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Yemen's Vulnerability to Climate Change: How to Strengthen Adaptation

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Cover photo: A girl collects water in Kaedna district in Hajjah governorate on January 22, 2023 // Sana'a Center photo by Ghader Murad.

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Executive Summary

This policy brief summarizes the environmental issues Yemen faces and outlines policy and technical responses to limit their impact. These include environmental problems caused by the absence of state intervention or by misguided policies, and those that are symptoms of global warming, pointing out the frequent synergy between them. Yemen, like other developing countries, suffers the consequences of climate change while having insignificant responsibility for causing them.

Water scarcity is Yemen's major environmental problem, which demands urgent attention. Other environmental issues include the deterioration of ecosystems, oil related and other pollution, sanitation issues, waste disposal, fisheries, and rising sea levels. The problems are due to a synergy between human interventions and external global warming features. In the course of earlier decades, state institutions, supported by external funding have developed numerous useful adaptation policies. However due to political inaction, they have not been implemented and regulations have not been enforced, resulting in the worsening of the situation.

There is an urgency for political authorities in particular to take concrete steps to mitigate and address Yemen's environmental issues. Specific recommendations are made for each sector and set of agencies which, if implemented, would enable Yemenis to continue living, and ideally flourishing, in their country. While prioritizing water management, other suggestions are important to restore the country's ecosystems and agricultural potential.

Introduction

Cyclone Tej struck the eastern part of Yemen in October 2023 with wind speeds 60 percent stronger than Cyclone Chapala in November 2015.[1] Yet the storm caused significantly less damage than both Cyclone Chapala, and Cyclone Megh, which struck southeastern Yemen the same month, thanks to climate change adaptation measures taken over the past decade.[2] This clearly indicates that even the limited action taken in recent years has meaningfully contributed to mitigating the impact of such events.

Extreme weather has become an increasingly serious issue that Yemenis must grapple with. While intensified in recent years, this phenomenon is not new – the country has suffered the impact of climate change for decades, long before it became obvious in other parts of the world. Despite the urgency of this emergency situation, decision makers are giving far too little attention to environmental problems, although their frequency and severity are both increasing, as evidenced by repeated instances of flooding, lighting strikes,[3] and drought over the past year.[4] As climate issues continue to play an increasing role in daily Yemenis' lives, all parties involved – local and international, government and private – will need to prioritize strategies to mitigate climate issues and promote civilian wellbeing.

[1] "Yemen Cyclone 2023 -DREF Operation, Appeal MDRVE013," IFRC, November 4, 2023, https://reliefweb.int/report/yemen/yemen-cyclone-2023-dref-operation-appeal-mdrye013?utm_source=rw-subscriptions&utm_medium=email&utm_campaign=country_updates_255

[2] "Yemen: Cyclones Chapala and Megh Flash Update," OCHA, November 9, 2015, https://reliefweb.int/report/yemen/yemen-cyclones-chapala-and-megh-flash-update-6-9-november-2015

[3] Flooding, Lightning strikes kill 8 in War-Hit Yemen," AFP, September 16, 2023, https://www.barrons.com/news/flooding-lightning-strikes-kill-8-in-war-hit-yemen-aa446fof

[4] "Farmers reel from drought as climate change takes toll in war-torn Yemen," Xinhua, September 15, 2023, https://english.news.cn/20230915/a6ac4212f82e4827923175 90f9bb720b/c.html

Main Causes of Yemen's Environmental Crisis

Water Scarcity

Water scarcity is Yemen's most visible and threatening environmental problem.[5] The country lacks permanent rivers and has highly variable rainfall, making groundwater extraction and rainwater harvesting traditionally the primary sources of water for domestic, agricultural, and industrial needs. Over one-third, or 1.4 billion cubic meters (bcm), of the 3.5 bcm of water used in Yemen annually is from non-renewable fossil aquifers.[6] Given the country's topography, rainfall varies from almost zero in arid areas to up to 800 millimeters (mm) per year in the few high rainfall areas in mountainous Ibb and Taiz governorates, with an overall average of less than 50 mm yearly over the whole country. Moreover, in recent decades, climate change has affected the timing and quantity of rain differently in the country's five agro-ecological zones, increasing it in some areas and decreasing it in others.[7] The high mountain range close to the Red Sea coast catches the monsoon rains and benefits from the humidity carried from the sea,[8] resulting in an area where rainfed agriculture is possible, and is therefore, the most densely populated part of the country. Overall, water availability per capita has dropped to 81 cubic meters and is predicted to fall further to 55 cubic meters by 2030,[9] far from the modest international minimum of 500 cubic meters assessed by the Falkenmark indicator, which assesses water scarcity.[10]

While the highest population density is in cities and the mountainous areas of western and southwestern Yemen, available water is far from matching needs, especially given the rapid population increase of the past three decades. As in other countries, between 80 and 90 percent of water in Yemen is used in agriculture.[11] Well irrigated surfaces have increased from 37,000 hectares in the 1970s to more than 400,000 hectares in the 2010s.[12]

[5] This paper is not addressing the water issue in detail. For the author's analysis of Yemen's water crisis see: Helen Lackner, "Community-based Water Practices in Yemen," in Marcus Dubois King, ed, *Water and Conflict in the Middle East*, London, Hurst, 2020, pp. 121-150; and Helen Lackner, "The future of Yemeni agriculture and water," in Noel Brehony and Amat al-Alim Alsoswa, *Building a New Yemen, Recovery, Transition and the International Community*, London, IB Tauris, 2022, pp. 175-190.

