Navigating Conflict: A Comprehensive Analysis of Water Security and Food Security in Yemen

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List of Abbreviations

ACLED	Armed Conflict Location and Event Data Project
AQAP	Al-Qaeda in the Arabian Peninsula
EIAs	Environmental Impact Assessments
ET	Evapotranspiration
FAO	Food and Agriculture Organization
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GPC	General People's Congress
IDPs	Internally Displaced Persons
IRG	Internationally Recognized Government
IWRM	Integrated Water Resource Management
LCs	Local Water Corporations
MENA	Middle East and North Africa
MOPIC	Ministry of Planning and International Cooperation
MWE	Ministry of Water and Environment
PPCPs	Public-Private-Community Partnerships
PPPs	Public-Private Partnerships
PDRY	People's Democratic Republic of Yemen
PLC	Presidential Leadership Council
STC	Southern Transitional Council
UAE	United Arab Emirates
UN	United Nations
WASH	Water, Sanitation and Hygiene
WEC	Water and Environment Centre
WFP	World Food Program

WWTPs	Wastewater Treatment Plants
YAR	Yemen Arab Republic

Units

BCM	Billion Cubic Metres
km2	square kilometres
l/s	litres per second
MCM	Million Cubic Metres
MCM/y	Million Cubic Metres per Year
mm	millimetres
y	Year

Executive Summary

Yemen has faced severe challenges to its water and food security due to ongoing conflict. This report examines the profound impact of the conflict on these vital sectors, detailing the destruction of essential infrastructure, the disruption of agricultural production, and the widespread humanitarian crisis that has emerged as a result. It also provides actionable recommendations to address immediate needs and ensure long-term resilience.

Before the conflict, Yemen was already grappling with extreme water scarcity, with annual per capita water availability far below the global threshold for water stress. The conflict has worsened these pre-existing vulnerabilities, leading to the destruction of key water infrastructure, fuel shortages, and supply chain disruptions that have undermined access to clean water and food. As of 2024, 27 percent of the population lacks access to safe water, and 17.6 million people—half of Yemen's population—are severely food insecure.

The humanitarian situation is dire, with 18.2 million people requiring aid, and 80 percent of the population living below the poverty line. Agricultural production has collapsed due to damaged irrigation systems and rising fuel costs, exacerbating the country's reliance on food imports. Malnutrition rates are alarmingly high, especially among children under five.

This report proposes a dual approach to address these interconnected challenges:

- **Immediate Relief:** Emergency food and water aid, alongside the rehabilitation of essential infrastructure, are necessary to alleviate the suffering of vulnerable populations.
- **Long-Term Solutions:** Integrated water resource management, climate-resilient agricultural practices, and strengthened governance structures are critical to rebuilding Yemen's water and food systems. Additionally, land tenure reforms and community-based resource management initiatives will help enhance resilience.

In conclusion, Yemen's crisis requires urgent action, both to provide immediate relief and to build sustainable, long-term solutions. A coordinated, multi-stakeholder approach—combining humanitarian, development, and peacebuilding efforts—is essential for overcoming the current crisis and ensuring a stable and resilient future for Yemen's population.

1 Introduction

Yemen, located at the southwestern tip of the Arabian Peninsula, has faced persistent challenges rooted in its socio-political landscape, economic vulnerabilities, and natural resource constraints. Over the course of its history, Yemen has been marked by deep divisions, both internal and external, which have shaped the course of its development and its current fragility. Despite its unification in 1990, when the Yemen Arab Republic (North Yemen) and the People's Democratic Republic of Yemen (South Yemen) merged, the country has struggled to achieve lasting stability. Instead, this unification set the stage for further political fragmentation, economic decline, and external intervention, which have contributed to the severe crises Yemen faces today.

The socio-political instability of Yemen is deeply tied to its history of ideological differences, border disputes, and civil wars.[1] Even after the formal unification of the north and south, political and regional tensions continued to undermine efforts at building a cohesive national identity. This instability was compounded by the emergence of local and regional strongmen, competing political factions, and the influence of external actors, which have contributed to Yemen's vulnerability to both internal strife and international intervention.

Beyond political instability, Yemen's socio-economic challenges have been equally profound. The country has long struggled with poverty, unemployment, and underdevelopment, compounded by limited natural resources and a rapidly growing population. Yemen's heavy reliance on its oil sector for economic growth has exposed it to the volatility of global markets. In recent years, a dramatic decline in oil production has further strained the national economy. From 264,000 barrels per day in 2010, Yemen's oil production has dropped to an average of 50,000–60,000 barrels per day between 2020 and 2022[2], triggering an alarming contraction in GDP and economic activity.[3]

Yemen is also one of the most water-scarce countries in the world. Water security has long been a critical concern, with the country's limited freshwater resources unable to meet the growing demands of its population. Agriculture, which is the primary source of livelihood for about 30 percent of Yemen's population[4], accounts for 90 percent of the country's water usage.[5] However, unsustainable agricultural practices, including the over-extraction of groundwater for irrigation, have led to severe water resource depletion. The combination of these factors—high population growth, inadequate water management, and an over-reliance on agriculture—

[1] "Yemen Unification: A Failed National Project," American Center for South Yemen Studies, May 29, 2023, https://americancentersy.org/2023/05/yemen-unification-failed-national.html.
[2] "Yemen Country Economic Memorandum 2022_World Bank," https://documents1.worldbank.org/curated/en/099050923091537357/pdf/P17826203eb7ac0030b5540af4456d0dd7c.pdf.
[3] Ibid.
[4] International Labour Organization, "Yemen Damage and Needs Assessment, Crisis Impact on Employment and Labour Market," January 2016.
[5] FAO, "Leveraging Water for Peace: FAO's Experience in Yemen," FAO-NearEast, April 3, 2024, https://www.fao.org/neareast/news/blog/blog-details/Opinions/2024/04/04/leveraging-water-for-peace--fao-s-experience-in-yemen/en.

has created a perfect storm of vulnerabilities in a country already susceptible to environmental and economic shocks.

The situation in Yemen worsened dramatically in 2015, when civil war broke out, escalating the country's already precarious state. The conflict has had devastating consequences for Yemen's people, economy, and infrastructure. Since the conflict began, an estimated 377,000 people have lost their lives[6], tens of thousands have been injured, and over four million individuals have been displaced, both internally and externally.[7] The conflict has decimated Yemen's already fragile infrastructure, destroying critical sectors such as water supply, agriculture, and healthcare. In 2024, it is estimated that 17.6 million Yemenis—approximately half of the population—are severely food insecure[8], and 27 percent lack access to clean water[9], with rural areas disproportionately affected.

The political landscape of Yemen today is deeply fragmented. The Houthi movement, also known as Ansar Allah, which controls the capital Sana'a and much of the northern part of the country, is at odds with the internationally recognized government (IRG), which its headquartered in the southern city of Aden. Despite a ceasefire in 2022, the political impasse persists, with no clear path to a lasting political resolution. This division has created a dual currency system, separate economic policies, and a lack of coordination between the two sides, further destabilizing the country's fragile economy. Humanitarian access is also severely restricted by bureaucratic barriers, particularly in Houthi-controlled areas, while the IRG struggles with its own internal divisions and weak governance in the South.

The impact of this fragmented governance is felt most acutely in Yemen's public services. Healthcare workers, teachers, and other public employees often receive little to no compensation, while the demand for services continues to grow due to Yemen's high population growth rate. Gender disparities further exacerbate the vulnerabilities faced by women, who have limited access to resources and opportunities in both conflict and post-conflict environments.

The social fabric of Yemen has also been severely damaged by the conflict. Children, who make up a significant portion of Yemen's population, are suffering from the psychological and physical scars of the ongoing violence. Women and girls face heightened risks of gender-based violence, displacement, and exploitation, while marginalized groups such as refugees, migrants, and internally displaced persons (IDPs) are particularly vulnerable in this environment of prolonged crisis. The fragmentation of Yemen into different regions controlled

[6] UNDP, "Assessing the Impact of War in Yemen: Pathways for Recovery," UNDP, November 23, 2021, https://www.undp.org/yemen/publications/assessing-impact-war-yemen-pathways-recovery.

[7] UN OCHA, "Yemen Humanitarian Needs Overview 2024," February 1, 2024, https://reliefweb.int/report/yemen/yemen-humanitarian-needs-overview-2024-january-2024-enar.

[8] Ibid.

[9] Ibid.

by local actors with competing interests and policies has made national recovery efforts increasingly difficult.

The focus of this report is to examine the profound impact of the ongoing conflict on Yemen's water and food security, two sectors' states prior to the conflict, the devastating effects of the conflict, and highlights the interconnected vulnerabilities that continue to undermine recovery efforts.

2 Overview of the Conflict in Yemen

2.1. Timeline of Key Events Leading to the 2014 Conflict

In 1990, the Republic of Yemen was founded through the merger of the Yemen Arab Republic (YAR) in the north and the People's Democratic Republic of Yemen (PDRY) in the South. The YAR emerged in 1962 after the overthrow of the Imamate theocracy in Sana'a, while the PDRY was established as a socialist state in 1967 following a hard-fought war of liberation against British colonial rule. The unification was initially met with optimism, as many envisioned a future of multi-party democracy, equitable development, and social progress.[10]

However, the early optimism was short-lived. After the unification, the leadership of the newly unified Republic of Yemen became marked by centralized control, reliance on patronage networks, and the dominance of family-led military institutions.[11] These policies led to widespread alienation, particularly in the South, where resentment grew due to perceptions of marginalization and the suppression of southern political aspirations.

In the early 2000s, the Houthi movement rose in the north, driven by grievances over economic marginalization and cultural tensions, the Houthis turned to armed resistance in 2004. This sparked a series of violent clashes known as the Sa'ada Wars, which ended with a fragile ceasefire in 2010. However, tensions remained high as both sides prepared for future confrontations.

The year 2011 marked a turning point. Inspired by the Arab Spring, widespread protests erupted across Yemen, demanding an end to Saleh's decades-long rule. Under international pressure, Saleh stepped down in November 2011 as part of a transition agreement. His vice president, Abdu Rabbo Mansour Hadi, was elected unopposed in February 2012 to lead a transitional government.

By early 2014, efforts to stabilize and establish a more democratic Yemen through the National Dialogue Conference had failed.[12] President Hadi's announcement of a plan to transform Yemen into a federation of six regions alienated both the Houthis and Saleh's supporters.[13] This discontent culminated in fighting throughout that year, leading to the Houthi takeover

[10] Middle East Monitor, "TIMELINE: Yemen Slide into Political Crisis and War," Middle East Monitor, April 11, 2023, https://www.middleeastmonitor.com/20230411-timeline-yemen-slide-into-political-crisis-and-war/; Arab Centre for Research and Policy Studies DC and Marcus Montgomery, "A Timeline of the Yemen Crisis, from the 1990s to the Present," Arab Centre Washington DC, October 3, 2024, https://arabcenterdc.org/resource/a-timeline-of-the-yemen-crisis-from-the-1990s-to-the-present/.

[11] New Arab, "Yemen's Unification Is a Divisive Chapter in History," https://www.newarab.com/ (The New Arab, May 26, 2022), https://www.newarab.com/opinion/yemens-unification-divisive-chapter-history.

[12] "Yemen's Imposed Federal Boundaries - Yemen | ReliefWeb," July 21, 2015, https://reliefweb.int/report/yemen/yemens-imposed-federal-boundaries.

[13] Ibid.

of Sana'a on September 21, 2014. The Houthi advance marked the beginning of a new phase in the conflict, prompting an international military intervention in March 2015.[14]

A coalition of Arab states, led by Saudi Arabia, and including the United Arab Emirates (UAE), Egypt, Pakistan, Jordan, Bahrain, Kuwait, Qatar, Morocco, and Sudan[15], aimed at rolling and back Houthi gains and supporting Yemen's stability. However, the conflict soon devolved into a protracted stalemate, characterized by sporadic fighting and failed peace negotiations. By late 2019, over two-thirds of Yemen's population—approximately 24 million people—were in need of humanitarian assistance due to violence, blockades, and collapsing infrastructure.[16] The humanitarian crisis deepened as water and food shortages became widespread, and disease outbreaks intensified.

In April 2022, amid ongoing instability within the IRG and internal divisions among anti-Houthi factions, President Hadi transferred his powers to a newly formed Presidential Leadership Council (PLC). Backed by Saudi Arabia and the UAE, the PLC aimed to unify anti-Houthi forces under a single governance framework. Chaired by Rashad Al-Alimi and comprising key military figures representing different factions within Yemen, the council sought to address both the conflict and the humanitarian crisis. Despite these efforts, significant challenges remained. Internal divisions persist within the PLC members over governance structures and military strategies against the Houthis, while economic conditions continue to deteriorate due to prolonged conflict and blockades.

2.2. Impact of Conflict on National Governance

The ongoing conflict in Yemen has shattered the nation's governance structures, leaving behind a legacy of fragmentation and despair. What began as a political struggle has devolved into a multi-faceted war, exacerbating pre-existing vulnerabilities and creating new challenges that have pushed Yemen to the brink of collapse.

The civil war has fragmented Yemen's political landscape, giving rise to multiple power centres that have effectively dismantled the central government's authority. Local militias and factions, each vying for control over territory and resources, have further complicated the governance vacuum. Over the past seven years, the frontlines of the conflict have remained relatively static, with the Houthi movement, controlling approximately one-third of the country's land. This includes densely populated and impoverished mountainous regions, as well as key strategic areas like Marib, home to vital oil and gas fields. Marib has become a focal point of intense military offensives since early 2020, underscoring the critical importance of territorial control in the ongoing conflict.

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[14] Middle East Monitor, "TIMELINE."

[15] Stig Stenslie, "'Decisive Storm': Saudi Arabia's Attack on the Houthis in Yemen," May 2015.

[16] UN OCHA, "Yemen: Humanitarian Response Plan (HRP) 2024," February 1, 2024, https://www.unocha.org/publications/report/yemen/yemen-humanitarian-response-plan-hrp-2024-january-2024-enar.

While much of the country is often described as being under the control of the IRG, this characterization is misleading. The IRG is just one of many factions controlling different areas (Figure 1). It maintains control over parts of Marib, Hadhramaut, Shabwa, Abyan, and Al-Mahra governorates, but its authority is frequently challenged by separatist groups and local forces advocating for autonomy.[17]

In southwestern Yemen, approximately 60 kilometres along the Abyan coast and in regions like Bab Al-Mandab and Tihama, southern separatist forces backed by the UAE exert significant influence. These include the Southern Transitional Council (STC) and militias led by Tareq Saleh, the nephew of former President Ali Abdullah Saleh (Figure 1). The STC, in particular, has emerged as a powerful player in the South, often clashing with IRG-aligned forces.

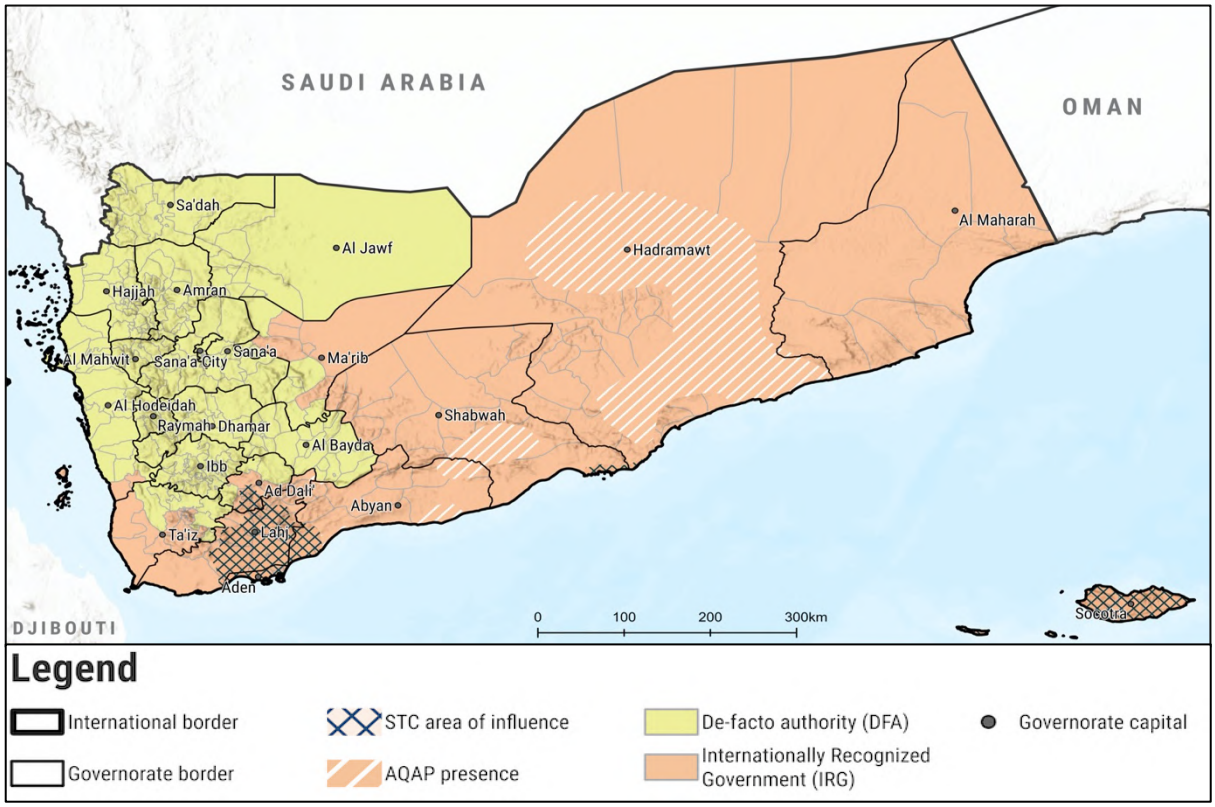

Figure 1 Areas of control as at 2024, the figure illustrates the influence of each conflict actor across various regions of Yemen (Source: ACAPS, 2025).

[17] Council on Foreign Relations (CFR), "Yemen's Tragedy."

