan River by up to 60%. Further, a 30-mile tunnel being constructed next to the dam may completely divert the river's course (Levkowitz, 2018).

Salinisation

Salinity is highly dynamic, depending on the season and freshwater input (Abdullah et al, 2015). Fawzi and Mahdi (2014) in their literature review concluded that salinity of waters of the Euphrates, Tigris and Shatt Al-Arab River increased significantly over time. They highlight that water quality is continuing to deteriorate in the Tigris, Euphrates and the Shatt Al-Arab River due to the absence of adequate river basin management programmes, the direct dumping of

[5] See https://www.reuters.com/article/us-iraq-turkey-dam/turkish-dam-project-threatens-rift-with-iraq-over-water-shortages-idUSKCN1J11YL

untreated domestic and municipal wastes, agricultural chemicals, and hazardous industrial substances into the waterways. In the Shatt al-Arab River water availability has significantly reduced and the natural regime of the river has drastically changed due to the construction of large-scale water infrastructure and major water diversions in the upstream basins in Turkey, Syria, Iran and Iraq. The saline water intrusion from the Arabian Gulf has increased into the Shatt al-Arab estuary and further upstream. The study noted serious negative impacts on human health, uses of water for agriculture and the ecosystem productivity. The study acknowledged the limited amount of available records on salinity levels because the reviewed studies only provided average salinity values for few locations and for a short period.

Abdullah et al (2016) conducted a quantitative analysis of intra-annual variability of salinity levels in the Shatt al-Arab River, Southern Iraq, to contribute to filling this gap in the literature highlighted by Fawzi and Mahdi (2014). River water quality in the watershed has notably deteriorated due to increasing water withdrawals, direct discharge of untreated wastewater and saline irrigation return flows. Apart from man-made activities carried out in the upstream part of the basin and along the river, salt intrusion caused by tidal forces is the main natural driver of salinity variation along the river (Abdullah et al, 2016: 357). They found that there was high variability in salinity both in space and time, and salinity dynamics were influenced by different sources of saline water inflows and withdrawals associated with irrigation, industrial and municipal waste, marshes and by seawater intrusion. Adapting a simple interpolation approach, the measured distance of seawater intrusion was 80 km upstream from the river mouth. The salinity of the Tigris increases along the river course, and the main factors governing this rise in salinity levels pertain to the reduction in river flow and discharge of saline waters from the irrigation return flows, groundwater, marshes and wastewater (Abdullah et al, 2016: 363). Salinity of the Euphrates River is also known to increase along the river course, with the main sources of salinity being from highly saline water discharges from irrigation return flows and marshes (Abdullah et al, 2016: 363).

The observed data show that the salinity of the Tigris and Euphrates as well the Shatt al-Arab River are higher during the irrigation season (November–April), when more return flows are expected. These return flows are considered the biggest polluter of surface water in Iraq. Cumulative impacts of historical irrigation practices in the absence of adequate drainage infrastructures have raised salt concentrations in agricultural soil profiles. Local irrigation activities along the river increased the salinity, through drainage water containing salts washed out from the soil profile. The large agricultural investments in the Mesopotamia plain, the area adjacent to and between the Tigris and Euphrates rivers, contribute to river water salinity and more pressure will be added with the planned agricultural expansion (Abdullah et al, 2016: 363).

Abdullah et al (2015 and 2016) in a number of studies highlight the lack of local and international studies on the Shatt al Arab River system, which can provide the needed scientific analysis and potential options to improve the salinity issues. Abdullah et al (2015) emphasises that salinity in the Shatt al Arab River is a major concern because the salinity levels are above the limits of both drinking and irrigation water standards. However, data on water quality of the Shatt al Arab River are even more scanty than data on water quantity, which limits a proper description and analysis of water quality dynamics of this tidal river (Adbullah et al, 2015: 221).