[6] Helen Lackner, *Yemen in Crisis, Devastating Conflict, Fragile Hope*, London, Saqi, 2023, p. 259.

[7] Taylor Hanna et al, "The Impact of Climate Change on Human Development in Yemen," UNDP, December 3, 2023, p. 17, https://www.undp.org/arab-states/publications/impact-climate-change-human-development-yemen

[8] "Climate Change Knowledge Portal," World Bank, https://climateknowledgeportal.worldbank.org/country/yemen-rep/climate-data-historical. Accessed October 2023

[9] Ibid.

[10] Helen Lackner and Abdulrahman Al-Iryani "Yemen's Environmental Crisis is the Biggest Risk for its Future," The Century Foundation, December 14, 2020, https://tcf.org/content/report/yemens-environmental-crisis-biggest-risk-future/

[11] "A Holistic Approach to Water Resource Challenges in Yemen," UNDP, November 2022, https://www.undp.org/sites/g/files/zskgke326/files/2022-12/Water%20Resources%20Challenges%20in%20Yemen.pdf

[12] Helen Lackner, *Yemen, Poverty and Conflict*, London, Routledge, 2023, p. 78.

Crop irrigation takes different forms: direct rainfall; irrigation from shallow and deep wells; and spate irrigation for staple crops like sorghum and maize. Deep-well irrigation is the most environmentally problematic form and has expanded recently due to investment from local sources and development financing. Water is pumped using diesel, electricity, and, more recently, solar power.[13] It is most accessible to wealthier landholders who cultivate high-value cash crops for local consumption and export, such as bananas, mangoes, grapes, qat, and pomegranates. This process is intensified by the concentration of landownership into fewer hands and the associated dispossession of many smallholders who are compelled to sell land when their shallow wells dry up; they are thus caught in a vicious circle of poverty. All of this is taking place alongside rapid population increase in a context of static, if not diminishing, resources.

Domestic water also remains a major problem. Thousands of rural households still depend on women and children collecting water from remote wells or springs, carrying it home on their heads or loaded onto donkeys – a process which can be cumbersome and unhygienic, despite "improved" wells which are slightly more sanitary. In cities, households that are connected to a municipal network rarely receive water daily. In Taiz, prior to the war, half of the city's households were connected to the municipal supply and received water once every 40 days at best.[14] At that time, households in Sana'a city received water twice a week. Sana'a has now lost the unenviable prospect of becoming the first world capital to run out of water, not thanks to any improvement, but rather to deterioration in other countries.[15]

Running out of water is not an instant process: rains fail, wells dry up, people fetch water from increasingly remote sources, move away temporarily, return when wells are replenished, move again when they dry up, and eventually settle into housing elsewhere. Forced migration due to water scarcity is not an overnight event compared to, for instance, migration following floods or earthquakes. People move to better-equipped locations, increasing pressure on services there – including access to water, sanitation, education, health, and employment. These pressures increase social tensions within and between communities. Eventually, Yemenis may be forced out of their country, most likely seeking refuge in exile in neighboring countries like Saudi Arabia, Oman, or the UAE.

[13] Musaed Aklan and Helen Lackner, "Solar-Powered Irrigation in Yemen: Opportunities, Challenges and Policies," Sana'a Center for Strategic Studies, April 29, 2021, https://sanaacenter.org/publications/main-publications/13849

[14] A. Noaman and A.W. Al-Sharjabe, "Efficient Management of Municipal Water: Water scarcity in Taiz City Yemen Issues and Options," *Proceedings of the International Association of Hydrological Sciences*, Vol 366, 2015, p. 186; Author's work on the World Bank-funded Taiz Pilot water project between 1996 and 1998.