Efforts to reconcile these factions, such as the Riyadh Agreement of 2019, have yielded limited results. This agreement came after STC forces expelled IRG from its capital, Aden, in August 2019. The Kingdom of Saudi Arabia has made significant efforts to mediate between these factions and restore IRG governance in Aden. While the STC is formally recognized as part of the IRG, tensions persist, and power-sharing arrangements remain largely unimplemented.

Although some non-STC ministers have returned to Aden recently, they do not effectively control or govern the area. The security elements outlined in the agreement remain largely unimplemented, allowing the STC to maintain greater control over Aden and its administration than the IRG. The STC, backed by the UAE, has consolidated its power in the South, often clashing with forces loyal to President Abd Rabbuh Mansur Hadi.[18]

This fragmentation has made cohesive national governance nearly impossible, as competing factions prioritize their own agendas over the collective good of the nation. The lack of unity among anti-Houthi forces has further complicated efforts to restore stability and governance, leaving Yemen in a state of prolonged disarray.

[18] Arms Trade Litigation Monitor, "Conflict Overview: Contexts."

3 The State of Water and Agriculture in Yemen: A Sectoral Overview

3.1. Yemen's Water Sector: Resources and Needs

Before the conflict, Yemen's water sector was already under immense strain due to overexploitation of resources, limited rainfall, and a growing gap between water supply and demand. This chapter provides an overview of Yemen's water sector before the conflict, focusing on its water resources, infrastructure, challenges, and the socio-economic and environmental implications of water scarcity.

3.1.1. Geographical and Climatic Context

Yemen's diverse topography and climatic conditions play a significant role in shaping its water resources. The country is divided into five primary geographical regions: Coastal Plains, Yemen Mountain Massif, Eastern Plateau Region, Desert, and Islands. Each region has distinct climatic characteristics, with rainfall patterns varying significantly across the country. This variability is driven by Yemen's unique geographical location on the Arabian Peninsula, surrounded by the Red Sea to the west and the Gulf of Aden to the south (Figure 2), combined with its dramatic elevation changes, ranging from coastal plains to mountainous highlands and arid desert regions.

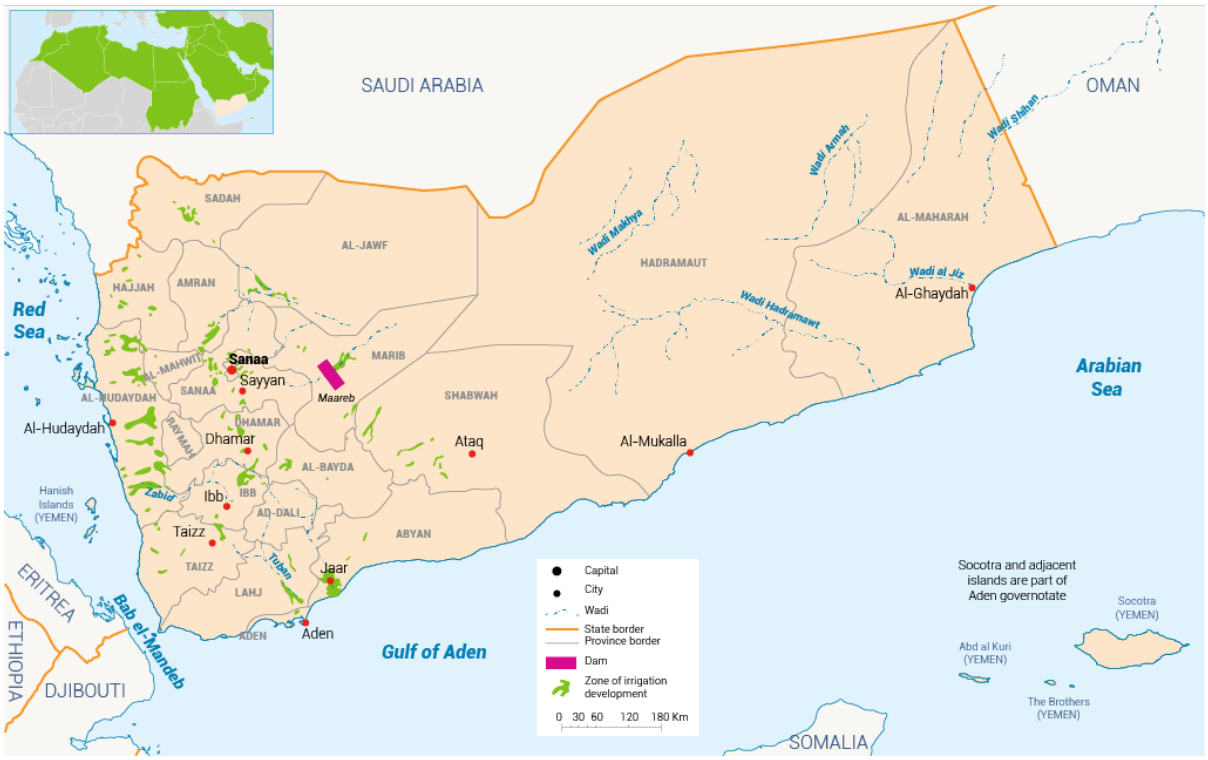

Figure 2 The Republic of Yemen map (Source: Noaman, A., Al-Nozaily, F.A. and Al-Mashreki, M.H. (2021)).

Rainfall Patterns and Distribution

Rainfall is the primary source of freshwater in Yemen, but its distribution is highly uneven both spatially and temporally (Figure 3). The country's climate is predominantly semi-arid to arid, with two main rainy seasons in highlands: the saif (April to May) and the kharif (July to September).[19] While the coastal areas receive approximately 80 percent of their annual rainfall during the winter months (December to March). The spatial variability of rainfall is largely dictated by topography and proximity to the Red Sea. The western and southwestern mountain slopes, which face the Red Sea and the Indian Ocean, receive significantly higher rainfall due to orographic effects, where moist air masses rise and cool over the mountains, resulting in enhanced precipitation on windward slopes. In contrast, the interior highlands and desert regions receive minimal rainfall.

The Coastal Tihama Plain receives approximately 150 mm of rain annually. Moving inland toward the foothills of the western mountains, rainfall increases to between 300 mm and 400 mm annually. In the western mountainous highlands, some areas receive over 1,000 mm annually, making them the most agriculturally productive regions. The central highlands, such as Sana'a, average around 200 mm of rainfall annually, while further north, toward Sa'dah, rainfall increases again due to elevation and geographical location. Figure 4 illustrates the rainfall and climatic zones in Yemen, highlighting the stark contrasts between regions.

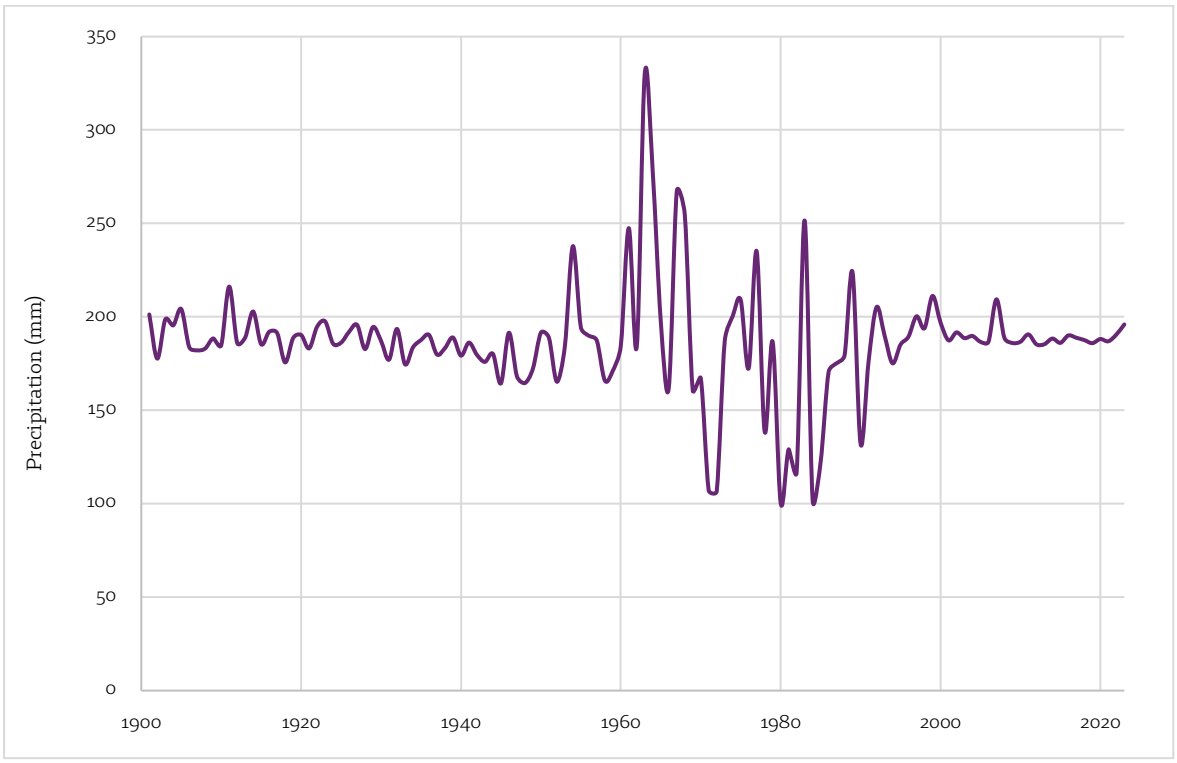

Figure 3 Annual precipitation of the Republic of Yemen for 1901 – 2023.

[19] "World Bank Climate Change Knowledge Portal-Yemen," https://climateknowledgeportal.worldbank.org/.

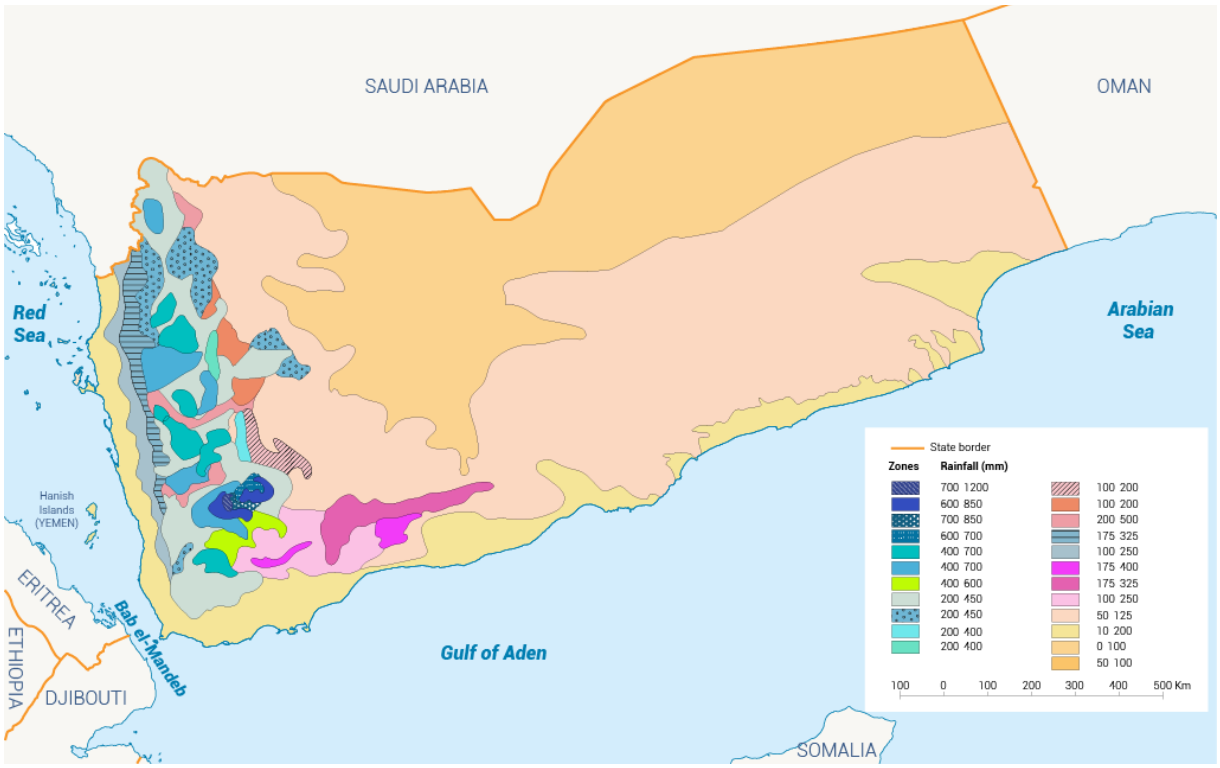

Figure 4 The rainfall and climatic zones in Yemen (Source: Noaman A., Al-Nozaily, F.A. and Al-Mashreki, M.H. (2021)).

Yemen's diverse topography divides the country into three distinct climatic subregions, each with unique rainfall characteristics and water challenges. Figure 5 provides a visual representation of Yemen's distinct climatic subregions.

1. Coastal Plains

The Coastal Plains include the Tihama region along the Red Sea and the Gulf of Aden. This region covers approximately 16 percent of Yemen's land area and experiences an arid, tropical climate with high temperatures and humidity. Annual rainfall averages 70–100 mm, with 80 percent occurring in winter. Rainfall is sporadic and often heavy, leading to high evaporation rates due to extreme heat and humidity. These conditions create hyper-arid environments, limiting water availability and posing significant challenges for water resource management.

2. Highlands

The western highlands receive the highest rainfall in Yemen, benefiting from orographic lift, where moist air from the Indian Ocean rises and cools. Annual rainfall ranges from 200–400 mm on slopes, with some areas, such as Ibb and Ta'izz, receiving over 1,000 mm. Summer temperatures average around 21°C, while winter temperatures can drop below freezing. Despite the relatively higher rainfall, the region relies heavily on traditional water harvesting

techniques, such as terraced fields, and faces challenges due to rainfall variability, requiring efficient water management for agriculture.[20]

3. Desert Regions

The central and eastern parts of Yemen are characterized by minimal rainfall and extreme climatic conditions. Annual rainfall is less than 50 mm, and temperatures often exceed 50°C. Rainfall is erratic and insufficient for agriculture[21], leading to severe water scarcity. The limited potential for rain-fed agriculture and the challenges in water resource management make this region particularly vulnerable to water stress.

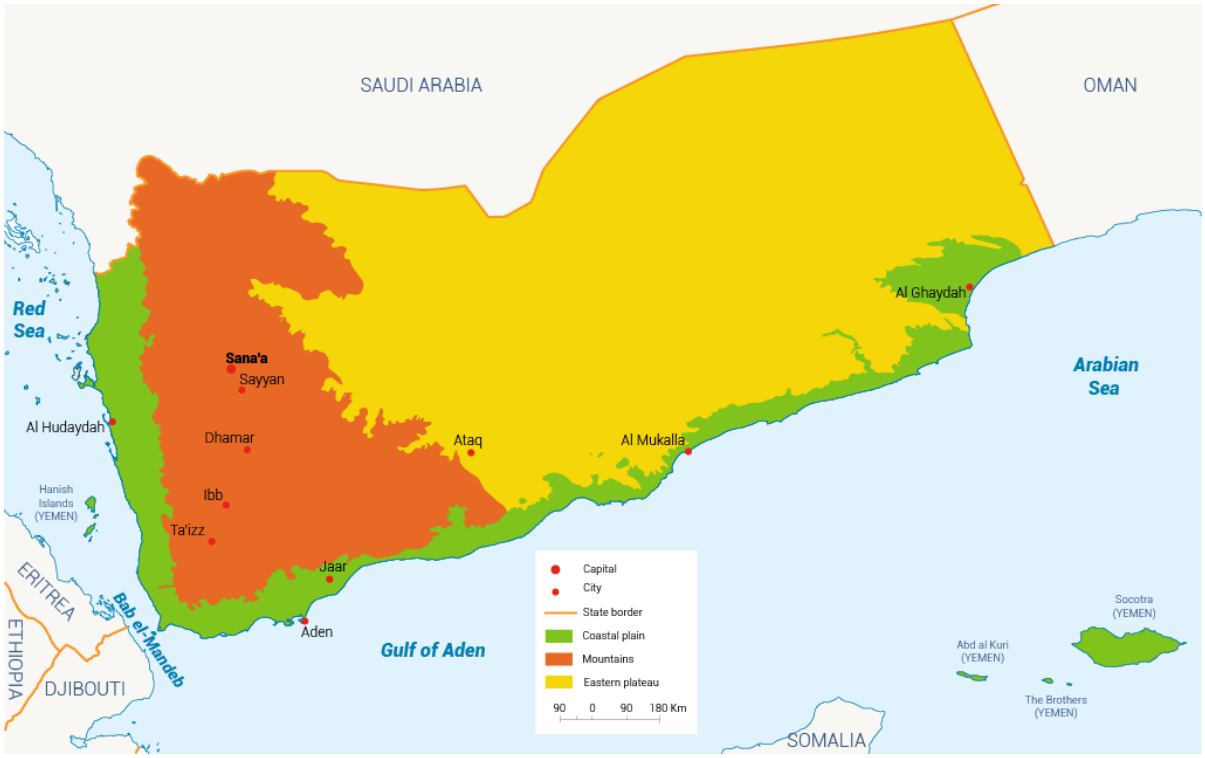

Figure 5 Distinct climatic subregions in Yemen (Source: Noaman, A., Al-Nozaily, F.A. and Al-Mashreki, M.H. (2021)).

Despite being the rainiest country in the Arabian Peninsula, Yemen faces significant water scarcity due to high rates of evapotranspiration (ET). Most of the rainfall is rapidly lost to the atmosphere, either through evaporation or transpiration from plants. In most areas, ET exceeds rainfall for the majority of the year, leaving insufficient water for rain-fed agriculture. Only a small fraction of the rainfall penetrates the soil to become soil moisture or percolates deeper to recharge groundwater. Surface runoff is limited, with less than 10 percent of the annual

[20] Ahmed Al-Ameri et al., "The Hydrogen (δD) and Oxygen (Δ18 O) Isotopic Composition of Yemen's Rainwater," *ARABIAN JOURNAL FOR SCIENCE AND ENGINEERING*, November 1, 2013, 1–14, https://doi.org/10.1007/s13369-013-0869-6.