Groundwater

Climate variability and continued surface water shortages are raising the importance of groundwater as a strategic water source for growing populations and as a means of balancing the demands for future uses (see Obeed Al-Azawi and Ward, 2016: 628). Obeed Al-Awazi and Ward (2016) highlight that Iraq is an under-studied region in the water resources management and policy literature, especially in relation to groundwater resources and use. Most of Iraq's groundwater aquifers are large-scale alluvial deposits located near the Tigris and Euphrates Rivers, but the majority have weak potential for extensive domestic use because of poor water quality (Obeed Al-Azawi and Ward, 2016: 629). Voss et al. (2013) studied the groundwater depletion using Gravity Recovery and Climate Experiment (GRACE) satellite mission in the north-central part of the Middle East. They concluded that during the period of 2003–2009, the groundwater usage in Iraq increased due to drought and surface water shortage in the region.

Groundwater tables fall when discharge exceeds recharge, although the level and extent of recharge is often uncertain and hard to measure (Obeed Al-Azawi and Ward, 2016: 644). Renewable groundwater supplies are the major factor required for sustainable groundwater management programmes. In recent years, fluctuating surface water supplies in both the Tigris and Euphrates Rivers, has prompted a call for the Iraq's aquifer waters to be managed carefully (Obeed Al-Azawi and Ward, 2016: 641). Sustainable aquifer management poses an especially urgent challenge in the southern part of the country.

The joint United Nations Educational, Scientific and Cultural Organisation (UNESCO) and EU programme "Advanced Survey of Hydrogeological Resources in Iraq" (ASHRI-2) was a pioneering initiative aimed at improving national capacities in the exploration, administration and integrated management of groundwater resources in Iraq. It also aimed to enhance the efficiency and effectiveness of public planning, as well as informed policy making in the National Water Sector (UNESCO Office for Iraq, 2017). ASHRI-2 ran between November 2013 and May 2018, and validated and updated essential data and information on Iraq's groundwater resources, improving the government's management capabilities in this field. Building upon UNESCO's long experience and studies in the field of drought and water resources' management in Iraq, ASHRI-2 crucially addressed water shortage and scarcity, and its dangerous outcome on socio-economic development, health, environment and eco-systems (UNESCO Office for Iraq, 2017). Further results from the project were not publically available.

Biodiversity loss

As a result of wars and the fragmentation of agricultural lands in industrial and urban activities, Iraq's biodiversity has deteriorated in type and density (World Bank, 2017: 99). In general, the industrial areas in Iraq are sited in heavily developed regions of low biodiversity and sensitivity. Biodiversity is particularly low in the central plain and the Baghdad region due to a history of sustained agricultural activity and the population density in the riverine areas (UNEP, 2007: 13).

There has been severe degradation of Iraq's biodiversity due to a number of factors, including unregulated hunting and harvesting of threatened species, trade in endangered species, uncontrolled development and a lack of protection in many of Iraq's most important biodiverse

sites (Nature Iraq[6], n.d.: 3). The World Bank (2017: 99) attributes the deterioration of biodiversity in Iraq to:

- overhunting and the use of poison, electrocution, and explosives in hunting;
- high salinity in lakes and rivers
- ecological pollution from wastewater, air pollution, plant waste, and thermal pollution from power plants; and
- the introduction of invasive species and exotic types of fish and animals, which has had a negative impact on indigenous species in their natural habitats.

Mesopotamian Marshes

The land between the Euphrates and Tigris (Mesopotamia) is the most fertile region in Iraq and comprises about 25% of Iraq's surface area. The wetlands once covered between 15,000 and 20,000 km^2 but covered less than 760 km^2 by 2000 (Fawzi and Mahdi, 2014: 8). The most serious threat to wetlands in Iraq has been the drainage and diversion of water supplies for agriculture, the oil exploration and use for production purposes, and for military purposes since the 1980s (Fawzi and Mahdi, 2014: 8). Dam building on the Euphrates in Turkey and Syria and the increasing utilisation of the waters of the Tigris and Euphrates for irrigation have greatly reduced the extent of seasonal flooding in the marshes.

Since 2001, there has been an international effort to restore the Mesopotamian Marshlands. Uncontrolled releases of Tigris and Euphrates River waters after the 2003 war partially restored some former marsh areas, but restoration is failing in others because of high soil and water salinities (Fawzi and Mahdi, 2014: 8). In addition, the environmental conditions that have developed are different from those prior to drainage. Upstream dams now control the volume and timing of water coming into the marsh, and the total volume of incoming water has diminished (Fawzi and Mahdi, 2014: 9). The Marshes have become very fragmented, affecting the survival of many species, the health of the Marshes and the people whose livelihoods depend on the environmental services provided by them.