[15] Daniel Shailer, " Mexico City imposes severe, monthslong water restrictions as drought dries up reservoirs," AP, November 11, 2023, https://apnews.com/article/mexico-city-water-restrictions-drought-f7c0ccd809d35894890aaf509d1d60c8; Harriet Barber, "The South American capital with a week's worth of water left," The Telegraph, July 7, 2023, https://www.telegraph.co.uk/global-health/climate-and-people/south-american-capital-with-a-weeks-worth-of-water-left/; Aryn Baker, "What's It's Like to Live Through Cape Town's Massive Water Crisis," Time, https://time.com/cape-town-south-africa-water-crisis/

Deterioration of Ecosystems

Deterioration of the country's biodiversity and ecosystems has been ongoing for decades and is worsening due to a combination of human action and global warming, affecting both land and sea. Terrestrial systems have been affected by the erosion of farmlands, terraces, soils, and rangelands, as well as oil exploration and extraction. Deforestation is partly due to the continuous cutting of trees for firewood and charcoal production, a problem worsened by poverty and the war, as people can't afford cooking gas and thus resort to the felling of the few remaining trees and bushes[16] as well as overgrazing. The shrubbery and native grasses in rangelands feed livestock, an essential source of income for many landless households, and protect soils, medicinal plants, and forestry. Agricultural work is accelerating the deterioration of rangelands through overgrazing. For instance, Yemen's sheep population increased by a third between 2001 and 2012, and the goat population rose from seven to nine million, an overall increase from 1.43 head per hectare in 2001 to 2.87 in 2012.[17] But even where shrubbery and trees are scarce, more are removed to expand agriculture, and native species have been overtaken and smothered by invasive species such as the *prosopis juliflora*.

Yemen has few so-called protected areas, and those that do exist are not effectively protected. Only one percent of the country's total mass has been declared protected.[18] The Socotra archipelago and Jabal Bura in Hudaydah governorate have been listed as UNESCO World Heritage Sites.[19] Yemen was known for its wildlife, including oryxes, leopards, and cheetahs. Now, the few remaining animals are hunted and suffer habitat loss from climate change and human actions.[20] The tradition of putting oryx horns on the corner of finished houses in Hadramawt encourages further killing.

The remaining mammal species are listed in the International Union for Conservation of Nature (IUCN) Red Book. Of the four species of gazelle found in Yemen three are endangered and the fourth is extinct in the wild, alongside cheetahs and Arabian oryxes. A few Arabian leopards, hyenas, baboons, honey badgers, ibex, and foxes remain while all marine turtles are endangered; According to the government's 2019 report to the Convention on Biological Diversity, "most sizeable mammals have long since been hunted into extinction in this country where firearms abound and a large proportion of the natural forests has been cut down,"[21] a reminder that direct human intervention as well as loss of habitat plays as big a role in the disappearance of species.

[16] Abdelrahman al-Eryani, former Yemeni Minister of Water and Environment, interview by the author, November 2023.

[17] "Yemen 6th Report to the Convention on Biological Diversity," Republic of Yemen, Ministry of Water and Environment, Environmental Protection Agency, March 2019, p. 26.

[18] "Terrestrial Protected Areas, Yemen," World Bank, https://data.worldbank.org/indicator/ER.LND.PTLD.ZS?locations=YE

[19] "UNESCO World Heritage Convention, Yemen," UNESCO, https://whc.unesco.org/en/statesparties/ye/

[20] "Yemen: War on Animals Amid Civil War," Holm Akhdar Environmental Consultancy, December 21, 2020, https://holmakhdar.org/news/investigations/3508/

[21] "Yemen 6th Report to the Convention on Biological Diversity," March 2019, pp. 39-40.

Coastal environments suffer from rising sea levels and erosion, according to an incomplete study by the Geological Survey Authority comparing coastal environments over 20 years.[22] Marine systems have suffered loss of wetland, mangrove degradation, loss of coral reefs, and erosion of coastal zones. Meanwhile, increased coastal urbanization, fishing, and pollution from ships damage coral reefs, mangroves, lagoons, and beaches.[23] Turtle breeding grounds have been lost and damaged; in east of Hadramawt, local feral dogs have eaten eggs laid by turtles in a 'protected' area.[24] Fisheries protection measures are not enforced and have been ignored by both powerful Yemeni fishing fleet owners and foreign fleets which have now hunted species to the brink of extinction.

[22] Ismail al-Ganad, senior official at the Geological Survey Authority, interview by the author, November 2023.

[23] "Yemen 6th Report to the Convention on Biological Diversity," March 2019, p. 25.

[24] Personal observation by the author.

Climate Change and the Anthropocene

Extreme weather events in Yemen such as cyclones are now more frequent: in 2015 two cyclones struck within a week,[25] with a further two in 2018,[26] and another major one in October 2023. Violent rains and floods do not compensate for droughts as the water flows too rapidly to be absorbed and replenish aquifers. They destroy terraces and wash away wadi banks and other water diversion structures. Their unpredictability affects the agricultural calendar while their increased frequency has exacerbated livelihood crises. Concurrently, the increased frequency of droughts prevents households from planning mitigation measures in advance by stocking cash, cereals, or fodder. Intense winds on drought-stricken lands blow away the cultivable topsoil and create sand and dust storms.