[21] "2016_USAID GCC Office_Climate Risk Profile_Yemen.Pdf," https://www.climatelinks.org/sites/default/files/asset/document/2016_USAID%20GCC%20Office_Climate%20Risk%20Profile_Yemen.pdf.

rainfall captured in streams and rivers. The mean runoff coefficient in larger catchments is only 5 percent, highlighting the challenges of harnessing rainfall for sustainable water use.[22]

3.1.2. Water Resources Availability

Yemen, a country with no permanent rivers, relies heavily on rainfall, surface water, and groundwater extraction as its primary water sources. However, its water resources are under immense strain due to overexploitation, limited surface water availability, and highly variable rainfall patterns.[23]

Conventional Water Resources

Surface Water

Yemen's surface water resources are a vital component of the country's water supply, playing a crucial role in agricultural irrigation and domestic water use. However, these resources are limited and face significant challenges due to overexploitation, climate variability, and inefficient management practices. Yemen's surface water is primarily derived from seasonal spate flows and springs, which exhibit significant spatial and temporal variability in both quantity and quality. The country's surface water resources are divided into four main drainage basins: the Red Sea Basin, the Gulf of Aden Basin, the Arabian Sea Basin, and the Rub Al Khali Interior Basin (Figure 6).

Total surface runoff is estimated at 2.5 BCM annually, with 1.0 BCM available for spate irrigation and 1.5 BCM for groundwater recharge.[24] Surface water accounts for approximately 30 percent of Yemen's total freshwater withdrawals, with the remaining 70 percent derived from groundwater.[25] Despite its importance, surface water resources are under increasing pressure due to overexploitation, climate change, and inefficient management practices.

Historical hydrological assessments conducted in the 1980s estimated Yemen's total water yield to be between 2,100 and 2,400 MCM/y, but more recent data from the World Bank indicates that only about 6 percent of the total rainfall is captured within surface-water systems in wadis as spate flow, amounting to roughly 2,000 MCM annually.[26]

To optimize surface water utilization, Yemen has developed a network of infrastructure, including diversion weirs, distribution canals, and dams. Approximately 50 diversion weirs

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[22] "FAO Aquastat- Yemen Country Profile," accessed November 11, 2024, https://www.fao.org/aquastat/en/countries-and-basins/country-profiles/country/YEM.

[23] "Water Resources Challenges in Yemen, UNDP Strategic Framework, November 2022.Pdf," https://www.undp.org/sites/g/files/zskgke326/files/2022-12/Water%20Resources%20Challenges%20in%20Yemen.pdf.

[24] "Water-Availability-Study-in-Yemen.Pdf," https://www.undp.org/sites/g/files/zskgke326/files/migration/ye/Water-Availability-Study-in-Yemen.pdf.

[25] Joint (UNDP and FAO) Project Proposal - Decentralised Cooperative Water Governance for Food Security and Peace in Yemen (CoWaGo), UNDP & FAO. (2020).

[26] World Bank, "Yemen - Assessing the Impacts of Climate Change and Variability on the Water and Agricultural Sectors and the Policy Implications," *World Bank Publications - Reports*, World Bank Publications - Reports, April 2010, https://ideas.repec.org//p/wbk/wboper/2943.html.

and 800 medium and small dams have been constructed, primarily in the highlands, to support rainwater harvesting and irrigation. These structures collectively irrigate around 120,000–150,000 hectares of agricultural land in the lowlands. However, the infrastructure faces challenges such as siltation, poor maintenance, and inefficient water distribution, limiting its effectiveness.

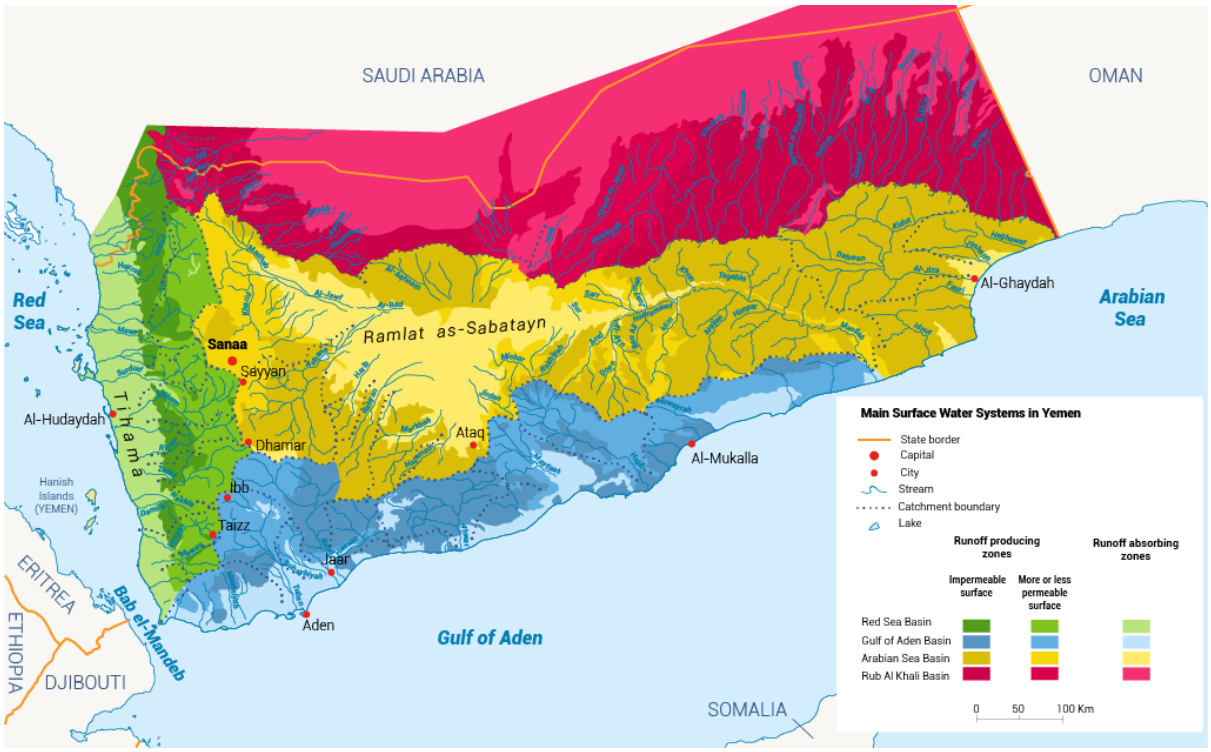

Figure 6 Main surface water systems in Yemen (Source: Noaman, A., Al-Nozaily, F.A. and Al-Mashreki, M.H. (2021)).

Groundwater

In Yemen, surface water runoff generated by rainfall creates intermittent flows through dry streambeds, known as wadis. These wadis are the primary source of groundwater recharge, playing a critical role in replenishing the country's aquifers. Figure 7 highlights the diversity of aquifer systems across Yemen, showcasing the varying hydrogeological conditions that have given rise to a wide array of groundwater development systems. Highly productive aquifers are found along the coastal regions, particularly in alluvial-filled wadis and in the fans and deltas formed by ongoing flooding and sedimentation processes. Significant aquifers are located in the Tihama Plain, Tuban Abyan, Ahwar, and Maiah in the south, as well as in Ramlat as-Sabatayn in the west and Wadi Hadhramawt in the east.[27]

[27] Dr. Abdulla Noaman, Dr. Fadhl Ali Al-Nozaily, and Dr. Mohammed Hezam Al-Mashreki, "Yemen Water Report," *Fanack Water* (blog), n.d., https://water.fanack.com/yemen/.

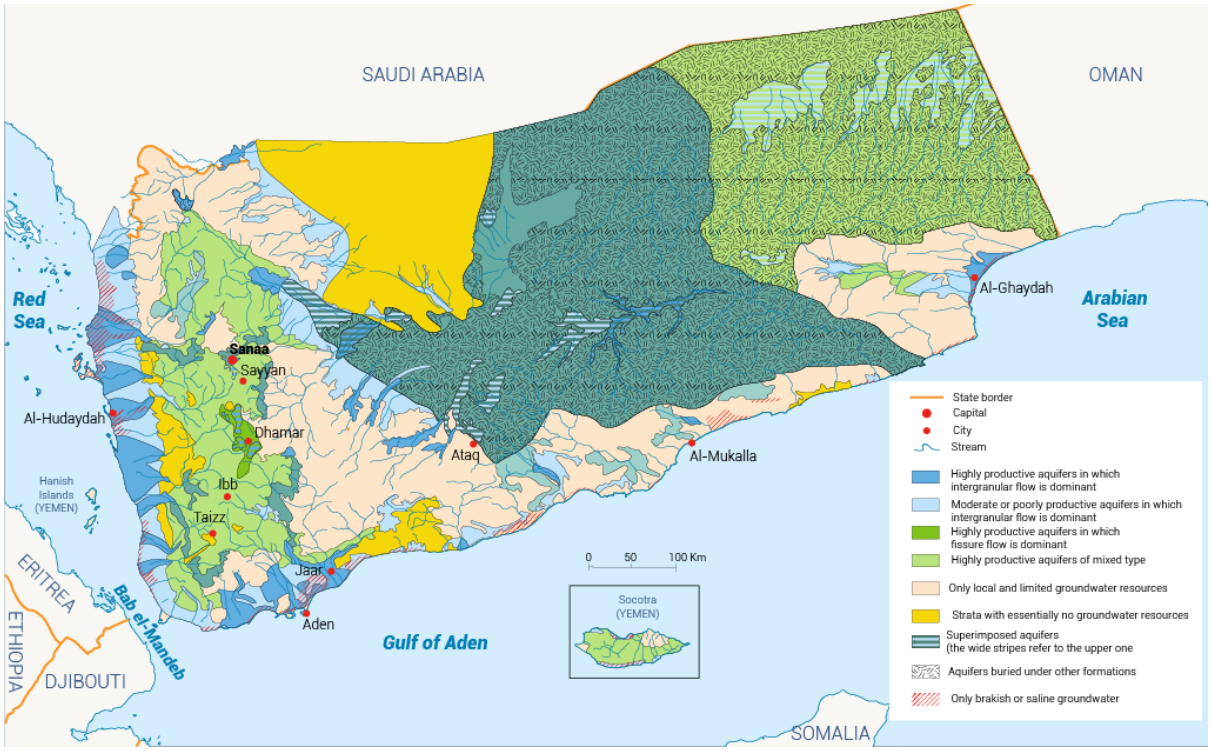

Figure 7 Main groundwater aquifers in Yemen (Source: Noaman, A., Al-Nozaily, F.A. and Al-Mashreki, M.H. (2021)).

Groundwater is a vital resource for Yemen's agriculture, domestic use, and industrial activities, with recharge primarily dependent on spate flows and rainfall. Runoff and springs in catchment areas are the main sources of groundwater replenishment. Estimates suggest that Yemen's renewable groundwater resources amount to approximately 1,000 million cubic metres per year (MCM/year), contributing to a total renewable water resource of 2,500 MCM/year. However, the total water demand is estimated at 3,400 MCM/year, resulting in an annual deficit of 900 MCM/year, which is increasingly met by overexploiting deep aquifers. This unsustainable practice has led to a rapid decline in groundwater levels, with aquifers depleting at rates of 1–7 metres annually, particularly in the Sa'adah Basin in the north, where declines can reach up to 6 metres per year. In some areas, drilling depths have extended to 800 metres to access diminishing reserves.

Groundwater withdrawals in Yemen are estimated at 2,500 MCM/year, accounting for approximately 70 percent of the country's total water use.[28] While aquifers contain substantial reserves of about 35,000 MCM, the annual recharge rate is only 1,300–1,500 MCM/year, primarily from infiltration in wadi beds.[29] The rate of groundwater overdraft is more than twice the recharge rate, leading to severe depletion, deteriorating water quality, and saltwater

[28] Bank.

[29] Dr. Abdulla Noaman, Dr. Fadhl Ali Al-Nozaily, and Dr. Mohammed Hezam Al-Mashreki, "Yemen Water Report," *Fanack Water* (blog), https://water.fanack.com/yemen/.

intrusion in coastal areas. If current trends continue, major aquifers could be fully depleted within 20 years, with devastating socio-economic consequences.

Groundwater Quality in Yemen

The quality of groundwater in Yemen has not been extensively studied, with electrical conductivity being the primary parameter measured at various sites. However, available data and observations highlight significant challenges related to groundwater deterioration, particularly in coastal and urban areas. In coastal regions, excessive groundwater abstraction has led to the intrusion of connate or seawater, severely degrading water quality. This issue is notably evident in the well-fields of Aden, where saline intrusion has rendered groundwater unsuitable for many uses.

In major cities, groundwater pollution is a growing concern due to increased water consumption and inadequate wastewater management systems. The absence of centralized wastewater collectors means that most households rely on cesspits, leading to the diffuse infiltration of contaminated water into aquifers. This contamination is exacerbated by high nitrate concentrations detected in deeper groundwater beneath urban areas, such as Sana'a, indicating the impact of untreated sewage and agricultural runoff.

Non-Conventional Water Resources

Rainwater Harvesting

Water harvesting, one of the oldest water management techniques, has deep historical roots in the Arab region, with Yemen standing out as a remarkable example of ancient ingenuity. The country's advanced water management systems, including the ruins of dams, reservoirs, and iconic mountain terraces, reflect a deep understanding of hydrological principles. Among these, the Marib Dam, dating back to the third millennium BC, approximately 4,000 years ago[30], is a testament to Yemen's historical engineering prowess. Archaeological excavations around Marib city have revealed irrigation structures from the same period, highlighting the region's long-standing reliance on floodwater irrigation. Remarkably, this practice continues today, making Marib one of the few places where runoff agriculture has been sustained since ancient times. The total dam capacity in the whole country is 462.5 million m^3.[31]

In Yemen's mountainous areas, traditional water harvesting practices have been preserved and passed down through generations. Communities have constructed cisterns to collect runoff from carefully selected catchment areas[32], ensuring water quality by locating these systems

[30] D. Prinz, "Water Harvesting — Past and Future," in *Sustainability of Irrigated Agriculture*, ed. L. S. Pereira et al. (Dordrecht: Springer Netherlands, 1996), 137–68, https://doi.org/10.1007/978-94-015-8700-6_10.

[31] "Yemen-AQUASTAT - FAO's Global Information System on Water and Agriculture.Pdf," https://openknowledge.fao.org/server/api/core/bitstreams/a4d54834-e8af-463c-8403-35592c138757/content.

[32] Taha M. Tahir, "Rainwater Harvesting: Community Based Managed Systems," *Journal of Science and Technology* 7, no. 1 (2002), https://doi.org/10.20428/jst.v7i1.233.

away from settlements. These cisterns, often built using locally manufactured materials like Khadad, have proven durable and resistant to environmental changes, demonstrating the effectiveness of indigenous knowledge in water management.

Yemen's hydraulic infrastructure is diverse and extensive, comprising over a thousand structures categorized into three main types. The first category includes 347 storage dams, constructed primarily in the highlands to store rainfall for irrigation, domestic use, and groundwater recharge. These dams are classified into large dams (capacity exceeding 500,000 m^3), medium dams (capacity between 200,000 and 500,000 m^3), and small dams (capacity below 200,000 m^3). The second category consists of 33 spate water diversion structures, designed to regulate and divert floodwaters in major wadis. The third category encompasses small water harvesting structures, such as cisterns, pits, and reservoirs, with storage capacities ranging from 500 m^3 to 50,000 m^3.[33]

According to the Food and Agriculture Organization (FAO) in 2008[34], Table 1 provides an overview of the major dams in Yemen with capacities equal to or exceeding 1 MCM. The table highlights key details such as their locations, major and sub-basin, and primary usage. These dams play a critical role in storing surface water, supporting irrigation, and mitigating the impacts of natural hazards in the region.

Table 1 Major dams in Yemen.

Name of Dam	Location	Major Basin	Completed /Operational Since	Reservoir Capacity (MCM)	Dam Usage
Al-Hidyn Karn Al-Asad	Al-Baydah	Al-Baydah Basin	No Data	1.2	Irrigation
Ma'areb	Marib	Arabian Sea Basin	1987	400	Irrigation, and Flood control
Raya'an	Sana'a	Sana'a Basin	1993	1.02	Irrigation, and others
Bait Al-Khardal	Sana'a	Ma'areb Basin	1999	2	Irrigation
Al-Rook	Al Bayda	Al-Baydah Basin	2000	1.8	Irrigation

[33] "Yemen-AQUASTAT - FAO's Global Information System on Water and Agriculture.Pdf."

[34] "FAO Aquastat- Yemen Country Profile," 2008, https://www.fao.org/aquastat/en/countries-and-basins/country-profiles/country/YEM.

Al-Khail Al-Awadh	Al Bayda	Al-Baydah Basin	2000	2.8	Irrigation
Wadi Mudrah	Marib	Ma'areb Basin	2000	1.5	Irrigation
Al-Gargoor	Sana'a	Sana'a Basin	2001	1	Irrigation, and others
Saybah	Sana'a	Ma'areb Basin	2002	1.249	Irrigation
Al-Amiriah	Al Bayda	Al-Baydah Basin	2004	1.069	Irrigation

In modern times, rainwater harvesting remains a critical strategy for addressing water scarcity in Yemen. The government, along with organizations like the Social Fund for Development and the Public Work Project, has constructed numerous water harvesting and diversion structures.[35] These systems aim to recharge groundwater and provide surface water, are particularly valuable in rural and urban areas. For example, in Sana'a, stormwater from streets and rooftops is harvested for domestic and agricultural use. Recent studies, have explored the potential of water harvesting along the Sana'a to Hodeidah road, focusing on water rights and infrastructure for irrigation.[36]

Innovative approaches, such as fog harvesting, have also been investigated in Yemen. Projects in the Manakha region, supported by the UNDP, have demonstrated the potential of fog collection as a supplementary water source for households in high-altitude areas.[37] While limited in scope, fog harvesting offers a resilient and sustainable solution for communities in water-scarce regions. Additionally, an estimated 270 million cubic metres of water annually flow from major wadis into the sea, highlighting the untapped potential for in-stream and off-stream water harvesting.[38]

Desalination

Brackish water is a naturally occurring resource in Yemen, present in both surface and groundwater systems across the country. However, excessive groundwater extraction has

[35] Noaman, Al-Nozaily, and Al-Mashreki, "Yemen Water Report."