The Hawizeh Marsh, which extends across the border into Iran, was designated as Iraq's first Ramsar Site[7] in 2007. Part of the Mesopotamian marshland complex fed by the Tigris and Euphrates rivers, the whole region is suffering from the construction of upstream water control structures, increasing water extraction for agriculture as well as reduced rainfall. As a result, the Hawizeh marsh was placed on Ramsar's register of threatened wetlands requiring priority attention (UN Iraq, 2018). In mid-2017, the Government of Iraq requested the Ramsar Secretariat to organise an advisory mission to the marshes to identify ways for future cooperation between Iraq and Iran as a first step towards the long-term conservation and sustainable development of the marshes, including ways to reduce the incidence of sand and dust storms. Areas of agreed future cooperation include carrying out waterbird surveys, creating a platform for exchanges of

[6] Nature Iraq has been active since 2004 in the Mesopotamian Marsh areas, as well as Kurdistan, northern, central and western Iraq, surveying areas to determine sites with the highest biodiversity and best water quality.

[7] A Ramsar Site is a wetland site designated of international importance under the Ramsar Convention on wetlands, an intergovernmental environmental treaty established in 1971 by UNESCO.

technical and scientific information on the ecology of the marshes, and joint celebration events on wetlands and water (UN Iraq, 2018).

Marine pollution

Another challenge is the pollution of Iraq's marine waters. The Iraq coastal water belt has a high fertility rate, which attracts the Gulf fish during mating seasons and is also the passageway for migrating fish from the Gulf into Iraqi waters. Recently, pollution from oil activities in the Iraqi ports has caused significant damage to regional waters, which has harmed biodiversity and negatively affected fisheries (World Bank, 2017: 99) (see section on salinity).

(Conflict) pollution

Previous conflicts have left Iraq with a legacy of environmental pollution. Not only did those conflicts directly lead to the spread of hazardous materials through the destruction of industrial and military targets, they also undermined the government's ability to effectively monitor and manage contaminated sites (Zwijnenburg and Postma, 2017: 5). Iraq has experienced widespread destruction of civil and industrial infrastructure from systematic and extensive sabotage and looting by ISIS, as well as from airstrikes and military operations to recapture these areas (UNEP, 2017: 2). In September 2017, UNEP's Post-conflict and Disaster Management Branch released an initial assessment of pollution issues in areas retaken from ISIS. The rapid scoping mission concludes that it will take time to fully comprehend the level of environmental damage given the lack of institutional memory over what occurred during the three years of ISIS occupation, and new contaminated sites are likely to be reported as inaccessible areas open up (UNEP, 2017: 2). In recent years, PAX has been using of open-source methods to monitor the environmental risks caused by the conflict with ISIS, with the aim of adding to the existing body of knowledge on potential sources of pollution. This information is reproduced in Zwijnenburg and Postma's (2017) report on conflict pollution in Iraq.

Contaminated sites and hazardous material

The importance of hazardous waste and land contamination issues on a particular site is strongly linked to its surroundings and in particular to the vulnerability of the local natural environment and population (UNEP, 2007: 13). Looting, leading to dumping of materials and land contamination has further exacerbated poor hazardous waste management practices in Iraq (UNEP, 2007: 16). Key concerns from the UNEP rapid scoping report include (UNEP, 2017; Zwijnenburg and Postma, 2017):

- the pollution problems from the Qayyarah oil fires and the Mishraq Sulphur Plant arson
- the potential risks from future sabotage of sulphur waste
- the risks from damaged ISIS ammunition manufacturing plants
- polychlorinated biphenyl (PCB) contamination from attacks on energy infrastructure
- the environmental challenges posed by the vast quantity of debris and waste
- concerns over the large quantities of asbestos present at various sites in Mosul
- past use of depleted uranium (DU) weapons, a radioactive and toxic heavy metal (Zwijnenburg and Postma, 2017).

The report also noted that the collapse of environmental governance and the destruction of environmental research laboratories would likely have a long-term impact on recovery and reconstruction efforts. Finally, the report noted that the weaponisation of water management infrastructure had created severe security risks through flooding and degradation of agricultural lands.