A study by the Geological Survey and Mineral Resources Authority from the Ministry of Oil and Minerals found that landslides often occur only when the slopes are saturated with water as a result of heavy rains, "as those slopes have not been exposed for hundreds of years and did not experience this number of slides except during this period as a result of heavy rains. These landsides and heavy rains have led to a rise in the level of the valleys with sediments and running water, which in turn led to an imbalance in the slopes, the burial and sweeping away of agricultural lands, the destruction of buildings and roads, and the expansion of areas unsuitable for agriculture and construction."[27]

Throughout the country, rising temperatures are a worsening problem.[28] In the past five decades, they have gradually increased in all five of the country's agro-ecological zones. The problem is intensified by the adoption of modern building techniques that have weak insulation, in contrast with traditional construction in many parts of Yemen where beautiful mud brick buildings provide excellent insulation against both heat and cold.

Rising sea levels are also of increasing concern. Since 1993, sea levels have risen by 3 mm per year and are estimated to rise to 0.54 m in total by 2100,[29] which would put most of the country's coastal areas at risk, particularly threatening the cities

[25] "Yemen: Cyclones Chapala and Megh Flash Update," OCHA, November 9, 2015, https://reliefweb.int/report/yemen/yemen-cyclones-chapala-and-megh-flash-update-6-9-november-2015

[26] "Yemen: Cyclone Mekunu Flash Update," OCHA, May 25, 2018, https://reliefweb.int/report/yemen/yemen-cyclone-mekunu-flash-update-1-25-may-2018-enar; "Yemen: Cyclone Luban Flash Update," OCHA, October 17, 2018, https://reliefweb.int/report/yemen/yemen-cyclone-luban-flash-update-2-17-october-2018-enar

[27] Ismail al-Ganad, senior official at the Geological Survey Authority, interview by author, November 2023.

[28] Karim Fahim and Ali al-Mujahed, "When Heat Worsens Hunger," Washington Post, October 12, 2023, https://www.washingtonpost.com/climate-environment/interactive/2023/yemen-extreme-heat-hunger-malnourishment/

[29] "Climate Change Impacts on Yemen and Adaptation Strategies," Yemen Family Care Association, 2023, p. 14.

of Hudaydah, Aden, and Mukalla, as well as all fishing communities and villages along the coast. Not only will this level of rise in seawater affect the infrastructure and living conditions for millions but will also impact nearby coastal aquifers and others within reach, causing salinization of water which is currently used both for domestic and agricultural purposes.

Pollution

Yemen's greenhouse gas emissions are very low,[30] however, 69 percent result from fossil fuel consumption for power generation, transportation, as well as oil exploration, vehicle emissions and by-products, industry, inadequate solid and liquid waste management, agricultural chemicals, and residential human and industrial waste.[31] Pollution from petroleum- and gas-operated vehicles has worsened air quality while careless disposal has waste products seeping into the soil, damaging it and affecting aquifers. Mainly a localized issue, oil exploration and production has led to significant pollution of different types, including spills along pipelines either through accident or deliberate, and the reinjection of polluted water and oil residues in the production process.[32] Ships at sea also regularly release (accidentally or otherwise) different types of oil-based waste products. The war has further contributed to environmental issues through the scattering of exploded and unexploded munitions such as landmines and cluster bomblets.[33]

Inadequate Sanitation and Human Waste Disposal Systems

Population increases and the 'modernization' of housing have increased domestic water usage and led to the abandonment of the traditional waterless 'long drop' sanitation mechanisms for high-rise buildings in many parts of Yemen. The latter used minimal amounts of water for human waste disposal while being ecologically adapted to the climate and producing fertilizer waste from solid waste and runoffs to fields for liquids. Modern sanitation needs more water, not only to flush toilets but also to transport the waste along sewage systems to its disposal sites. Insufficient treatment plants for cities and towns, and their complete absence for rural areas, have led to the accumulation of polluted wastewater near residential areas, spreading disease by acting as mosquito breeding grounds and concentrating salmonella and other bacteria, causing gastric diseases.

[30] Helen Lackner, "Climate Change and Conflict in Hadhramawt and al Mahra," Berghof Foundation,December 21, 2021, pp. 13 and 19, https://berghof-foundation.org/library/climate-change-and-conflict-in-hadhramawt; "Leaker Ghost Tankers: Pollution in the Port of Aden," Pax for Peace, August 1, 2022, https://paxforpeace.nl/news/leaking-ghost-tankers-pollution-in-the-port-of-aden/

[31] "Yemen 6th Report to the Convention on Biological Diversity," p. 49

[32] Yasmeen al-Eryani "Oil Extraction Industries' Impacts on Health, Livelihoods and the Environment in Hadramawt," Sana'a Center for Strategic Studies, December 14, 2020, https://sanaacenter.org/publications/analysis/12203

[33] "Guide to Explosive Ordinance Pollution of the Environment," Geneva International Centre for Humanitarian Demining (GICHD), December 15, 2021, https://www.gichd.org/publications-resources/publications/guide-to-explosive-ordnance-pollution-of-the-environment-1/