[36] Abdullah A. Al-Maswari et al., "Potential of Road Rainwater Harvesting in Yemen – Its Social, Environmental and Economic Benefits: A Case Study of Sana›a – Hodeida Road, Yemen," *Journal of Science and Technology* 25, no. 1 (December 14, 2020): 23–64, https://doi.org/10.20428/jst.v25i1.1695.

[37] "Manakha Rainwater and Fog Harvesting – UNDP.Pdf, https://www.undp.org/sites/g/files/zskgke326/files/migration/ye/UNDP-YEM-Booklet.pdf.

[38] Frenken, *Irrigation in the Middle East Region in Figures.*

exacerbated salinity levels, particularly in coastal basins. This resource is utilized in various sectors, including the rock-cutting industry in highland regions and the irrigation of salt-tolerant crops in coastal plains. In Taiz city, brackish water is mixed with freshwater for domestic water supply without prior desalination.

Despite its widespread use, the total quantity of brackish water in Yemen remains poorly quantified, though estimates approximately 300 million cubic metres (MCM) per year are usable for agriculture, primarily in the Tehama coastal region.[39] Additionally, around 3.1 MCM/year of brackish water is used for municipal supply in Taiz city.

Desalination has been proposed as a potential solution to Yemen's escalating water crisis. However, its implementation faces significant challenges, including high operational and infrastructure costs, which could render clean water unaffordable for much of the population. Traditional desalination methods also rely heavily on fossil fuels, contributing to greenhouse gas emissions and environmental concerns such as chemical usage and the discharge of warm brine, which poses risks to marine ecosystems and human health. Despite these challenges, desalination remains a critical consideration for addressing Yemen's water scarcity.

Yemen's desalination infrastructure is limited, with two primary facilities. The Al-Haswah Electricity Station in Aden, the country's first desalination plant, produces approximately 69,000 m^3/day of desalinated water, which is mixed with freshwater for Aden's water supply. The plant also generates electricity for the city by heating seawater. Currently, it is operating at a rate of about 10 MCM annually.

The second facility, located in Al-Mokha, 100 km south of Ta'izz Governorate, was constructed before the conflict but was destroyed during an airstrike in 2016 (more details in section 4.1.3). Its current operational status remains unclear. By 2002, Yemen's total installed gross desalination capacity reached 76,596 m^3/day, with production peaking at about 25 million cubic metres annually in 2006[40], making a 151 percent increase compared to 1989 levels and significantly contributing to Aden's water supply.

There are also reports that, recent developments include the construction of two small desalination plants in Al-Mokha and Bab-al-Mandeb, producing 700 m^3/day and 1,000 m^3/day, respectively. These plants, reportedly locally financed, began operations in February 2023. Additionally, plans are underway for a larger project in Aden, with studies being conducted for a pilot project capable of producing 10,000 m^3/day to serve 10,000 house connections across eight districts.

[39] "Regional Workshop Use of Brackish Water for Agricultural Production in the Near East and North Africa: Status, Good Agricultural Practices and New Developments Cairo - Egypt/June 10-12, 2013," n.d.

[40] "Regional Workshop Use of Brackish Water for Agricultural Production in the Near East and North Africa: Status, Good Agricultural Practices and New Developments Cairo - Egypt/June 10-12, 2013."

The potential for brackish water utilization in Yemen is substantial but remains underexplored. While it is extensively used in agriculture and industry, its full exploitation is hindered by a lack of comprehensive investigation and infrastructure development.

Wastewater Treatment

Until 2014, 43 wastewater treatment plants (WWTPs) were in operation, primarily located in the capitals of governorates and select secondary cities. Design capacity was about 435,000 cubic metres per day of treated wastewater and actual production around 300,000 cubic metres per day. Nine additional plants were under construction.

However, the rapid urbanization and population growth in these areas have outpaced the capacity of these facilities. For instance, the WWTP in Sana'a was designed to treat 25,000 m^3/day of wastewater but now receives over 50,000 m^3/day. Similarly, the plant in Ibb city, designed for 5,000 m^3/day, now processes more than 10,000 m^3/day. This overcapacity has led to insufficient treatment, resulting in the discharge of poor-quality water unsuitable for irrigation.

The quality of treated wastewater varies significantly across regions, influenced by the treatment methods, plant capacity, and operational conditions. For example, the treated water in Hajah is of very good quality, while in Taiz, it is often substandard. This variability directly impacts farmers' willingness to use treated wastewater for irrigation, as poor-quality water can harm crops and soil health. The Ministry of Agriculture and Irrigation has flagged this issue, emphasizing the need for appropriate treatment to prevent environmental pollution and ensure water safety.

In 2000, Yemen produced approximately 74 million m^3 of wastewater, of which only 46 million m^3 were treated. Despite this, only 6 million m^3 of treated wastewater were utilized for agricultural purposes that year. Currently, the total actual flow of treated wastewater stands at around 125,000 m^3/day, or 45.5 million m^3 annually, representing roughly 55 percent of the total design capacity of the existing treatment plants.

Among the operational treatment plants, three stabilization pond systems in Aden, Yarim, and Amran have design capacities of 60,000 m^3/day, 3,500 m^3/day, and 6,000 m^3/day, respectively. These stations became operational in December 2002.

3.1.3. Water Demand

Water use in Yemen significantly exceeds the country's renewable water resources. The annual renewable water resource is estimated at approximately 2.5 billion cubic metres (BCM), with 60 percent derived from groundwater and the remaining 40 percent from surface water. In 2010, annual water use was estimated at around 3.9 BCM, resulting in an overall annual

deficit of 1.4 BCM.[41] By 2020, water use had risen to an estimated 5.1 BCM, reflecting a 76 percent increase over three decades since 1990. This escalation has widened the annual deficit to 2.6 BCM. During this period, the domestic and industrial sectors accounted for about 20 percent of total water use, while the agricultural sector consumed the remaining 80 percent. Notably, municipal and industrial water use has increased tenfold over the past 30 years.[42]

The growing gap between water supply and demand is being addressed through the extraction of non-renewable fossil groundwater resources. The annual water deficit of 2.6 BCM is met by corresponding levels of groundwater extraction, leading to an average annual groundwater depletion estimated at 14±5 BCM. This depletion represents approximately 15–25 percent of Yemen's total annual rainfall, underscoring the country's heavy reliance on groundwater to meet its water needs.

Yemen's water resources are managed within four main drainage basins, divided into 14 water management regions. Of these, five regions are classified as critical due to low basin recharge rates and excessive extraction. For example, in the Sana'a Basin, groundwater extraction for agriculture—primarily for qat cultivation—and municipal water supply exceeds annual recharge by more than four times. This has resulted in an annual water deficit of around 271 million cubic metres (MCM) and a decline in groundwater tables by two to four metres annually. Current pumping depths in this basin exceed 1,000 metres.[43] Similarly, other basins face significant deficits: the Sa'ada Basin has an annual deficit of 85 MCM, the Amran Basin 79 MCM, the Taiz Basin 39 MCM, and the Rada'a Basin 28 MCM. These basins are among the most densely populated and agriculturally active regions in the country. The depletion of groundwater resources is exacerbated by the presence of over 100,000 unlicensed and unmonitored private wells, as well as a fleet of more than 800 active drilling rigs.

3.2. Yemen's Agriculture: A Sector Under Strain Before the Conflict

Yemen's agricultural sector has long been a cornerstone of the country's economy and livelihoods, employing over half of the workforce (54 percent) and serving as the primary source of income for 73 percent of the population, either directly or indirectly.[44] Despite its critical role, the sector faced significant challenges even before the outbreak of conflict in 2014. These challenges stemmed from a combination of environmental, economic, and structural factors that limited productivity and undermined food security. This section examines the state of Yemen's agriculture prior to the conflict, highlighting the key issues that placed the sector under strain.

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[41] "National Agriculture Policy 2013-Ministry of Agriculture and Irrigation.Pdf," accessed February 13, 2025, https://faolex.fao.org/docs/pdf/bgd183265.pdf.

[42] "Yemen - Water Sector Support Project: Environmental Assessment: Executive Summary," Text/HTML, World Bank, https://documents.worldbank.org/en/publication/documents-reports/documentdetail/899901468170660361/Executive-summary.

[43] "Water Availability Study in Yemen.Pdf."

[44] "Smallholder Agricultural Production Restoration and Enhancement Project, Food and Agriculture Organization of the United Nations.," https://openknowledge.fao.org/server/api/core/bitstreams/8207757f-f0b2-42fa-bb08-883403b226e3/content.

3.2.1. Economic Importance of Agriculture and Dependency on Imports

Agriculture was a vital component of Yemen's economy, contributing 17.5 percent to the national GDP in 2010.[45] Approximately 74 percent of the population lived in rural areas, where agriculture provided direct employment for 33.1 percent of the workforce. When accounting for related sectors such as transport, processing, and trading, the sector employed 54 percent of the workforce.[46] Despite its modest contribution to GDP, agriculture played a crucial role in rural development, food security, and poverty alleviation. Between 2006 and 2009, the sector experienced an average annual growth rate of 7.5 percent, with significant increases in the production of grains, coffee, and honey. However, this growth was achieved using outdated technologies, highlighting the sector's potential for further development with improved practices and investments.

Yemen's agricultural sector struggled to meet the country's food needs, relying heavily on imports to fulfil local demand. Approximately 80 percent of the food consumed in Yemen was imported in 2012, including staples such as wheat, rice, oil, sugar, and milk. Domestic production accounted for only 20 percent of overall food availability, with self-sufficiency limited to certain cereals like sorghum, millet, and barley. Wheat, a key staple, was largely imported, with 95 percent on average for the period (2010-2014).[47] This heavy reliance on imports made Yemen vulnerable to global price shocks, as seen during the 2008 food crisis.

3.2.2. Water Scarcity and Resource Constraints

Agriculture accounted for 90 percent of Yemen's water use, placing immense pressure on the country's limited and fragile water resources. According to the World Bank, only 5 percent of Yemen's 24 million hectares of land was arable, with small and fragmented plots averaging one hectare in size. These constraints limited the sector's ability to contribute significantly to rural incomes or address trade imbalances in food items. The over-extraction of groundwater, particularly for irrigation, led to rapidly declining water tables, threatening the sustainability of agricultural production. Climate change further exacerbated these challenges, with irregular rainfall patterns and prolonged droughts reducing yields and increasing the vulnerability of rain-fed agriculture.

The cultivation of water-intensive crops, particularly qat, dominated Yemen's agricultural landscape. Qat, a cash crop, accounted for a significant portion of water use and arable land, often at the expense of staple food crops. While qat provided income for many farmers, its widespread cultivation undermined food security by diverting resources away from essential

[45] Central Statistics Organization, Statistic book, 2010.

[46] National Agriculture Sector Strategy 2012-2016, Ministry of Agriculture and Irrigation.

[47] "GIEWS Country Brief: Yemen 03-June-2014 - Yemen | ReliefWeb," https://reliefweb.int/report/yemen/giews-country-brief-yemen-03-june-2014.

food production. Cereals, qat, and fodder accounted for 80 percent of total arable land use, with wheat representing only 16 percent of the area cultivated for cereals.[48]

Yemen's agricultural exports were far below their potential due to inadequate packaging, poor handling practices, and limited knowledge of international market requirements. High-quality produce often fetched low prices due to a lack of sorting, grading, and cold storage facilities. Strengthening exporter associations, improving knowledge of sanitary and phytosanitary standards, and developing stronger trade relationships could enhance the competitiveness of Yemeni agricultural products in global markets.

3.2.3. Land Resources and Productivity Challenges

Mountainous terraced agriculture, while visually striking, faced high population density and land fragmentation due to inheritance practices. In coastal and plains areas, limited water resources further constrained agricultural productivity. Land degradation and desertification were significant issues, requiring better land registration, legislative frameworks, and policies to preserve arable land. Improving productivity through modern techniques and sustainable practices was essential to overcoming these challenges.

[48] National Agriculture Sector Strategy 2012-2016, Ministry of Agriculture and Irrigation.

4 Nexus Between Conflict, Water Security, and Food Security

4.1. Interrelationship Between Conflict and Water Scarcity

4.1.1. Availability of Water Resources

Yemen's water crisis, deeply rooted in decades of unsustainable management, has been dramatically exacerbated by the ongoing conflict, creating a vicious cycle that threatens to push the country further into chaos. Even before the 2014 conflict, the country faced sever water scarcity, with per capita water availability in 2010 standing at just 132 cubic metres per year —far below the international water poverty line of 500 cubic metres. Groundwater, which accounts for nearly all of its water supply, has been overexploited for decades, with an annual depletion rate of approximately 0.9 million cubic metres[49]—far exceeding natural replenishment and threatens the country's long-term water sustainability. Agriculture, the largest consumer of water, accounts for 90 percent of usage[50], has been a major driver of this over-extraction, further straining the country's fragile water systems.

The conflict has significantly exacerbated this crisis by dismantling Yemen's unified water governance system, which was essential for regulating drilling activities and implementing sustainable water management strategies to prevent over-extraction. In the absence of effective oversight, unregulated and illegal borehole drilling has proliferated. For example, in Sana'a an estimated 100,000 wells—many of them unauthorized—driving water tables to dangerously low levels. Wells that once tapped into ancient aquifers, some containing water accumulated over 8,000 years, have been depleted in just three decades. Today, wells in the Sana'a basin reach depths of up to 1.2 kilometres, with an average depth of 350 metres, reflecting the desperate scramble for water. This unregulated extraction has made water access increasingly costly and technologically challenging, particularly in regions like Sana'a and Amran, where deep wells are required, and in Hajjah, where extensive pumping is needed for shallow wells.

Another critical factor linked to the conflict is the widespread adoption of solar-powered pumps, driven by the collapse of the national grid and soaring diesel prices due to the conflict, has further accelerated groundwater depletion. Solar power, once a niche solution, has become the primary energy source for 75 percent of urban households and 50 percent of rural

[49] National Water Resource Authority (NWRA) progress report (2002).

[50] Amer Al-Ghorbany, "The Potential of Strategic Environmental Assessment for Integrated and Sustainable Water Resources Management in the Republic of Yemen: Scenario-Based Strategic Assessment of the Water Resources Policies Adopted in 'Yemen's Strategic Vision 2025,'" 2014, https://www.semanticscholar.org/paper/The-potential-of-strategic-environmental-assessment-Al-Ghorbany/0125a77f2dd7e319a688f61affd57231f489d1f2.

households by 2016[51], providing a cost-effective and reliable alternative to diesel-powered systems in a context of energy shortages. However, unlike diesel-powered systems, which are constrained by fuel costs and availability, solar-powered pumps can operate continuously throughout the day at minimal cost, enabling unchecked groundwater extraction. This shift has supported agricultural recovery—evidenced by a notable increase in local farming activities in 2019 after a wartime decline, but it has also led to a sharp increase in groundwater pumping.[52] Without government regulation or oversight in Yemen's fragile context, this unsustainable practice threatens to deplete already strained aquifers, undermining long-term water sustainability and deepening Yemen's water crisis.

Figure 8 provides analysis of water stress levels across major basins in Yemen, highlighting the balance between water withdrawals and recharge rates measured in million cubic metres per year (MCM/y), in 2020. These visualizations illustrate the growing pressure on water resources, driven by over-extraction and limited recharge. The data sourced from Yemen's Ministry of Water and Environment.

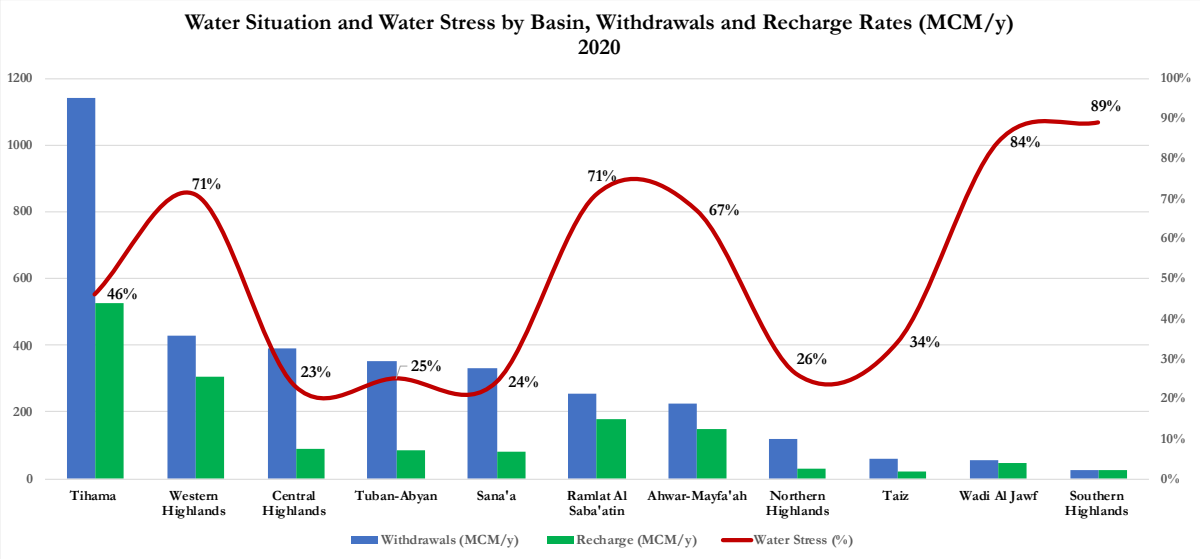

Figure 8 Water situation and water stress by basin, withdrawals and recharge rates (MCM/y) 2020.

