DESK REVIEW

REPORT ON MIGRATION, ENVIRONMENT, AND CLIMATE CHANGE IN YEMEN

IOM
UN MIGRATION

This Desk Review was prepared by Dr. Erin Mcfee as a consultant for the International Organization for Migration (IOM) within the framework of the project "Strengthening resilience of Arab states in Western Mediterranean and wider Arab region against climate risks and improving human mobility management in the climate change context".

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Cover photos: Displaced women go back to their shelter after fetching water from a water point in a remote area on Yemenâs west coast. ˝IOM/Rami Ibrahim 2021˝ © International Organization for Migration 2021

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ACRONYMS

AAP	Accountability to Affected Populations
AQAP	Al Qaida in the Arabian Peninsula
ASR	Assisted Spontaneous Return
CBD	Convention on Biological Diversity
CCCM Cluster	Camp Coordination and Camp Management Cluster
CIA	Central Intelligence Agency
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CIVIC	Center for Civilians in Conflict
CMS	Convention on the Conservation of Migratory Species of Wild Animals
CSO	Civil Society Organization
DCAF	Geneva Center for Security Sector Governance
EM-DAT	Emergency Event Database
ERW	Explosive Remnants of War
FAO	Food and Agriculture Organization
FSAC	Food Security and Agriculture Cluster
FSIN	Food Security Information Network
GDP	Gross Domestic Product
GIS	Geographic Information System
GSC	Global Shelter Cluster
HLP Rights	Housing, Land, and Property Rights
HSA Group	Hayal Saeed Anam Group
IAHE	Inter-Agency Humanitarian Evaluation
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICRC	International Committee of the Red Cross
IDP	Internally Displaced Person
IHD	Integral Human Development
ILO	International Labour Organization
IOM	International Organization for Migration
IPC	Integrated Food Security Phase Classification
IRW	Islamic Relief Worldwide
ISIL	Islamic State of Iraq and the Levant
MECC	Migration, Environment, and Climate Change
MENA	Middle East and North Africa
NACRA	National Committee for Refugee Affairs
ND-GAIN	Notre Dame Global Adaptation Initiative
NDC	National Dialogue Conference
NFI	Non-food Item
NGO	Non-governmental Organization

NUPI	Norwegian Institute of International Affairs
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
PA	Participatory Assessment
QIP	Quick Impact Projects
RF	Random Forest
RS	Remote Sensing
SIPRI	Stockholm International Peace Research Institute
SPI	Stream Power Index
TWI	Topographic Wetness Index
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention for Climate Change
UNHCR	United Nations High Commissioner for Refugees
UNY	United Nations Yemen
USAID	United States Agency for International Development
UXO	Unexploded Ordnance
VHR	Voluntary Humanitarian Return
WASH	Water, Sanitation, and Hygiene
WFP	World Food Programme
WPS	Women, Peace, and Security
WRO	Women's Rights Organizations

1. BACKGROUND

1.1 The Context

Yemen's landscape comprises a predominantly desert climate, characterized by arid conditions. It is positioned at the southern tip of the Arabian Peninsula and has a surface area of approximately 527,970 square kilometers. Along its west coast, the climate turns hot and humid due to its proximity to the sea. The western mountains present a more temperate climate influenced by seasonal monsoons. In these areas, the weather exhibits greater variability. Conversely, the eastern regions of Yemen are marked by an exceptionally harsh desert environment, with extremely high temperatures and minimal precipitation. The estimated population of the country is 31.6 million people as of 2023 and is distributed unevenly across its varied topography, with notable population centers in cities such as Sana'a and Aden. The population is linguistically diverse, with Arabic being the predominant spoken language. Yemen's ethnic background is predominantly Arab, although there are also Afro-Arab, Afro-Asiatic, South Asian, and European groups (CIA, 2023).

Yemen's vulnerability to climate change and its dire consequences remains a persistent concern among scientists, policymakers, and the country's 33 million inhabitants. The country is facing **among the world's worst water and food crises** due to its highly arid climate and fast-depleting groundwater reserves, ranking as the 12th most water scarce country in the world (Acacia Water, 2021; FSIN, 2022; Kuzma et al., 2023). Groundwater depletion is alarmingly high in various regions of Yemen, particularly impacting the highlands, where annual declines in the water table range from 2 to 6 meters (FAO, 2023a). The high scarcity of water significantly impacts food security and nutrition climate-induced human mobility. Rapid population growth puts massive pressure on the limited water resources in Yemen due to over-extraction of groundwater, changing rainfall patterns, and inadequate water management policies. **This scarcity has led to conflicts over agricultural and domestic water supplies** and has significantly burdened vulnerable populations.