Fisheries

Marine fisheries are a major resource for Yemen with its long coasts on both the Red Sea and Arabian Sea. Despite international and national regulations, overfishing has continued at the expense of sustainability and to the detriment of local artisanal fishers as powerful larger ships have impinged on areas closer to the coast.[34] Protection has been ineffective and law enforcement weak due to lack of funds as well as willingness on the part of authorities. Some marine species are close to extinction. Lobster catches in Al-Mahra in the early 2000s were observed as notably low; during a days-long visit to fisher communities, only one was found available for purchase.[35]

[34] Natheer Alabsi and Teruhisa Komatsu, "Characterization of fisheries management in Yemen: A case study of a developing country's management regime," Marine Policy, Volume 50, December 2014, pp. 89-95, https://www.sciencedirect.com/science/article/pii/S0308597X14001456

[35] Personal observation by the author.

Existing Adaptation Initiatives and Policies

Environmental Policies

The 2009 Yemen National Adaptation Programme of Action (NAPA) listed many projects and strategies to address the environmental crisis.[36] It focused on water management and coastal issues, including the development of integrated coastal zone management and the restoration of mangroves. It emphasized the importance of increased awareness, as well as the addition of climate change issues in school syllabi. It proposed the establishment of a Climate Change Database. It addressed many of the issues faced by rural people with programs on the restoration and rehabilitation of terraces, which would increase cultivable land, assist replenishment of aquifers, and reduce the disappearance of topsoil. It also recommended research and promotion of crops resistant to drought, heat, and salinity. Sustainable land management to combat desertification and land degradation is relevant for water management and other aspects of the environment.

Issues relating to domestic and other energy uses were addressed by the National Strategy for Renewable Energy and Energy Efficiency, also issued in 2009. This initiative focused on a number of projects, including concentrated solar power for electricity in the national grid, integrating 400-megawatt (MW) wind farms into the national grid, 200 MW of geothermal power, all by 2025, as well as 6 MW biomass power plants using landfill gas and individual solar home systems in rural areas to cover 110,000 households.[37]

The Yemen 6th Report to the Convention on Biological Diversity in 2019 assessed progress on environmental issues, and found that less than a quarter of planned mitigation and adaptation measures had been implemented.[38] Many issues had been neglected: sustainable production and consumption, habitat fragmentation, sustainability of fisheries and agriculture, pollution, invasive alien species, genetic diversity, vulnerable ecosystems, and protected areas. Causes listed included institutional weakness, ineffective planning and management, and low public awareness. The latter is one aspect that has changed in recent years, as the deteriorating situation has led to strong public calls for improved preparedness to cope with extreme weather events. Despite the increasing number of environmentally related problems, the National Plan for Disaster Risk Reduction had not been completed by

[36] "Yemen National Adaptation Programme of Action Official Document," UNDP, April 2009, https://www.adaptation-undp.org/resources/assessments-and-background-documents/yemen-national-adaptation-programme-action-napa

[37] "National Strategy for Renewable Energy Efficiency, Executive Summary," Ministry of Electricity and Energy, General Department for Renewable Energy, 2009; "Yemen 6th Report to the Convention on Biological Diversity," March 2019, p. 51.

[38] "Yemen 6th Report to the Convention on Biological Diversity," March 2019.

2022.[39] The Ministry of Water and Environment's Environmental Emergency Unit's role and responsibilities for strategies and actions is unclear even to people directly concerned with these issues.[40]

By contrast with official inaction, local-level initiatives have been relatively active. In Hadramawt, the Environmental Protection Agency (EPA) created local teams that have prepared plans to mitigate disasters.[41] It also trained agricultural associations on disaster management, spate irrigation, and the problems of improper waste disposal. The Geological Survey Authority prepared flood and landslide risk maps in Hadramawt and Al-Mahra.[42]

Recent field work throughout the country identified a high level of awareness and concern about the impact of climate change,[43] especially considering devastating rains leading to flash floods and the increased number of cyclones. Many people's overall perception is that total rain flows are reducing, and the timing of rainy seasons is changing. Droughts are more frequent, air temperatures are rising, and water tables are dropping. Citizen adaptation measures reflect the hopelessness of the situation, with many people emigrating, searching for non-agricultural jobs, converting agricultural land into residential spaces, and selling land. Calls for state intervention to protect the environment and enforce existing regulations were almost universal among the hundreds of study participants, whether rural or urban.

There are many reasons for ineffective implementation of environmental adaptation. A main factor is the lack of commitment by political leaders on all sides of the current conflict, while others include insufficient finance and expertise, and the multiplicity of involved agencies. Officials in the sector expressed a lack of financing for environmental adaptation initiatives as well as the imbalance between discourse and action from international financiers.[44]

[39] "Global Forum for Disaster Risk Reduction: Summary of Session Seven [AR]," Global Platform for Disaster Risk Reduction, Indonesia Forum, May 23-28, 2022, https://globalplatform.undrr.org/publication/byan-aljmhwryt-alymnyt-llmntdy-alalmy-llhd-mn-mkhatr-alkwarth-aldwrt-alsabt-baly

[40] Maha al-Salehi, environmental researcher at Holm Akhdar, and Omer bin Shehab, official at the EPA in Hadramawt, interviews with the author, Hadramawt, November 2023.