The collapse of water infrastructure has further compounded the crisis. Water production has fluctuated dramatically, with utilities struggling to maintain even minimal supply levels due to the collapse of submersible pumps, shortages of spare parts, and fuel shortages. In Sana'a, water production fell by 72 percent between 2014 and 2016, leaving residents with an average consumption of just 6 litres per capita per day (lpcd)—a stark contrast to the 62 lpcd recorded in 2009, according to the Ministry of Water and Environment. Even in relatively better-off areas like Abyan, where consumption stands at 141 lpcd, the overall trend is one of decline,

[51] Dawud Ansari, Claudia Kemfert, and Hashem Al-Kuhlani, "Yemen's Solar Revolution: Developments, Challenges, Opportunities," n.d.

[52] FAO, "The Benefits and Risks of Solar Powered Irrigation - a Global Overview," 2018, https://openknowledge.fao.org/items/765f2bb9-d893-4cb2-a2d6-416c74e6a62f.

with the national average dropping to 46 lpcd in 2016[53], reflecting a widespread decline in availability. Physical and administrative water loss, averaging 37 percent, have further reduced efficiency, as damaged infrastructure and disrupted governance systems have made it increasingly difficult to manage and conserve water resources effectively.

4.1.2. Accessibility to Water Supply

Yemen's public water supply system, once a critical lifeline for its urban population, has been pushed to the brink of collapse by years of conflict, creating inaccessibility and scarcity. The conflict has devastated the country's already fragile infrastructure, leading to a significant decline in water accessibility. In 2017, only 59 percent of the urban population within the service areas of Local Corporations (LCs) was connected to the public water supply network—a 9 percent drop from the 68 percent coverage recorded in 2014. This decline reflects the direct impact of the conflict, with stark regional disparities highlighting how violence exacerbates water shortages. Cities like Hajjah (99 percent) and Mukalla (91 percent), which are not conflict frontlines, maintain relatively high coverage rates. In contrast, cities such as Sa'ada (36 percent) and Taiz (38 percent), which are strongholds and frontlines of the armed conflict, have seen their water systems deteriorate to alarming levels[54] due to prolonged fighting, infrastructure damage, and limited access for repairs.

Even in areas with high connection rates, water coverage does not equate to sufficiency. Chronic shortages in water production mean that many households receive far less than the minimum target of 40 litres per capita per day (lpcd). The public water supply system, once reliable, has been crippled by power supply interruptions, operational failures, and deteriorating infrastructure. To mitigate frequent power outages, many LCs have turned to generators to operate wells and pumping stations. However, severe fuel shortages and financial constraints have rendered this solution ineffective, leading to significant deficits in water production. In conflict-affected regions like Sana'a, Amran, and Taiz, the situation is further exacerbated by plummeting water tables, which make extraction increasingly difficult and costly.

The influx of internally displaced persons (IDPs) has placed additional strain on already overburdened systems, while the lack of maintenance for facilities and networks has further degraded the quality and reliability of water supply. The result is a system in disarray. In many areas, the regular supply of water through public networks is no longer guaranteed. Cities like Sana'a, Dhamar, Amran, and Hajjah, which once enjoyed 18 hours of daily water supply, now receive water for only 3 hours per day or week. Despite these efforts, most LCs struggle to meet the minimum target of 40 lpcd, leaving millions of Yemenis without access to sufficient water for their daily needs.

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[53] "Yemen Water Sector Report, GIZ.Pdf, https://www.giz.de/de/downloads/giz2018-en_Yemen-Water-Sector_Stage-3-Part-1.pdf.

[54] "Performance Monitoring of Urban Water Supply and Sanitation Utilities, Summary Report (January – December 2013), GIZ – Water Sector Program," accessed February 16, 2025, https://www.giz.de/de/downloads/giz2013-en-summary-report.pdf.

The Rise of Private Water Suppliers: A Costly Alternative

For the 40 percent of the urban population not connected to the public water supply system, private water suppliers have become a critical—yet costly—alternative. These suppliers, who draw water from private boreholes, springs, or dug wells, fill a gap left by the failing public system. However, their services come at a steep price. While the average tariff for public water is 250 Yemeni Rial (YER) per cubic metre, private suppliers charge four to five times more, with prices soaring to on average 1,000 -1,200 YER per cubic metre.[55] For many Yemenis, already grappling with economic hardship, these exorbitant costs are simply unaffordable.

The private water sector operates largely in the shadows, with little to no data available on production capacity, the number of facilities, or the quality of water provided. This lack of oversight raises serious concerns about the sustainability and safety of private water extraction, particularly in a country where groundwater resources are already critically overexploited.

Yemen's water supply crisis is a stark illustration of the devastating interplay between conflict and resource insecurity. The war has not only destroyed critical infrastructure but also disrupted the systems and resources needed to maintain and operate water networks. Power shortages, fuel scarcity, and financial constraints have crippled public utilities, while the unregulated private sector has stepped in to fill the void, often at the expense of long-term sustainability. The consequences of this crisis extend far beyond water scarcity. Inadequate access to clean water exacerbates public health challenges, fuels social and economic instability, and deepens the humanitarian crisis.

4.1.3. Water Infrastructure Status

There is mounting evidence that conflict parties have deliberately targeted water infrastructure, potentially as a strategic tactic to exacerbate hardship and suffering among the population. The conflict has inflicted catastrophic damage on the country's water infrastructure, creating a humanitarian disaster of staggering proportions. The destruction is not uniform—its magnitude varies across governorates and utilities—but its consequences are regionally devastating. From direct physical damage caused by airstrikes, ground combat, exchange of artillery shells, and natural disasters to the insidious erosion of systems due to financial collapse and operational failures, the crisis has left Yemen's water infrastructure in a state of near-collapse. The interconnectedness of these challenges underscores the gravity of the situation, as each layer of damage compounds the next, creating a vicious cycle of decline that threatens the survival of millions.

The physical destruction of water infrastructure is a stark and harrowing reminder of the brutality of the conflict. In governorates such as Aden, Abyan, Lahij, Sa'ada, and Sana'a, the damage is extensive and multifaceted. Offices, storage facilities, reservoirs, wells, valve

[55] Yemen water specialist, by online interview, 11th November 2024.

chambers, and distribution networks have been reduced to rubble in many areas. The scale of destruction varies, but the consequences are uniformly dire: interrupted water supply, dysfunctional collection systems, and untreated wastewater flowing into communities, exacerbating public health risks and spreading disease.

In some areas, the situation is particularly catastrophic. Taiz, Haradh, and Mukha have been in critical condition for years, with infrastructure damage so severe. Despite these challenges, some Local Water Corporations (LCs), such as those in Aden, Lahij, Abyan, Sana'a, Sa'ada, and Hudaydah, have begun rehabilitation efforts with support from funding agencies.

The Coalition bombing campaign, for example, has repeatedly targeted both urban and rural drinking water facilities, damaging them through airstrikes and ground combat. A particularly notable case is the water supply system in Nushour, Sa'ada, which has been struck three times during the conflict, cutting off safe drinking water for 10,500 people, prompting strong condemnation from UNICEF as it works tirelessly to maintain the facility's operations.[56]

A comprehensive assessment conducted by the Water and Environment Centre (WEC) of Sana'a University in 2017 underscores the staggering scale of destruction. Between September to November 2016, the WEC evaluated 18 governorates, revealing that water and sanitation infrastructure in every one of them had been severely impacted by the conflict—whether through direct attacks or the inability to perform essential maintenance. During the period 2014–2016, a total of 962 WASH and healthcare facilities were damaged, with 39 percent completely destroyed. Among these, 438 were water facilities serving both urban and rural areas, 497 health units, and 27 sanitation installations.[57] The primary causes of this devastation were air strikes, ground combat, and the conflict-induced scarcity of spare parts and fuel.

Sa'ada governorate bore the brunt of the destruction, with 145 WASH facilities entirely destroyed, followed by Taiz (137), Al-Hudaydah (127), Al-Byadah (116), and Hajjah (77)—areas either under Houthi control or located on the frontlines of the conflict.[58] While the WEC data provides a stark snapshot of the damage, the absence of detailed contextual information makes it challenging to fully assess the impact. However, the sheer scale of the damage is undeniable, and its consequences are felt daily by millions of Yemenis.

The destruction of water infrastructure continues unabated. According to the UN Humanitarian Country Team (2019), from October 2017 to September 2018, a staggering 15,170 conflict incidents were recorded, including airstrikes, armed clashes, and shelling.[59] Many of

[56] UNICEF, "Access to Water Continues to Be Jeopardized for Millions of Children in War-Torn Yemen," July 24, 2018, https://www.unicef.org/press-releases/access-water-continues-be-jeopardized-millions-children-war-torn-yemen.

[57] Water and Environment Centre (WEC) of Sana'a University (2017), The War Crisis in Yemen: Humanitarian and Infrastructure Aspects of WASH.

[58] Ibid.

[59] OCHA and UNCT Yemen, "Yemen: 2019 Humanitarian Needs Overview," February 14, 2019, https://reliefweb.int/report/yemen/yemen-2019-humanitarian-needs-overview-enar.

these incidents resulted in the damage or destruction to civilian facilities. Each attack deepens the crisis, pushing Yemen further toward the brink of collapse.

While direct damage is visible and immediate, the indirect consequences of the conflict are equally—if not more—destructive. The financial and operational collapse of LCs has led to insufficient operation and maintenance (O&M) of critical infrastructure. Since 2015, the absence of investment programs has left utilities unable to maintain or rehabilitate their systems adequately. Borehole pumps and booster pumps are failing at an alarming rate, leading to operational breakdowns and a shortened lifespan for essential electro-mechanical equipment.

Network leakage is another critical issue. Pipes that burst or deteriorate cannot be repaired due to a lack of materials, equipment, and tools. This not only results in significant water losses but also renders the utilities incapable of operating their water supply systems efficiently. The cumulative effect is a system that is barely functional, unable to meet the needs of a population already grappling with the horrors of war.

Dams

Table 2 provides a detailed overview of dams in Yemen that have been targeted and damaged by airstrikes during the conflict:

Table 2 Targeted dams during the conflict in Yemen

Date	Target	Governorate	Location	Source
07/02/2016	Soqam dam	Marib	Sirwah, Al-Mahjazah	Yemen Data Project
26/03/2016	Al-Awadh dam	Bayda	Radman, Al-Awadh	Yemen Data Project
03/12/2016	Al-Hayathim dam	Sana'a	Nihm	Yemen Data Project
10/12/2016	Mahalli dam	Sana'a	Nihm, Mahalli	Yemen Data Project
26/12/2016	Al-Aqran dam	Sana'a	Nihm, Al-Aqarn	Yemen Data Project
29/12/2016	Al-Aqran dam	Sana'a	Nihm, Al-Aqran	Yemen Data Project
09/03/2017	Al-Aqran dam	Sana'a	Nihm, Al-Aqran	Yemen Data Project

Al Mocha Desalination Plant: A Symbol of Destruction

The Al-Mocha desalination plant, located north of Al-Mocha on the coast of Taizz Governorate and privately owned by the Yemen Company for Desalination, serves as a stark example of the destruction of critical water infrastructure during the conflict. The plant was reportedly targeted on four occasions: three times in 2016 (January, October, and November) and once in January 2017.[60] Satellite imagery from May, 2016, confirms significant damage to the plant's structures (Figure 9).

Figure 9 Al Mocha desalination plant (left: satellite imagery from November 2013, right: satellite imagery from May 2016 (Google Earth)).

The damage to the Al-Mocha desalination plant has had severe implications for the local population. Satellite imagery from 2023 shows the plant's current status, revealing the extent of the damage and the challenges in restoring its functionality (Figure 10). Cracks in the water tanks were visible in earlier imagery, but the full extent of the damage remains unclear due to limited visibility in available footage.

[60] "Yemen Data Project," Yemen Data Project, n.d., https://yemendataproject.org/.

Figure 10 Al Mocha desalination plant, satellite imagery date January, 2023, Google Earth.

Destruction of the Coca Cola Factory in Sana'a: A Case Study of Civilian Infrastructure Loss in Yemen's Conflict

The alleged Saudi-led airstrike on the Coca Cola factory in Sana'a is another poignant example of the destruction of civilian infrastructure during the conflict in Yemen. The factory was reportedly hit on December, 2015. The strike caused a massive explosion, reducing the facility to ashes. The damage is clearly visible in satellite imagery from December 2015, which starkly contrasts with imagery from September 2015, showing the facility intact prior to the attack (Figure 11).

Figure 11 Coca Cola factory in Sana'a, (left: satellite imagery from September 2015, right: satellite imagery from December 2015 (Google Earth)).

The destruction of the Coca Cola factory highlights the broader impact of the conflict on Yemen's economy and civilian infrastructure. While the factory was not directly related to water infrastructure, its targeting underscores the widespread nature of attacks on civilian sites, which have devastating consequences for livelihoods and economic stability. The Coca Cola factory attack, like the targeting of the Al-Mocha desalination plant, reflects the destruction of vital infrastructure.

By December 2024, satellite imagery reveals that the Coca Cola factory has effectively disappeared from the site (Figure 12). The once-prominent industrial facility, which played a role in Yemen's economy, is now absent, leaving behind an empty plot of land. This transformation underscores the long-term impact of the conflict on Yemen's infrastructure and economic capacity.

Figure 12 Coca Cola factory, satellite imagery date December, 2024, Google Earth.

4.1.4. Accessibility to Sanitation Service

Yemen's sanitation systems, once a blend of traditional and modern practices, have been pushed to the brink of collapse by years of conflict, neglect, and underinvestment. Historically, Yemeni towns relied on traditional dry toilets with urine separation, a system used for centuries, where faeces were collected, dried, and repurposed as fuel or fertilizer. However, the rapid urbanization of the 1960s and 1970s led to a shift toward centralized and decentralized wastewater collection systems, including sewer networks that discharged treated or untreated wastewater into wadis or the sea. Today, Yemen's sanitation infrastructure is a patchwork of

poorly developed public systems and private cesspits, reflecting the country's broader struggles with resource management and infrastructure maintenance.

Public sanitation systems in Yemen are severely underdeveloped. Cities like Sa'ada, Mansouria, and parts of Hajjah lack sewer systems entirely, while others, such as Abyan and Lahij, have only a few sewer lines managed by local councils. Even in areas with sewer networks, coverage is uneven and often inadequate. For example, Amran, Ta'izz, and Al Shehr have connection rates as low as 36–40 percent, while Zabid and Aden fare slightly better at 74 percent and 69 percent, respectively.[61] For the majority of Yemenis not connected to public systems, private cesspits—often poorly designed and unregulated—serve as the primary means of wastewater disposal.

These cesspits, built without proper specifications or sanitation standards, pose significant environmental and public health risks. Groundwater pollution and soil clogging are common, leading to wastewater overflow into streets and public spaces. The absence of dry or compost toilets in most areas further exacerbates the problem, leaving communities vulnerable to contamination and disease.

For those connected to public sewer systems, wastewater is typically collected and transported via gravity or pumping to treatment plants or directly discharged into wadis or the sea. Cities like Aden, Hudaydah, and Mukalla rely on multiple sewer pump stations, which increase operational costs and maintenance demands. Frequent power outages further complicate operations, often causing wastewater to flood streets and neighbourhoods.

Yemen's wastewater treatment plants (WWTPs) employ a variety of systems, including stabilization ponds, Imhoff tanks, trickling filters, and activated sludge processes. However, these facilities face numerous challenges. High biochemical oxygen demand (BOD5) levels in wastewater—ranging from 500–1200 mg/l, far exceeding recommended concentrations—make treatment difficult, due to the low water availability and consumption which affect the characteristics of the wastewater. Energy-intensive systems, such as activated sludge, are particularly vulnerable to power cuts, while low-cost options like stabilization ponds struggle with inefficiencies and overcapacity. In cities like Sana'a, Ibb, and Hajjah, WWTPs are overwhelmed by inflow volumes, leading to untreated wastewater discharge, environmental degradation, and foul odours that affect nearby communities.

The ongoing conflict has inflicted both direct and indirect damage on Yemen's sanitation infrastructure. In cities like Aden, Abyan, Lahij, Sa'ada, and Sana'a, critical facilities—including offices, reservoirs, wells, and treatment plants—have been destroyed or severely damaged. Natural disasters, such as the Chabala Hurricane in 2015, further compounded the crisis, devastating networks, pumping stations, and treatment plants in Al Shehr and Mukalla.

[61] "Yemen Water Sector Report, GIZ.Pdf."

Flooding in Hajjah in April 2016 caused additional losses and disrupting wastewater treatment systems.

Indirect damage has been equally devastating. Chlorination facilities have fallen into disrepair, while network leaks go unaddressed due to a lack of materials and tools. The result is a system operating far below capacity, and poor sanitation.

Power outages have further crippled sanitation services. Utilities have attempted to mitigate the problem with generators and, in some cases, solar panels, but these solutions are costly and unsustainable. The price of diesel, essential for generator operation, has quadrupled in some areas, from 60 YER to 240 YER per litre.

4.1.5. Quality of Water

Yemen's water quality crisis has reached a critical juncture, with the nation bearing the highest burden of cholera globally. The interplay between conflict, deteriorating public water and sanitation infrastructure, and inadequate access to safe drinking water has created a perfect storm for waterborne diseases, threatening the health and survival of millions. Yemen's cholera crisis is a grim testament to the devastating impact of poor water quality. As of 1 December 2024, the country reported 249,900 suspected cholera cases and 861 associated deaths, accounting for 35 percent of the global cholera burden and 18 percent of global cholera-related mortality. The sharp increase in cases and deaths—37 percent and 27 percent higher, respectively, compared to November 2023—underscores the escalating severity of the crisis.[62] This surge is attributed to updated data from Yemen, reflecting the widespread and persistent nature of the outbreak. This crisis is fuelled by the consumption of contaminated potable water and vegetables irrigated with untreated wastewater, highlighting the dire state of Yemen's water systems.

Public utilities, already stretched to their limits by years of conflict, are ill-equipped to address the growing water quality crisis. Many LCs lack the laboratory equipment, chemicals, and materials needed to conduct essential water tests. In some areas, such as Amran, Abyan, and Lahij, laboratories are entirely absent, leaving water quality unchecked and untreated. Even where chlorination facilities exist, they are often damaged, non-functional, or lacking the necessary chemicals to effectively treat water. The result is a system that produces water unsuitable for direct consumption, exposing millions to the risk of waterborne diseases.