Oil fires and oil sector expansion

In Iraq, oil refineries were already a local source of pollution due to inadequate governance and control measures. However, the recent conflict has turned oil and gas industry facilities into a major source of health and environmental risks. Both militant groups and local people have tapped refineries, tanks, pipelines and oil fields for their income potential. Airstrikes by the US-led coalition targeted the oil industry in order to deprive ISIS of oil-revenue (Zwijnenburg and Postma, 2017: 7). As Iraqi forces regained territory from ISIS, the group employed scorched earth tactics by setting alight oil wells, and the resulting oil spills, fires and smoke clouds have caused immense harm to the environment. The resulting smoke plumes from the wells obscured the sun for months, leading locals to refer to it as the “Daesh Winter”. Oil fires release harmful substances into the air such as sulphur dioxide, nitrogen dioxide, carbon monoxide, polycyclic aromatic hydrocarbons (PAHs), particulate matter and metals (Zwijnenburg and Postma, 2017: 9). PAX has identified four main oil-producing areas affected by these tactics: Al-Qayyarah, Hamrin Mountains, Baiji oil refinery, and Kirkuk’s Oil Infrastructure. Without access to functioning oil facilities, ISIS and communities also began to use artisanal oil refining methods to produce petrol and diesel, another source of environmental risk (Zwijnenburg and Postma, 2017: 8). UNEP’s (2017: 2) rapid scoping mission also highlighted the artisanal oil refining on the outskirts of both eastern and western Mosul as another important legacy of the conflict. Makeshift refineries use rudimentary practices creating a localised but a potentially significant pollution footprint. Large tracts of farming and grazing land have been affected by oil pollution and spills, not only directly threatening the health of local communities and their livestock, but also their livelihoods (Zwijnenburg and Postma, 2017: 10; UNEP, 2017). Zwijnenburg and Postma (2017: 12) highlight that further verification on the ground to assess the magnitude of oil spills and their environmental impact is needed.

Also, the continual flaring of associated and natural gas in oil fields leads to high levels of emissions, which has been linked to the deterioration of air quality in Iraq (World Bank, 2017: 99). The worsening of air quality in Iraq has also been linked to the use of low quality fuel in transport, power generation, and the industrial sectors, as well as emissions from industrial facilities, dust storms, open burning of waste and an increase in illegal logging (World Bank, 2017: 99).

Debris

Combat in urban environments, such as in cities like Mosul and Ramadi, can create long-term environmental health risks. Industrial sites, which store or process toxic chemicals, are often situated in or near populated areas. Critical infrastructure, such as power and water networks also contain toxic materials, and can create hazardous waste when damaged (Zwijnenburg and Postma, 2017: 15). The millions of tonnes of debris and rubble produced by the destruction of residential and commercial areas presents a major challenge for clean-up, as they may include mixed forms of solid and hazardous waste. When explosive weapons hit buildings and structures there is a direct release of particulate matter that may include concrete, cement and sometimes

asbestos. This can lead to environmental contamination and present a human health hazard. Managing the debris resulting from the destruction of entire city blocks also carries risks (Zwijnenburg and Postma, 2017: 15). The cost of transporting the 10 million tonnes of debris out of Mosul alone is estimated at US$250million (UNEP, 2017).

Weaponisation of water management infrastructure

UNEP (2017: 3) highlight that ISIS also seized control of critical dams and barrages to exert hydrologic domination over downstream cities and rural areas by either cutting off water supplies or releasing a flood wave to drown government-controlled areas. The 2014-2015 “drought” in central and southern Iraq was largely a result of ISIS blocking water flows. An initial assessment by the Ministry of Water Resources estimates direct damages to hydraulic infrastructure at US$600 million. Water installations need urgent rehabilitation and maintenance.

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Acknowledgements

We thank the following experts who voluntarily provided suggestions for relevant literature or other advice to the author to support the preparation of this report. The content of the report does not necessarily reflect the opinions of any of the experts consulted.

- Hassan Partow, UN Environment Iraq
- Dr. Jehan Baban, The Iraqi Environment and Health Society-UK (IEHS-UK)
- Wim Zwijnenburg, PAX

Suggested citation

Price, R.A. (2018). *Environmental risks in Iraq.* K4D Helpdesk Report. Brighton, UK: Institute of Development Studies.

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