[41] Helen Lackner, "Climate Change and Conflict in Hadhramawt and al Mahra," Berghof Foundation, December 21, 2021, https://berghof-foundation.org/library/climate-change-and-conflict-in-hadhramawt

[42] Ismail al-Ganad, senior official at the Geological Survey Authority, interview by the author, November 2023.

[43] Fieldwork for the pending report: "Charting the Course: A Rapid Water Security Diagnostic for Yemen," World Bank, 2024.

[44] Omer bin Shehab, official at the EPA in Hadramawt, and Dr. Ismail al-Ganad, senior official at the Geological Survey Authority, interviews by the author, November 2023.

Water Management Policies

Long left to 'free market' approaches which contributed to the over-exploitation of this essential and limited resource, state management finally emerged with the establishment of the National Water Resources Authority in 1995.[45] Although officially responsible for water management, it lacks enforcement capacity and relevant staffing. In 2002, the Water Law was passed, followed almost a decade later by its by-laws. The law remains institutionally weak, primarily because the authority over irrigation, the main user of water, was promptly returned to the Ministry of Agriculture and Irrigation thus depriving the Ministry of Water and Environment of the ability to address and control this crucial issue.

In January 2011, the National Conference for the Conservation and Management of Water Resources in Yemen was held after years of efforts by concerned officials and experts. It produced a 'Sana'a Declaration' which only weakly addressed the problems, largely because the government led by Ali Abdullah Saleh was unwilling to address the overdraft of water by powerful landowners.[46] However, what little progress had been made was brought to a standstill later that year with the uprisings and the end of the Saleh regime. With the internationalization of the civil war and political fragmentation, environmental issues have worsened significantly in the past decade. Even the few positives have seemed to fade – while a lack of electricity and diesel reduced deep-well pumping for irrigation in the early stages of the war, wealthy farmers have developed solar pumping to allow for the continued depletion of deep aquifers. This has rapidly worsened Yemen's water problem and caused experts to abandon hope that some of the fossil aquifers might be saved by the conflict.[47]

In the absence of government intervention, individuals and communities have adapted to the declining environmental crisis in different ways. Community initiatives to increase awareness of the problems have become widespread, alongside calls for government action to address the fundamental problem. Among these are efforts to expand water harvesting for domestic and agricultural use, and to address issues related to solid waste management.[48] Lessons from traditional local expertise and knowledge have helped people adapt to the changes, including expanding spate irrigation and other forms of water harvesting.[49] Recent fieldwork has also shown that many people, aware of the risks but lacking alternatives, are

[45] Yehya Qahtan and A.M. al-Asbahi, "Water Resource Information in Yemen," UN Statistics Division, June 2005, https://unstats.un.org/unsd/environment/envpdf/pap_wasess3a3yemen.pdf

[46] C. Ward, N. AbuLohom, and S. Atef eds, "Management and Development of Water Resources in Yemen," Sheba Center for Strategic Studies, 2011, Annex 4.

[47] Musaed Aklan and Helen Lackner, "Solar-Powered I rrigation in Yemen: Opportunities, Challenges and Policies," Sana'a Center for Strategic Studies, April 29, 2021, https://sanaacenter.org/publications/main-publications/13849

[48] Abdelrahman al-Eryani, Former Yemeni Minister of Water and Environment, interview by the author, November 2023; Lackner, "Climate Change and Conflict," Berghof Foundation, 2021.

[49] Maha al-Salehi, environmental researcher at Holm Akhdar, interview by the author, November 2023.

adopting unsustainable responses to the water crisis. These include drilling new wells or deepening existing ones, as well as building in wadi beds liable to floods.[50] Faced with reduced water availability, people have taken to using brackish water for most domestic uses and, whenever they can afford it, to purchasing purified water for drinking and cooking, as well as using water filters. Positive actions also exist, including building water harvesting reservoirs and filtering structures to slow water flows and replenish the aquifers, and rehabilitating irrigation channels.

In agriculture, farmers are adapting in different ways: clearing waste from blocked channels, building gabion barriers, and installing filters and PVC piping. Cropping pattern adaptations include switching to less water-intensive crops, planting windbreaks to reduce the impact of wind and protect soils, clearing agricultural areas from invasive species, and modifying the cropping calendar to adjust to changing rainfall timings. Eventually, with diminishing returns and worsening living conditions, people envisage abandoning agriculture and taking up different economic activities.[51]

[50] Maha al-Salehi, environmental researcher at Holm Akhdar, and Omer bin Shehab, official at the EPA in Hadramawt, personal interviews by the author, November 2023.