The private water sector, which has emerged as a critical alternative to the failing public system, operates without oversight or regulation. Private suppliers, who draw water from boreholes, springs, or dug wells, provide water of unknown quality to a population already

[62] World Health Organization (WHO), "Yemen Reports the Highest Burden of Cholera Globally," World Health Organization - Regional Office for the Eastern Mediterranean, 2024, http://www.emro.who.int/media/news/yemen-reports-the-highest-burden-of-cholera-globally.html.

grappling with scarcity. The absence of authority control over private water sources poses a significant risk to consumers, further exacerbating the public health crisis.

The resurgence of cholera is not an isolated event but part of a broader pattern of waterborne disease outbreaks that have plagued Yemen for years. Between 2017 and 2020, the country experienced its largest cholera outbreak in recent history, with transmission persisting ever since.[63] The outbreak has placed an additional burden on an already strained health system, which is struggling to cope with multiple disease outbreaks amid ongoing conflict and economic collapse.

The cholera crisis is a symptom of deeper systemic failures. Damaged public water and sanitation infrastructure, poor community hygiene practices, and limited access to timely treatment have created an environment where waterborne diseases thrive. The lack of access to safe drinking water is particularly acute in a country where more than a decade of conflict has left critical infrastructure in ruins.

Cholera and other waterborne diseases exacerbate poverty, displacement, and social instability, creating a vicious cycle that undermines efforts to rebuild and recover. The economic collapse and crumbling health infrastructure further hinder the ability to respond effectively, leaving millions vulnerable to preventable diseases.

4.1.6. Local Water Corporations (LCs) Performance

Before the onset of the crisis in 2014, the performance of Yemen's Local Water Corporations (LCs) could be described as moderate, though far from optimal. Key performance indicators such as the frequency of water supply, non-revenue water, operational cost coverage, and collection efficiency painted a picture of utilities struggling to meet basic standards. Most LCs, with the exception of Ta'izz, managed to provide water at least once a week. Water losses ranged from 13 percent to 45 percent[64], indicating significant inefficiencies in distribution networks. While operational cost coverage was nearly achieved by most LCs, collection efficiency varied widely, revealing systemic inconsistencies in revenue management. Even then, the system was fragile, operating on the edge of sustainability.

However, the eruption of conflict plunged the LCs into a downward spiral of dysfunction, exposing and exacerbating their vulnerabilities. The interconnectedness of the crisis—rooted in conflict, economic collapse, and institutional failure—has created a perfect storm, crippling the ability of LCs to deliver even the most basic water and sanitation services. The gravity of the situation cannot be overstated: what was once a system teetering on the edge of adequacy

[63] UN News-Global perspective Human stories, "Yemen Bears World's Highest Cholera Burden, Deepening Humanitarian Crisis | UN News," December 23, 2024, https://news.un.org/en/story/2024/12/1158491.

[64] "Performance Monitoring of Urban Water Supply and Sanitation Utilities, Summary Report (January – December 2013), GIZ – Water Sector Program," https://www.giz.de/de/downloads/giz2013-en-summary-report.pdf.

has now become a catastrophic failure, with dire consequences for public health, economic stability, and social cohesion.

The collapse of public power supply was the first domino to fall. Frequent interruptions or outright failures of electricity grids left LCs unable to operate water and wastewater pumps, as well as treatment plants. Compounding this, the LCs lacked the resources to replace deteriorating public energy infrastructure with reliable alternatives. Generators, where available, were rendered useless due to the scarcity and exorbitant cost of fuel. The high and fluctuating prices of fuel—or its outright unavailability—further crippled operations, leaving LCs in a perpetual state of paralysis.

Financial shortages became a crippling bottleneck. Without adequate revenue, LCs could not procure fuel, spare parts, or alternative energy sources such as solar systems. The lack of funding also prevented the purchase of essential operation and maintenance materials, stalling even the most basic rehabilitation efforts. Investment programs, critical for urgent rehabilitation and extension projects, were suspended or terminated altogether. The result is a system in disrepair, unable to meet the growing demands of a population already suffering from the ravages of war.

The human and institutional toll of the crisis has been equally devastating. Skilled staff are in short supply, and those who remain face low morale due to unpaid salaries. The absence of governance and effective management has left LCs without the guidance needed for emergency planning, rehabilitation, or network extension. Inefficient work processes and delays are further exacerbated by the lack of IT and office equipment, hindering even the most basic administrative functions.

The physical infrastructure of water and sanitation services has not been spared. Facilities have been damaged or vandalized, while looting of essential equipment—vehicles, machinery, and materials from stores and laboratories—has further depleted the LCs' capacity to function. Depleted water resources, such as dried-up wells, have added another layer of complexity to an already dire situation.

The financial viability of LCs has been eroded by a combination of low revenues and poor payment compliance. Customers, many of whom are themselves struggling economically, are either unable or unwilling to pay their fees, leading to a collapse in revenue collection. The absence of customer water metres compounds the problem, resulting in estimated—and often inaccurate—billing that further undermines trust and compliance.

The unstable economic and political situation has created an environment where recovery seems increasingly out of reach. Each challenge feeds into the next, creating a vicious cycle of decline. The inability to restore services leads to further revenue losses, which in turn prevents the investment needed to address the very issues causing the decline.

4.2. Interrelationship Between Conflict and Food Insecurity

4.2.1. Food Insecurity and Malnutrition

Yemen's descent into one of the world's most severe food security and nutrition crises is a harrowing testament to the devasting nexus between protracted conflict, economic collapse, and environmental devastation. Since 2015, the nation has been ensnared in a war that has weaponized hunger, transforming food insecurity and malnutrition into tools of suffering. Today, Yemen teeters on the brink of famine, with over half its population—17 million people—grappling with acute food insecurity and 3.5 million suffering from acute malnutrition.[65] This catastrophe is not incidental but systemic, born of decades of fragility, amplified by violence, and entrenched by a collapsing state. The human toll is staggering: 250,000 people have died, directly from fighting or indirectly from lack of access to food, health services, and infrastructure. Among the dead, 60 percent are children under the age of five—a grim reminder of the war's generational devastation.[66]

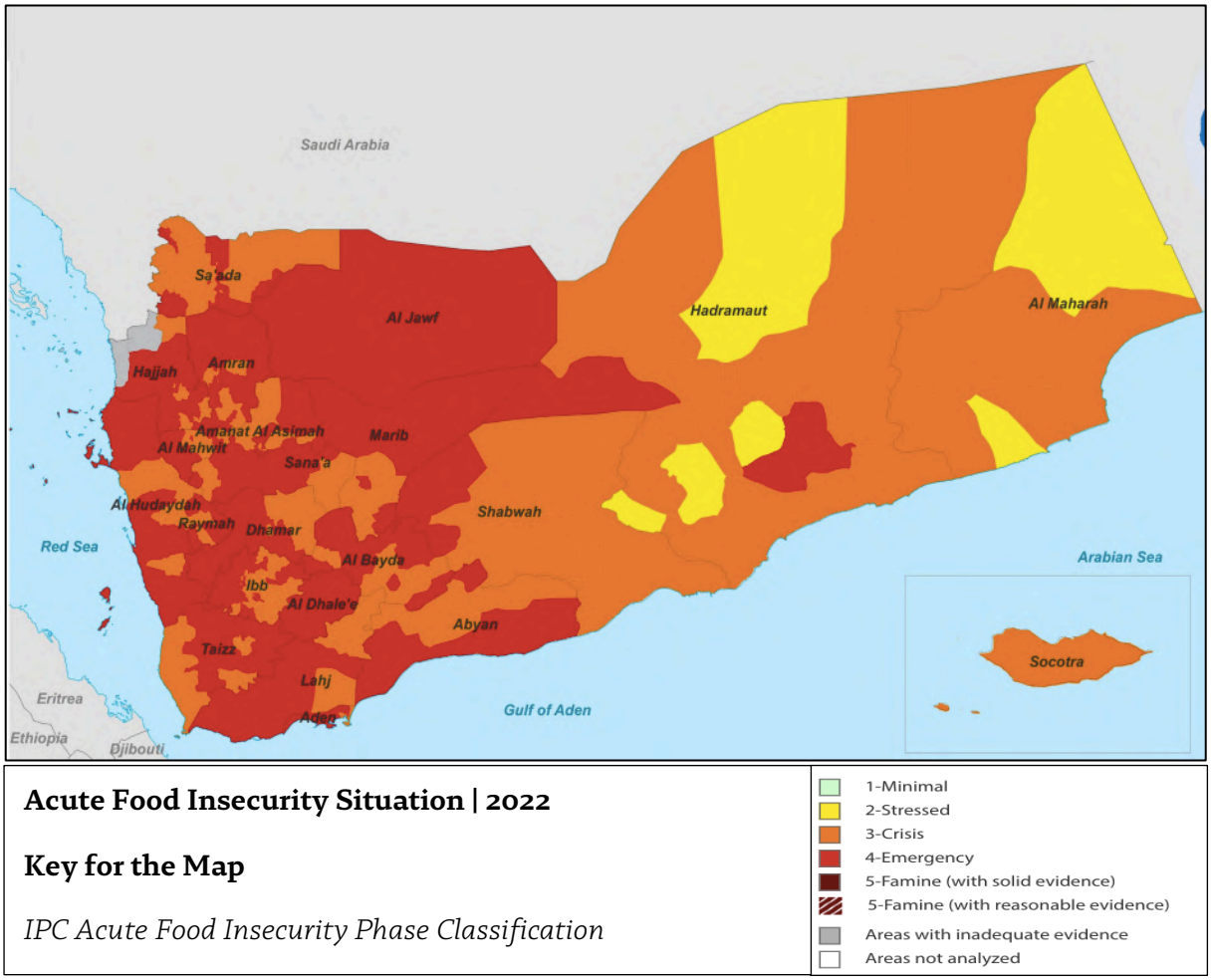

Figure 13 Acute food insecurity phase classification

[65] "World Bank-Yemen Country Overview," Text/HTML, World Bank, 2024, https://www.worldbank.org/en/country/yemen/overview.

[66] UNDP, "A Roadmap to Recovery: Addressing Poverty in Yemen's Ongoing Conflict," UNDP, February 26, 2024, https://www.undp.org/arab-states/news/roadmap-recovery-addressing-poverty-yemens-ongoing-conflict.

The ongoing conflict in Yemen has significantly exacerbated food insecurity across the nation. According to the Global Food Security Index 2022[67] (Figure 13), Yemen scored a mere 40.1 out of 100 on the Food Security Index, reflecting severe challenges in ensuring access to sufficient and nutritious food. This score places Yemen among the lowest-ranked countries globally, standing at 111th out of 113 countries assessed in 2022 (Table 3).

Table 3 The global food security index 2022 - Yemen

The Global Food Security Index 2022 – Yemen		
Index	**Score**	**Rank (out of 113 countries)**
Overall food security score	40.1	111
Affordability	46.4	95
Availability	26.9	112
Quality and Safety	48.7	98
Sustainability and Adaptation	37.8	105

Long before the conflict erupted, Yemen's agriculture systems were crippled by unsustainable practices, leaving the country heavily dependent on food imports. Approximately 90 percent of Yemen's food supply came from abroad[68], creating a fragile foundation that made the population vulnerable to external shocks. Agriculture, which provided livelihood for over 70 percent of the population and employed nearly 30 percent of Yemenis[69], was undermined by decades of inefficient farming practices, groundwater over-extraction, and a shift to cash crops. This pre-existing vulnerability set the stage for a deepening crisis when the conflict erupted.

The 2014 conflict ignited a chain reaction of destruction, exacerbating Yemen's food security vulnerabilities and plunging the country into an unprecedented humanitarian disaster. The conflict disrupted agricultural production, destroyed critical infrastructure, and halted oil exports, which accounted for 70 percent of government revenue.[70] Moreover, blockades on key

[67] "Global Food Security Index (GFSI)," https://impact.economist.com/sustainability/project/food-security-index.
[68] "Yemen Market Study, World Food Programme, 2010.Pdf," https://documents.wfp.org/stellent/groups/public/documents/ena/wfp230278.pdf.
[69] International Labour Organization, "Yemen Damage and Needs Assessment, Crisis Impact on Employment and Labour Market," January 2016.
[70] Economic Studies Unit, "Suspension of Oil Exports from Yemeni Government-Controlled Areas Enters Its Third Year – Assessing Efforts to 'Contain' Crisis," October 28, 2024, https://epc.ae/en/details/featured/suspension-of-oil-exports-from-yemeni-government-controlled-areas-enters-its-third-year-assessing-efforts-to-contain-crisis.

ports like Al Hodeidah, a lifeline for 80 percent of imports[71], severed access to food and fuel. Currency depreciation, with the Yemeni Rial lost 71 percent of its value against US dollar over the past five years[72], and rampant inflation spiked food prices, rendering basics unaffordable for millions. Active fighting ravaged farms, markets, and infrastructure, displacing 4.8 million people internally[73] and trapping communities in conflict zones without access to aid. The conflict's economic toll—halting oil exports, slashing remittances, and paralyzing institutions—strangled household incomes, pushing 46.7 percent of families into extreme poverty.[74]

The conflict has been the key driver of acute food insecurity and malnutrition, particularly in the frontline districts under government control. The loss of foreign exchange crippled import capacities, while inflation devoured wages, leaving millions unable to afford food. According to the Integrated Food Security Phase Classification (IPC), over 4.7 million people in government-controlled areas alone faced high levels of acute food insecurity, classified as Crisis or Emergency.[75] Among them, more than 1.2 million are in the most severe category—Emergency—one step from famine.[76] Malnutrition and disease feed on each other in a vicious cycle, with collapsing healthcare, water, and sanitation systems leaving 15.3 million without clean and safe drinking water[77] and 20.3 million without access to adequate healthcare.[78] Diseases like cholera, diphtheria, and measles surge in malnourished populations, while 1.3 million pregnant or lactating women face acute malnutrition, jeopardizing the health of future generations.

The 2022 Truce: A Temporary Respite Amid Persistent Conflict and Food Insecurity

The 2022 UN-brokered truce offered a brief respite in Yemen's protracted conflict, reducing violence and conflict incidents by 60 percent, reopening critical ports like Al Hodeidah, and increasing fuel imports by 40 percent. These developments spurred a temporary boost in economic activity, improved market functioning, and enhanced access to humanitarian assistance, providing a glimmer of hope for millions facing food insecurity. However, the truce's expiration in October 2022 without renewal plunged Yemen back into uncertainty, leaving the population vulnerable to the ongoing cycle of instability and deprivation.

Even during the truce, intermittent localized fighting, shelling, and displacements in key frontlines such as Ta'iz, Al Hodeidah, Ma'rib, Al Jawf, Lahj, Shabwa, and Al Dali continued to disrupt livelihoods, sever road access, block aid delivery, and displace thousands of civilians. These internal frontiers, which separate areas under different political-military control,

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[71] Ensuring Yemen's lifeline: the criticality of all Yemeni ports, UN OCHA report.
[72] "Yemen Food Security Update, WFP, 2025.Pdf," https://docs.wfp.org/api/documents/WFP-0000164199/download/.
[73] "Yemen | World Food Programme," March 29, 2024, https://www.wfp.org/countries/yemen.
[74] UNDP, "A Roadmap to Recovery."
[75] IPC - Integrated Food Security Phase Classification, "Yemen: Acute Food Insecurity Situation," 2024, https://www.ipcinfo.org/ipc-country-analysis/details-map/en/c/1157981/.
[76] IPC - Integrated Food Security Phase Classification.
[77] "Yemen | OCHA," February 13, 2025, https://www.unocha.org/yemen.
[78] "Humanitarian Action for Children 2024 - Yemen - Yemen | ReliefWeb," December 28, 2023, https://reliefweb.int/report/yemen/humanitarian-action-children-2024-yemen.

perpetuate the cycle of instability by limiting overland travel, displacing civilians, disrupting livelihoods and essential public services, and complicating supply chains. While the impact on food insecurity was less severe compared to the pre-truce period, these disruptions exacerbate pre-existing vulnerabilities, leaving communities trapped in a precarious state of deprivation. The truce's failure to address the root causes of the crisis—political fragmentation, economic collapse, and institutional decay—left any prospect of recovery a distant mirage.

Climate Shocks Are Deepening Yemen's Food Insecurity Crisis

Given that the conflict continues to be the primary driver of challenges in Yemen, additional risk factors are emerging as a crisis within the broader crisis. In October 2023, Tropical Cyclone Tej unleashed its fury on Yemen's southeastern coast, leaving a trail of devastation in its wake. The governorates of Al Maharah, Hadramout, and Socotra bore the brunt of the storm, with over 15,939 people displaced, 400 homes reduced to rubble, and more than 5,000 hectares of crops, fisheries, and critical infrastructure obliterated.[79] This catastrophic event was not an isolated incident but part of a growing pattern of climate shocks that are pushing Yemen—a country already ravaged by years of conflict and economic collapse—to the brink of a humanitarian catastrophe.

Just months later, in August 2024, heavy rains during the peak of the Kharif rainy season triggered widespread flooding, further compounding the suffering of Yemen's agricultural communities. The floods ravaged 341,296 hectares of land, including 217 hectares of urban and rural settlements[80], directly affecting 424,123 individuals.[81] The agricultural sector, a lifeline for millions, was hit particularly hard: 98,726 hectares of farmland—home to herbaceous crops, shrub crops, orchards, and date palms—were damaged, while 279,400 ruminants, primarily sheep and goats, perished or were displaced.[82] The destruction of irrigation infrastructure, including canals, water pumps, and storage tanks, has left vast swathes of agricultural land waterlogged and unusable, crippling recovery efforts and threatening future harvests.

Such climate shocks—intensified by global warming—lay bare the fragility of communities already broken by war. The loss of crops and livestock, coupled with the devastation of irrigation systems, has shattered livelihoods and disrupted critical food supply chains. For a country where 5 million people are already facing emergency levels of hunger, this is a devastating blow. The floods have not only wiped-out immediate sources of food and income but have also undermined the ability of farmers to plant for the next season, setting the stage for a prolonged food security crisis.

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[79] "Tropical Cyclone Tej - Oct 2023 | ReliefWeb," August 11, 2024, https://reliefweb.int/disaster/tc-2023-000212-yem.

[80] FAO, "Rapid Assessment of Flood Impacts on Yemeni Agriculture - August 2024 - Yemen | ReliefWeb," September 11, 2024, https://reliefweb.int/report/yemen/rapid-assessment-flood-impacts-yemeni-agriculture-august-2024.

[81] IFRC, "2024 Yemen Floods Disaster Brief, August 2024 - Yemen | ReliefWeb," September 2, 2024, https://reliefweb.int/report/yemen/2024-yemen-floods-disaster-brief-august-2024.

[82] FAO, "Rapid Assessment of Flood Impacts on Yemeni Agriculture - August 2024 - Yemen | ReliefWeb."

4.2.2. Agricultural Infrastructure

The ongoing conflict in Yemen has systematically destroyed the country's agricultural infrastructure, which has played a vital role in the livelihoods of millions. This destruction has not only disrupted food production but also exacerbated an already dire food security crisis. Key agricultural systems, including irrigation networks, storage facilities, and farming equipment, have been decimated by airstrikes, ground fighting, and neglect, significantly affecting the nation's capacity to produce food and meet the needs of its population.

One of the most critical components of Yemen's agricultural infrastructure is its irrigation systems, particularly spate irrigation, which is essential for farming in the country's coastal regions. In areas like Hodeidah, which is a key agricultural governorate, the conflict has caused extensive damage to irrigation infrastructure. Airstrikes and ground fighting have destroyed canals, wells, pumps, and other water systems. This disruption of water access has led to widespread crop failures, especially in regions that rely on spate irrigation for growing crops such as wheat, sorghum, and other staples. According to the Food and Agriculture Organization (FAO), these damaged irrigation systems have led to severe shortages in water availability for agricultural production, leaving many farmers unable to cultivate their land.[83]

The intentional targeting of agricultural infrastructure has been documented as part of the broader conflict strategy. The Armed Conflict Location and Event Data Project (ACLED) has recorded more than 1,600 conflict incidents that directly impacted agriculture, with 489 of these concentrated in the southern Tihamah and 220 in the northern highland plains—regions historically crucial for crop production.[84] This data suggests a deliberate targeting of agricultural hubs, which has had devastating consequences for food production in these regions.

ACLED's analysis reveals also a shifting pattern of attacks over the course of the conflict. In the early stages of the conflict, central upland areas, known for their fertile land and staple crop production, were the primary targets. However, in more recent years, there has been a noticeable shift in focus toward the Tihamah and the northwestern uplands. This shift mirrors the changing frontlines of the armed conflict, as territorial control and strategic priorities evolve, further exacerbating the disruption to food systems.

According to data from the Yemen Data Project, there has been a significant number of attacks directly targeting agricultural infrastructure between 2015 and 2022 (Figure 14). These attacks have severely damaged key components of Yemen's agricultural sector, including farms, food storage facilities, plant nurseries, and other essential infrastructure. The number of

[83] FAO, *Yemen | Agricultural Livelihoods and Food Security in the Context of COVID-19* (FAO, 2021), https://doi.org/10.4060/cb3247en.
[84] ACLED, "Yemen Database," *ACLED* (blog), December 17, 2024, https://acleddata.com/tag/yemen/.

documented attacks reflects the scale of the damage, with critical agricultural assets being repeatedly targeted throughout the conflict.

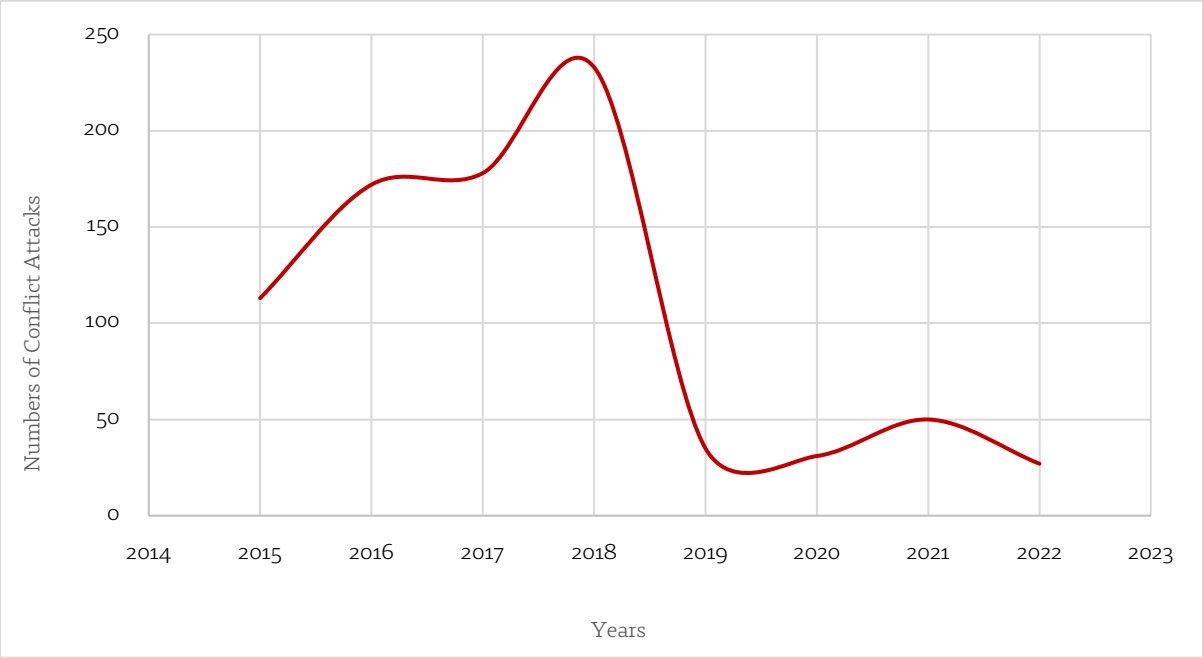

Figure 14 Number of conflict attacks associated with the agriculture sector 2015-2022.

The destruction of these agricultural systems has not only led to immediate crop losses but has also hampered long-term recovery prospects for Yemen's food production capacity. The absence of necessary infrastructure has made it difficult for farmers to restore their operations and has limited the country's ability to generate enough food to meet its needs.

The destruction of agricultural infrastructure has had cascading effects on Yemen's food security. With critical irrigation systems, storage facilities, and farming equipment rendered inoperable, Yemen has seen an increase in crop failures and food shortages. This has contributed to a significant rise in food prices, which has made essential goods increasingly unaffordable for a large portion of the population. As of 2024, over half of Yemen's population—17.6 million people—are severely food insecure. This situation has been exacerbated by the collapse of local agricultural production, as many farmers are unable to produce enough food to feed their families or supply local markets.

Moreover, the destruction of storage facilities and processing infrastructure has led to the loss of harvested crops and food reserves, further diminishing Yemen's ability to recover from food shortages. As the conflict continues, the agricultural sector's ability to recover remains severely compromised, and without significant investments in rehabilitation and reconstruction, the country's food security will remain under threat.

4.2.3. Displacement and Loss of Agriculture Livelihoods

The conflict has not only shattered the nation's agricultural infrastructure but also displaced millions, unravelling livelihoods and deepening food insecurity in ways that are both profound

and enduring. For most Yemenis, the greatest impact of agricultural stress has been the loss of livelihoods rather than the direct destruction of crops—though the latter remains critical for subsistence farmers in remote areas. This dual crisis has been exacerbated by severe funding shortfalls, with the World Food Programme (WFP) forced to halve rations in 2020[85], leaving millions teetering on the brink of famine. The COVID-19 pandemic further strained humanitarian resources, while Houthi obstruction of aid shipments compounded the suffering.

The conflict has triggered one of the world's largest internal displacement crises, with 4.5 million internally displaced persons (IDPs) by the end of 2023—the sixth-largest such crisis globally.[86] Of these, 1.6 million live in 2,431 camp-like sites, while 2.9 million reside in host communities, often in precarious conditions. Displacement has been particularly severe in frontline areas like Marib, Al Hodeidah, Shabwa, Ta'izz, and Al Dali, where reduced conflict in 2023 offered a glimmer of hope for resuming livelihoods. However, the food security situation for newly displaced populations remains dire, especially in areas with high IDP concentrations such as Marib City and Harib districts in Marib governorate, and Hays district in Al Hodeidah governorate.

Displacement has not only uprooted communities but also disrupted agricultural labour. In the first two years of the war alone, the agricultural sector lost 50 percent of its workforce, with 73,000 jobs lost in Hodeidah governorate—a region historically vital for crop production.[87] While some areas like Aden and Marib saw population increases due to displacement, agriculture in these regions remains in distress, unable to absorb the influx of displaced workers. The loss of labour has crippled farming activities, leaving fields untended and harvests uncollected.

The displacement crisis has created a vicious cycle of poverty and food insecurity. Displaced populations often lack access to land and water, leading to disputes with host communities and hampering the provision of shelter, health, and WASH services.[88] Based on the 2022 SMART surveys, levels of acute malnutrition are higher among displaced children (12.3 percent) compared to host communities (9.8 percent), reflecting the dire conditions in IDP camps.

The collapse of agricultural livelihoods has triggered a cascading humanitarian crisis, severely undermining food security across Yemen. Displaced populations, even in areas where security conditions have improved, often lack the resources and infrastructure necessary to resume

[85] WFP, "Yemen Teeters on the Brink as Conflict and Economic Crises Grind on - Yemen | ReliefWeb," September 23, 2020, https://reliefweb.int/report/yemen/yemen-teeters-brink-conflict-and-economic-crises-grind.
[86] UN OCHA, "Yemen Humanitarian Needs Overview 2024," February 1, 2024, https://reliefweb.int/report/yemen/yemen-humanitarian-needs-overview-2024-january-2024-enar.
[87] International Labour Organization, "Yemen Damage and Needs Assessment, Crisis Impact on Employment and Labour Market."
[88] OCHA, "Yemen Humanitarian Needs Overview 2023," December 20, 2022, https://reliefweb.int/report/yemen/yemen-humanitarian-needs-overview-2023-december-2022-enar.

farming. This has intensified competition over already scarce resources—such as land, water, and grazing areas—further straining relations between internally IDPs and host communities. At the country level, the self-reported priority needs among IDPs were shelter (41 percent), food (24 percent) and financial assistance (23 percent). However, in Al-Hudaydah, where the destruction of irrigation systems and farmland has rendered local food production nearly impossible, food assistance emerges as the top priority for 35 percent of IDPs, followed by shelter (26 percent) and financial support (20 percent). For returning IDP households, the need for food was even more acute, with 96 percent in Ma'rib, 92 percent in Al-Hudaydah and 86 percent in Aden[89] citing it as their most pressing concern. These figures underscore the devastating interplay between displacement, agricultural collapse, and food insecurity, highlighting the urgent need for targeted interventions to restore livelihoods and stabilize food systems.

The biomass losses caused by displacement have been devastating. In some cases, population movements have led to the abandonment of farmland, while in others, the loss of agricultural labour has rendered fields unproductive. The scale of displacement and agricultural collapse underscores the urgent need for comprehensive humanitarian and recovery efforts. By 2023, an estimated 2.9 million forcibly people displaced due to fighting, extreme weather, and pressure on informal settlements.[90]

4.2.4. Cropland Production

The conflict has had a devastating impact on agricultural production, significantly reducing cropland production. According to a World Bank Group satellite analysis conducted in collaboration with ICARDA, active cropland production decreased by 76 percent between 2014 and 2017.[91] This dramatic decline highlights the severe disruption of agricultural activities caused by the conflict.

This was revalidated by analysis changes in the Normalized Difference Vegetation Index (NDVI), a key indicator of vegetation "greenness" that reflects the density and health of ground cover. NDVI values range from +1 to -1, with higher positive values indicating dense, healthy vegetation and lower or negative values signifying poor or sparse vegetative cover. Using data from the USGS, NDVI changes were tracked from 2015 to 2024, revealing significant declines in vegetation cover over time (Figure 15). These figures visually confirm the previously reported decrease in cropland productivity, aligning with findings that highlight the severe impact of conflict, water scarcity, and environmental stressors on Yemen's agricultural landscape.

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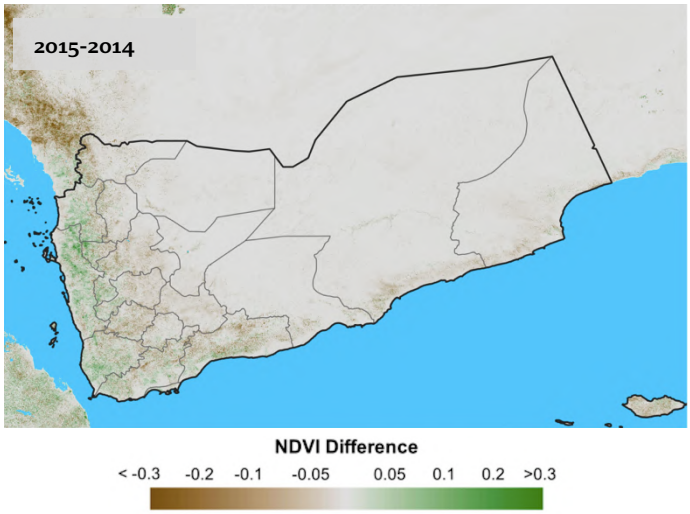
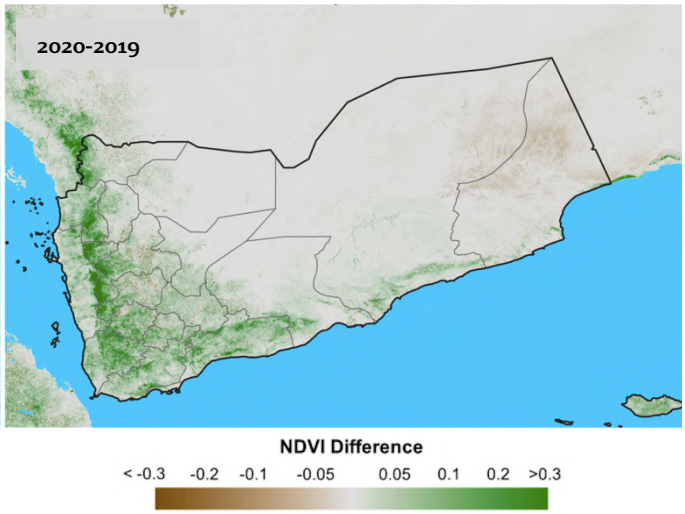
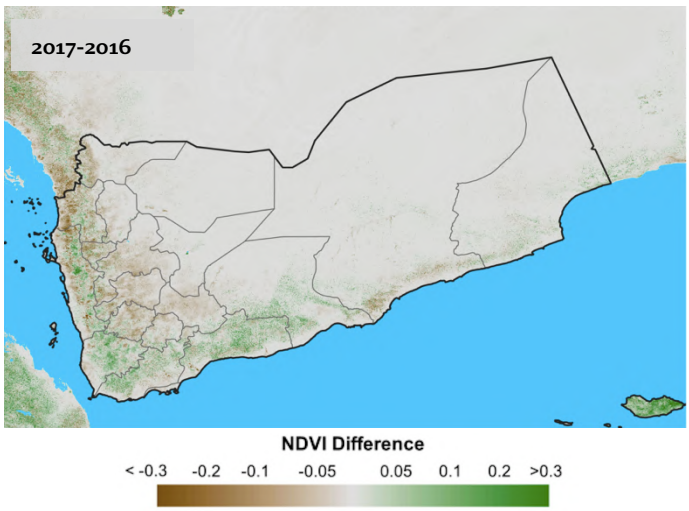
[89] International Organization for Migration (IOM), "DTM Yemen - Flow Monitoring Datasets - December 2022 | Displacement Tracking Matrix," December 2022, https://dtm.iom.int/datasets/dtm-yemen-flow-monitoring-datasets-december-2022.

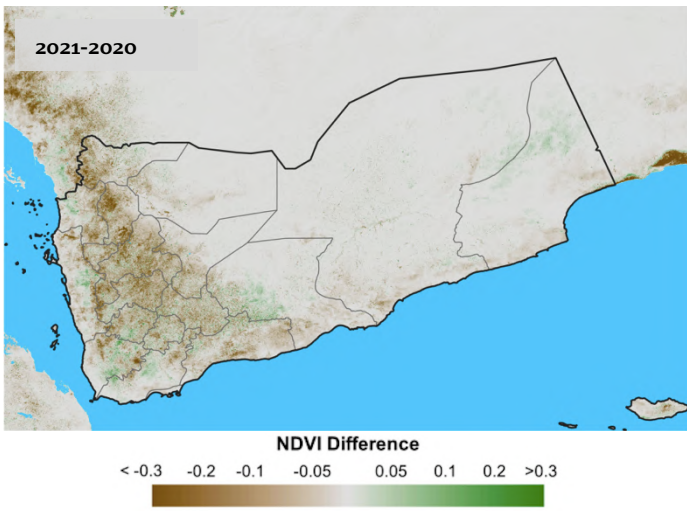
[90] "Global Report on Food Crises (GRFC), Food Security Information Network (FSIN)-2024.Pdf," accessed February 18, 2025, https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2024-full.pdf.

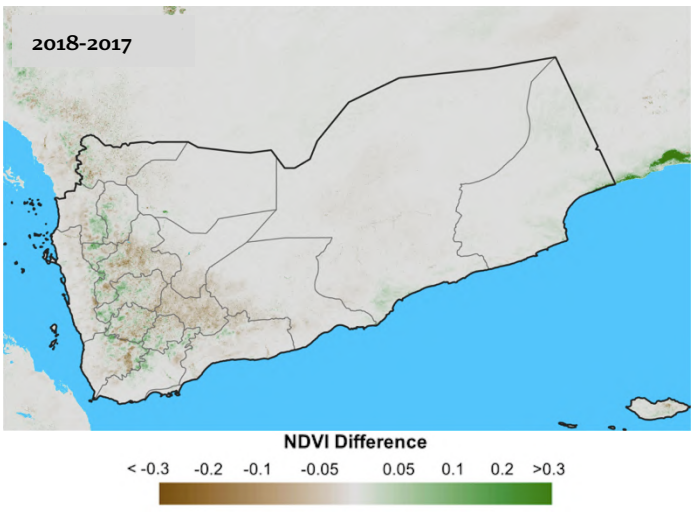
[91] "Food as a Weapon in Yemen, The Targeting of Food Security in a New War" https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=9011318&fileOId=9011323.