[51] Fieldwork for the pending report: "Charting the Course: A Rapid Water Security Diagnostic for Yemen," World Bank, 2024.

Lessons Learned

Alongside people elsewhere, Yemenis suffer from the acceleration of global warming. Two features are country-specific. First, military interventions, ranging from the spread of landmines to the presence of explosive remnants, have exacerbated environmental and human suffering already present in Yemen. Second, the increased use of solar water pumping in agriculture is leading to a more rapid exhaustion of fossil aquifers at the expense of both sustainability and basic human needs. It is clear from the implemented adaptation strategies that addressing global warming is now a priority for Yemenis, and has become part of 'normal' life, regardless of official institutions' inaction.

Although in the past Yemen received limited development aid, the war has brought a massive increase in humanitarian aid, including some development investments, none of which is optimally designed. Two examples stand out: support for rural communities to repair and reconstruct terraces is targeted at poor farmers rather than at complete watersheds, so it is destroyed at the first rains;[52] second, aid organizations have been ineffective at supporting the distribution of cooking gas, forcing people to cut the remaining trees and bushes, worsening desertification. The lesson for international supporting institutions is that a holistic perspective, including a focus on environmental issues, is essential and should be implemented within a long-term strategy.

With respect to rural water, worsening scarcity has both strengthened community-level cooperation and encouraged conflicts. Positive responses have improved rainwater harvesting and replenished shallow aquifers, while war-driven negligence has led to unsustainable increased reliance on emergency strategies (truck deliveries) at the expense of lasting infrastructure solutions.[53] Lack of actual knowledge about the availability of water is a further impediment. The lesson is that there is no room for ‹one size fits all' approaches and that all strategies must take into consideration specific circumstances, both technical and social. What works well in one context may be a recipe for failure elsewhere.

The neglect of biodiversity and its protection led to the extinction or near-extinction of indigenous fauna and flora. While the importance of ensuring the survival of the remaining wildlife and flora is now better understood, most destructive actions are due to poverty and desperation rather than lack of concern. The lesson is that poverty alleviation will reduce environmentally damaging activities.

Yemen's environmental crisis has also shown that there are circumstances when doing nothing is more effective than intervention. For instance, planting trees does not compensate for the destruction of old mature ones; rather than expanding irrigated cropping areas, it would be better to improve irrigation efficiency and develop rainfed crops which are those of poorer households.

[52] Abdelrahman al-Eryani, former Yemeni Minister of Water and Environment, interview by the author, November 2023.

[53] Bassam al-Khameri, "Water project launched amid dire shortages," Yemen Times, November 20, 2014, https://reliefweb.int/report/yemen/water-project-launched-amid-dire-shortages

Reviving traditional indigenous practices is important to restore Yemen's environment but must be adapted to modern climatic and socio-economic circumstances. For example, traditional mud brick housing has excellent insulation but requires technical adaptations to address the new type of violent longer-lasting rainfall that damages it. Meanwhile, new technologies can be deceptively dangerous. The positive expansion of solar energy for domestic purposes lays a good basis for the future but has also led to the expansion of solar pumping to irrigate crops at the expense of smallholders and sustainable domestic water supplies. An innovation can have both a positive and negative impact, and both need to be assessed to maximize efficacy.

The suitability of internationally promoted policies to the Yemeni context must be examined carefully, both socially and technically. For example, there is much evidence that privatization of urban water supplies has failed to ensure reliable and reasonably priced water and sanitation services to residents.

Conclusion

As elsewhere in the world, regardless of whether the tipping point of the climate change catastrophe has been reached, environmental disasters will only worsen in coming years. Yemen is among the countries that suffer most from the extremes of heat, floods, and droughts. It is therefore urgent to implement adaptation and mitigating measures to reduce the life-threatening impact of global warming. While citizens can and should act, the main policy and infrastructural interventions are state responsibilities: those who control the different fragments of the country must act, ideally in a coordinated manner. The time for empty rhetoric is past. Addressing the environmental crisis must be prioritized over and above short-term political gains and competition.

State response has been inadequate: authorities have done little or nothing to mitigate or minimize the impact of environmental problems. Some would say that state inaction has been criminal as it exposes citizens to danger and leads to avoidable injuries and deaths. Political neglect at the highest level has been partially compensated by citizen initiatives (supported to some extent by local administration and civil society organizations) but it is not enough. The most prominent environmental issues require significant state policy decisions and/or infrastructure investments, which are beyond the capacity of citizens or community-level organizations. This imbalance between official and individual responsibility demonstrates the need for reviewing governance and prioritization mechanisms. This is especially true for the water sector. Priority must be given to human domestic needs, followed by those of livestock and industry. Diverting a small percentage of water away from agriculture to these needs will allow Yemenis to stay in Yemen and even flourish.

Finally, international and bilateral development agencies have also failed to give these issues the attention they require, by concentrating on short-term humanitarian interventions and failing to address urgent and lasting environmental issues. This is not entirely surprising given most of these states' actions, or lack thereof, in their own countries.

Recommendations

First and foremost, politicians should prioritize environmental issues, in particular water, for the future of the country. Yemenis are suffering considerably as a result of inaction by national authorities. **Without water, there is no life.** Women and marginalized groups should be involved in all recommendations listed below.

Institutional

State representatives, i.e. the factions ruling different areas in the name of 'government', should:

- Establish powerful environmental institutions at national and local levels, or strengthen existing ones such as the EPA.
- Follow the steps outlined in the National Plan for Disaster Risk Reduction strategy.
- Establish a National Climate Emergency Center.
- Develop a national strategy to mitigate climate change. Government, civil society, and specialized institutions should be involved in its formulation.
- Create and implement Early Warning Systems throughout the country to enable people to take timely coping measures before major weather events.

General environmental issues

- Individuals and groups should use existing natural resources more efficiently to maximize their benefit for people and the environment.
- The education system, government, and civil society organizations should work to increase awareness of the importance and urgency of all environmental issues, including biodiversity; media awareness campaigns, training of administrators at local and national levels, training of community members and leaders, inclusion of environmental issues in school syllabi from an early age and throughout the education system are all important steps.
- All political negotiations should prioritize environmental issues.
- Planning authorities should ensure complementarity rather than overlap of concerned agencies, with a clear hierarchical structure.
- International agencies should finance community and individual environmental protection initiatives that mitigate climate change problems. This should include strategies to 'prevent harm,' e.g. do nothing rather than intervene in a harmful way.
- All official agencies and community leaders should enforce existing laws and regulations.

- Research institutions, government, and funding agencies should implement research on the past and present impact of global warming at the community, watershed, and agro-ecological zone levels. This is essential to learn the relevant lessons and avoid repeating mistakes.
- State agencies, international funders, and all researchers should consult citizens on suggestions to address, mitigate, and solve environmental problems.
- Parties across the environmental sector should study traditional indigenous practices and adapt them to the current situation.
- Relevant government and private sector institutions should reduce pollution from oil by-products as well as general waste (control plastics, regulate oil production companies, and develop environmentally friendly waste disposal for cities, towns, and villages).
- Local communities should 'green' the environment, reduce tree and bush destruction for firewood, and plant trees in open areas, irrigating them with 'gray' water. Government parties should finance these initiatives.

Water

State representatives, i.e. the factions ruling different areas in the name of 'government', and local authorities should:

- Decree that human domestic uses have priority over all other water uses, followed by livestock and industrial needs. Allow deep-well agricultural irrigation on a sustainable basis (i.e. ensuring lasting supply for other uses) only after other needs have been fulfilled.
- Establish national regulations and mechanisms to ensure that water is managed at basin/watershed level. Management structures should empower users as a whole and operate according to clearly defined principles.
- Enforce water management regulations, prevent illegal and unregulated drilling of wells, and effectively penalize lawbreakers. Distances between wells, extraction rates, and focus on replenishment should be explicit principles.
- Support community committees to effectively manage water use for domestic and agricultural water, including on conflict management practices.
- Improve sustainable structures and management mechanisms to ensure that rural people have adequate access to potable water as well as sanitation; these should take into consideration the availability and sustainability of the resource within the entire basin.
- Develop sustainable desalination for urban and other coastal settlements.

Agriculture

Given the importance of rural life, and the fact that about 70 percent of Yemenis live in rural areas and half the population depends, directly or indirectly, on agriculture, this sector must be given particular attention.

- Government, international agencies, and local communities should invest in the rehabilitation of terraces in complete watersheds, thus protecting soils, water, and agricultural production.
- Government and international agencies should prioritize and support rainfed agriculture through research and development of drought-resistant, fast-maturing cash and staple crops.
- Government and local enforcement agencies should allow deep-well irrigation only where it is sustainable without depleting fossil aquifers and does not reduce availability for domestic use.
- Government and local enforcement agencies should control and regulate the use of deep pumping, whether solar or other, to safeguard the shallower aquifers and thus the resource for all.
- Government and international funding agencies should ensure that there is a reduction in the cultivation of thirsty crops like bananas, qat, and mangos. Local needs should have priority over export potential.
- Government and local authorities should support smallholders in particular to increase incomes through advice, technology, and finance for water harvesting and saving mechanisms.

Rural and urban livelihoods

- Government and international funding agencies should study and support economic activities and enterprises that are environmentally friendly and adapted to climate change.
- Government and the private sector should develop enterprises that demand less water and cause less pollution.
- Government and urban authorities should take measures to reduce the impact of increased temperatures on living conditions: insulate housing and adapt traditional mud brick housing to cope with violent and lasting rainfall, while retaining their valuable insulation properties.
- Government and urban authorities should revive the local water authorities in towns and cities, providing their staff with technical and managerial training and strengthening their capacity to promote awareness both of climate change's implications and of which adaptation and mitigation measures should be taken.

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