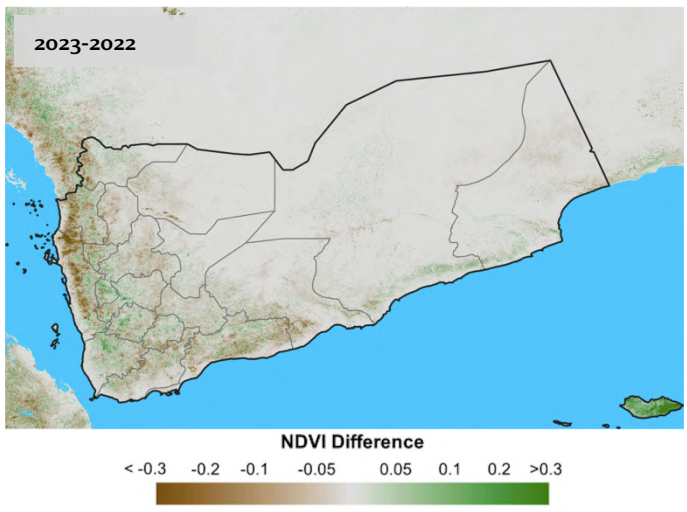

2015-2014
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3


2020-2019
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3


2017-2016
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3


2021-2020
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3


2018-2017
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3


2023-2022
NDVI Difference
< -0.3 -0.2 -0.1 -0.05 0.05 0.1 0.2 >0.3

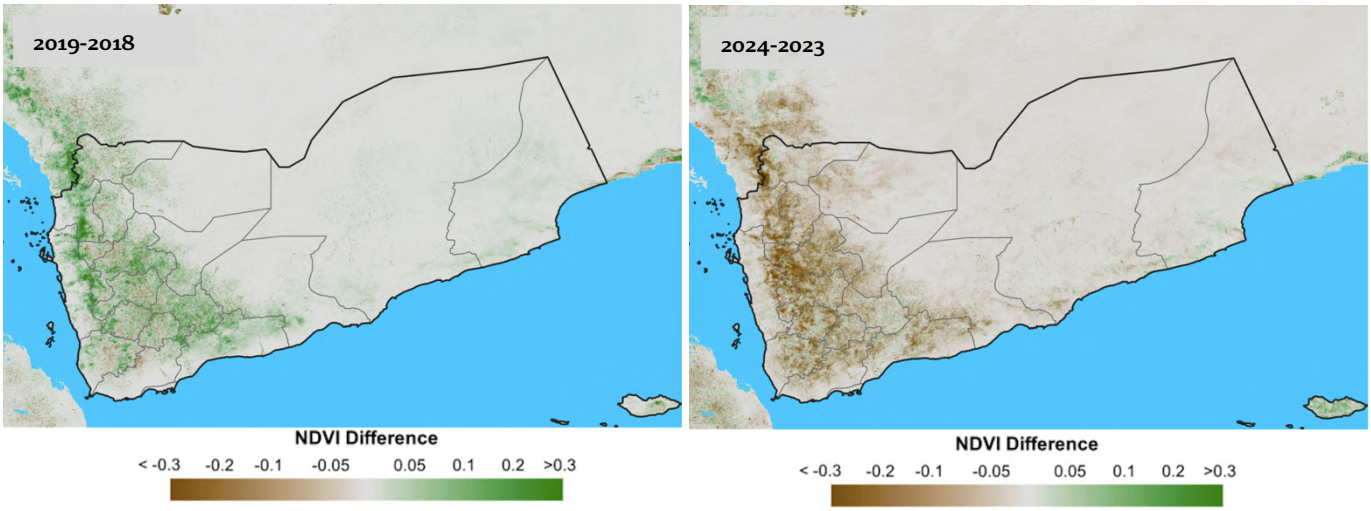


Figure 15 NDVI changes in Yemen from 2015 to 2024.

The conflict has worsened agricultural conditions through multiple channels, including water scarcity, fuel shortages, and damage to infrastructure. Data from a 2019 UNDP report[92] underscores these challenges, noting that water scarcity has become the most critical factor limiting agricultural productivity. Fuel shortages have further compounded the problem by increasing the cost of irrigation, making it unaffordable for many farmers. In 2016 alone, the total cultivated area in Yemen decreased by an average of 38 percent. Regions heavily reliant on agriculture, such as the Tihama area, experienced even more severe declines. In Tihama, all groundwater-dependent agricultural activities were suspended, cultivated areas fell to just 39 percent of pre-war levels, and crop yields dropped to 42 percent of pre-war production levels.

Case Study: The Decline of Tihama's Date Farms and Its Impact on Food Security

The Tihama Plain, located on Yemen's western coast, is one of the country's most fertile agricultural regions. Known for its lush farms producing dates, mangoes, bananas, cotton, millet, corn, wheat, papaya, and watermelon, Tihama has long been a cornerstone of Yemen's agricultural output. However, the conflict has devastated this once-thriving agricultural hub, with severe consequences for food security and local livelihoods.

Before the war, Tihama's date palm farms were a vital component of Yemen's agricultural heritage and food security. Dates, a nutrient-rich fruit, have been cultivated in Yemen for centuries, providing both sustenance and economic value. According to the FAO's Global Forest Resources Assessment 2015[93], Yemen had approximately 34,526 hectares of date palm agriculture, with 5,181 hectares under cultivation. A 2015 publication by the University of

[92] UNDP, "Assessing the Impact of War on Development in Yemen," UNDP, 2019, https://www.undp.org/yemen/publications/assesing-impact-war-development-yemen.

[93] "FAO's Global Forest Resources Assessment 2015," https://openknowledge.fao.org/server/api/core/bitstreams/077ddafb-1021-4bde-afee-d5c28b2cad25/content.

Aden[94] noted that Yemen had over four million date palms between 2008 and 2012, producing around 58,000 metric tons of dates annually. Hudaydah, a key governorate in Tihama, was home to 59 different date palm cultivars and ranked as the second-largest date-producing region in Yemen, after Hadhramaut.

However, when the conflict began in 2014 has severely disrupted date palm farming in Tihama. Satellite imagery from Google Earth reveals the alarming disappearance of major date palm plantations, which were once easily identifiable by their distinct planting patterns in long rows and squares. Modern farms, which typically used 8×8 metre spacing have been particularly affected. Older farms with 5×5 metre spacing have also suffered significant losses.

The decline of Tihama's date farms is not solely a result of direct conflict but also stems from systemic issues exacerbated by the war. A widespread looting of agricultural land by military parties, coupled with forced labour practices reminiscent of feudal systems, has further marginalised local farmers. The war has intensified these challenges, pushing many communities into deeper poverty and food insecurity.

Environmental factors have also played a role in the decline of date palm production. Drought, desertification, and the lack of irrigation infrastructure have threatened the survival of date palms in Tihama, concerns that were raised as early as 2016. The combination of conflict, environmental stress, and systemic exploitation has led to a dramatic reduction in cultivated areas and yields, undermining both food security and the economic stability of local communities.

The disappearance of Tihama's date farms is a stark reminder of the broader impact of Yemen's conflict on agriculture and food systems. The following figure highlights the key date farm areas in Tihama, illustrating their historical significance and distribution across the region (Figure 16). Two specific case studies, supported by satellite imagery, demonstrate the disappearance of date farms in certain areas (Figures 17&18), underscores the dramatic changes that have occurred since the conflict began:

[94] Saeed Ba-Angood, "Date Palm Status and Perspective in Yemen," in *Date Palm Genetic Resources and Utilization: Volume 2: Asia and Europe*, ed. Jameel M. Al-Khayri, Shri Mohan Jain, and Dennis V. Johnson (Dordrecht: Springer Netherlands, 2015), 241–63, https://doi.org/10.1007/978-94-017-9707-8_7.

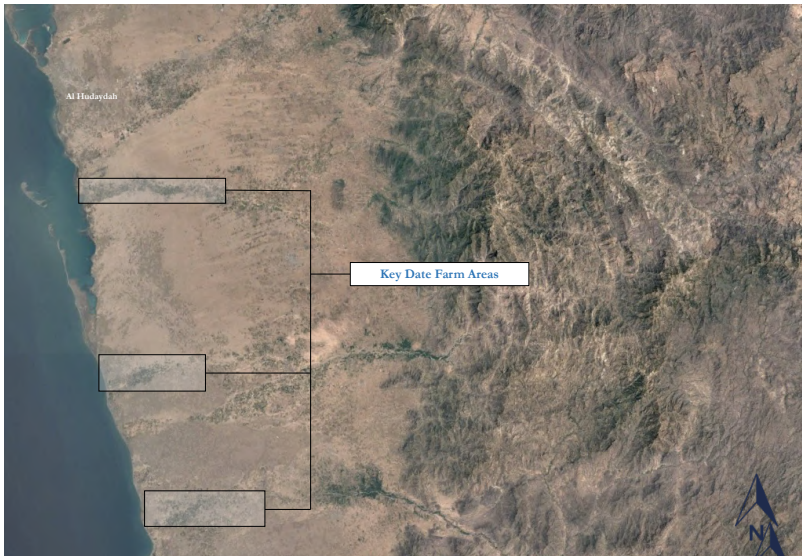


Figure 16 Major date farms area in Tihama Plain.

The date plantations near the coast are at the end of the outflow of the Wadi Raima, south of Hudaydah, close to Ad Durayhimi.

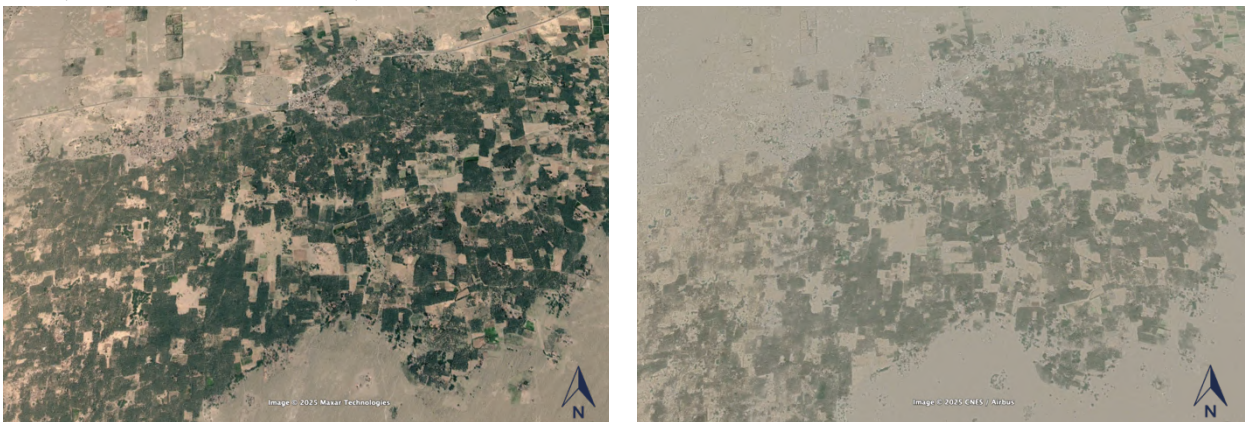


Figure 17 The date farms, south of Hudaydah city, close to Ad Durayhimi. (left: satellite imagery from June 2011, right: satellite imagery from September 2019 (Google Earth)).

The date plantations close to At Tuhayta

Figure 18 The date farms, close to At Tuhayta. (left: satellite imagery from July 2010, right: satellite imagery from June 2018 (Google Earth)).

5 Recommendations

This section presents a comprehensive set of recommendations aimed at addressing Yemen's critical water and food security challenges, as identified through key informant interviews with stakeholders in the water and agriculture sectors, and further refined and validated during a virtual workshop with national and regional experts. The proposed recommendations are designed to tackle the conflict-driven disruptions detailed in Chapter 4, offering actionable solutions for immediate relief and long-term resilience.

However, the effectiveness of these recommendations hinges on sustained peace and stability in Yemen. The ongoing conflict has severely undermined food production, disrupted supply chains, and weakened governance structures, making recovery efforts exceptionally difficult. In a post-conflict scenario, these interventions—rooted in sustainable, conflict-sensitive, and inclusive approaches—can help restore agricultural productivity, improve water management, and strengthen local livelihoods.

Actionable Recommendations for Water Security	
Availability of Water Resources	- Rehabilitate damaged water harvesting structures, such as cisterns, wadi pits and terraces, to improve water storage and availability. - Promote the use of water-efficient crops and practices to reduce groundwater demand. - Scale up rainwater harvesting initiatives to improve water availability in arid regions. - Implement managed groundwater aquifer recharge projects to restore depleted aquifers. - Invest in research and development to improve rainwater harvesting technologies, as well as groundwater monitoring and management.
Water Supply	- Establish community-based water distribution points in conflict-affected areas. - Provide water trucking and distribute water purification kits to vulnerable communities. - Mobilize emergency funding to support the rehabilitation of existing desalination plants in conflict-affected areas. - Distribute portable solar desalination units to remote and off-grid areas.
Water Infrastructure	- Repair damaged water infrastructure, such as wells, pipelines, and reservoirs, to restore access to safe drinking water.

	- Modernize irrigation infrastructure to improve efficiency and reduce losses. - Expand wastewater treatment infrastructure to increase the availability of treated water. - Rehabilitate water distribution networks to ensure efficient delivery of desalinated water to communities.
Quality of Water	- Rehabilitate damaged wastewater treatment plants to improve water quality. - Promote the use of treated wastewater for agricultural irrigation. - Conduct environmental impact assessments (EIAs) for new desalination projects. - Implement measures to minimize the environmental impact of brine discharge from desalination plants.
Government Performance	- Establish task forces to coordinate water security efforts among stakeholders. - Develop and update national policies for sustainable water resource management. - Strengthen local governance structures to improve water resource management.
Community Engagement and Capacity Building	- Train local communities in basic water management and conservation practices. - Establish community-led water management committees to oversee local water resources. - Strengthen the capacity of local governments and NGOs to manage water resources effectively.
Information Systems	- Support the establishment of national data system

Actionable Recommendations for Food Security	
Agricultural Infrastructure Rehabilitation	- Repair and rehabilitate critical on-farm and community-level infrastructure, including irrigation systems - Support the construction and rehabilitation of rainwater harvesting structures (e.g., cisterns and micro-irrigation systems).
Sustainable Agricultural Practices	- Promote climate-resilient farming practices and distribute high-quality, climate-smart seeds.

	- Implement soil conservation and erosion control measures, such as check dikes, vegetative barriers, and community-based forest management. - Prepare investment plans for the restoration of the agriculture sector in accessible districts. - Train farmers in efficient irrigation practices to reduce water waste and enhance crop productivity. - Implement large-scale reforestation and land rehabilitation programs to improve soil health and increase crop yields. - Invest in research on climate-resilient crops and sustainable farming techniques.
Food Assistance and Nutrition Support	- Scale up emergency food aid programs to address acute hunger and malnutrition. - Distribute micronutrient supplements to vulnerable populations, including children and lactating mothers. - Enhance coordination among stakeholders to ensure services reach the most vulnerable populations.
Strengthening Local Livelihoods and Economic Opportunities	- Develop home-based agri-food business plans, focusing on dairy production, beekeeping, and food processing. - Provide tools, equipment, and materials for agri-food processing and marketing at the community level. - Strengthen key agricultural value chains to increase income opportunities for rural households. - Promote diversification of livelihoods to reduce dependence on single crops or sectors. - Formulate evidence-based investment programs for agricultural and fisheries restoration.
Community Engagement and Capacity Building	- Invest in education and awareness campaigns to promote sustainable agricultural management practices, climate-resilient crops and farming techniques. - Implement farmer field schools to train farmers in planting, protecting quality seeds, soil conservation, and sustainable land use practices. - Develop in-service training programs for agricultural extension staff in climate-smart agriculture and modern farming techniques.

6 Conclusion

Yemen's conflict has severely exacerbated pre-existing water and food security challenges, pushing an already vulnerable population deeper into crisis. Even before the conflict, Yemen faced acute water scarcity due to over-extraction of groundwater, inefficient agricultural practices, rapid urbanization, and climate variability. The conflict has further destabilized water systems through infrastructure damage, fuel shortages, disrupted supply chains, and declining household purchasing power—leading to a dramatic reduction in water access for drinking, sanitation, and agriculture.

The conflict's impact on food security has been equally devastating. Agricultural production has plummeted, with cereal output falling to 41 percent of pre-war levels, exacerbating poverty in rural and coastal regions. In 2024, 17.6 million people—half of Yemen's population—are severely food insecure, while nearly half of all children under five suffer from moderate to severe stunting, reflecting a deepening malnutrition crisis. High fuel prices and damaged irrigation systems have crippled farming, while reliance on water-intensive cash crops like qat persists due to its economic viability. The collapse of water and sanitation services has also contributed to health crises, including over 2.5 million suspected cholera cases from 2016 to 2022, with 27 percent of Yemenis lacking access to safe water and 49 percent unable to secure sufficient drinking water when needed.

The humanitarian situation remains dire, with 18.2 million people requiring assistance in 2024 and 4.5 million still displaced, many enduring repeated displacements. However, Yemen's long-term water and food security remains precarious, requiring strategic humanitarian and developmental interventions. Post-conflict recovery must prioritize rebuilding water and farming infrastructure, improving agricultural sustainability, and integrating water security into peacebuilding efforts. Without urgent action, water scarcity will continue to undermine stability, economic recovery, and food security, leaving millions at risk of prolonged hardship.

This report underscores the need for coordinated efforts that address both immediate humanitarian needs and long-term water resource management, ensuring Yemen's path to recovery is sustainable and inclusive. Future work must explore actionable solutions to these critical challenges, particularly as climate change and population growth further strain already depleted resources.