Climate change is expected to exacerbate these challenges, with temperatures rising, rainfall patterns becoming more unpredictable, and land degradation and desertification persisting or worsening (Lackner & al Eryani, 2020). The frequency of slow-onset processes is also on the rise in Yemen. **Rising sea levels** have increased the salinity of aquifers near the coast, leading to water supply deterioration and agricultural production decline (Lackner & al Eryani, 2020). In addition to climate change, factors such as environmental degradation, urbanization, demographic shifts, and migration patterns may be contributing to the nation's growing vulnerability. **Unregulated overfishing and pollution** from hydrocarbon extraction have also negatively impacted Yemen's fisheries and health (Zabara & Zumbrägel, 2022).

The country is expected to face a wide array of climate-related challenges, including increased water scarcity, diminished water quality, more frequent droughts, shifting precipitation patterns, land degradation, reduced agricultural output, infrastructure damage, coastal zone deterioration, and the proliferation of vector-borne and water-borne diseases (Al-Akel, 2020; Price, 2022). And yet, Yemen is woefully underprepared to confront climate shocks, **ranking 174th out of 185 countries on the Notre Dame Global Adaptation Index** (ND-GAIN, 2022).1 Despite its vulnerability to climate change, however, Yemen's contribution to global CO2 emissions remains minimal, accounting for a mere 0.03% as of 2020 (Price, 2022).

Yemen's economy is classified as low-income and Yemen is consistently ranked as one of the least developed countries in the world (UNCTAD, 2022). Yemen's fragile economy has been impacted by the **civil war**, resulting

1) This comprehensive assessment hinges on two core domains: vulnerability and readiness. Vulnerability scrutinizes the nation's capacity to adapt to and withstand the adverse impacts of climate change while readiness evaluates a country's capability to efficiently employ investments for adaptation actions. Together, these factors provide an in-depth snapshot of Yemen's ability to address climate change challenges (ND-GAIN, 2023).

in severe damage to its infrastructure, trade networks, and economic institutions. While the country traditionally relied on oil and gas revenues, its reserves have been dwindling. The ongoing conflict has exacerbated existing challenges, leading to widespread poverty, food insecurity, and unemployment. Furthermore, Yemen faces the issue of high inflation, which further compounds the economic strain felt by its population (ICRC, 2021).

The humanitarian crisis in Yemen has displaced over 4.5 million people . Simultaneously, it is **a major transit hub for mixed migration flows** from East Africa and the Horn towards Saudi Arabia and other Gulf Cooperation Council countries (IOM, 2023b). The number of arrivals of migrants and other mobile populations in Yemen from the Horn of Africa has significantly increased in recent years, driven by political and economic instability as well as serious droughts and other climate hazards in countries like Ethiopia and Somalia. Despite its own conflicts and environmental challenges, Yemen remains attractive to migrants who view it as a better alternative. However, Yemen struggles to support the growing immigrant population, as Gulf countries enact stricter border restrictions and push migrants to stay closer to their countries of origin. As a result, in-between countries like Yemen are burdened with an immigrant population they cannot fully support (Binwaber, 2023). Amidst these challenges, the city of Aden, serving as southern Yemen's largest urban center and a temporary capital since 2015, grapples with a diverse population mix, encompassing non-displaced residents, returnees, internally displaced persons (IDPs), and migrants and refugees (Zabara & Zumbrägel, 2022). The city of Marib is also increasingly becoming a refuge for migrants aiming to move westward, seeking economic opportunities and further migration to Saudi Arabia and beyond (IOM, 2022a). However, the growing migrant population in Marib has sparked various social issues, including HLP tensions, labor exploitation, and physical and psychological abuse of migrants (IOM, 2023d). The diverse population in Yemen poses unique complexities for humanitarian endeavors and protection efforts. For these reasons, approaches to orderly migration and sustainable development require a holistic approach that considers the environment, climate change, and migration as they intersect with one another.

1.2 Migration – Evidence from the Past

The overall number of individuals in need of general protection services in 2023 stands at 17.7 million with more that 11 million children are in need of humanitarian protection (UNICEF, 2023). Among them, **1.6 million (36%) are residing in displacement camps or settlements**. This represents a 4 percent increase in the number of people in need over 2022. Several factors contribute to this increase, including ongoing insecurity, conflict, climatic shocks, and challenging economic conditions that elevate protection needs (OCHA, 2022).

Yemen plays a vital role as a host nation for a significant number of migrants, refugees, and asylum seekers who predominantly reside in urban and semi-urban regions. Amidst the challenges of the COVID-19 pandemic, these communities encountered unique hardships, including heightened levels of intolerance, marginalization, economic difficulties, and protection issues[1]. The vulnerabilities are particularly acute for young people and women, who are disproportionately exposed to the negative consequences of scarce resources and challenges to accessing services that may effectively support the psychological and physical consequences of survivorship. Furthermore, Yemen officials have worked to mitigate the challenges posed by smugglers and traffickers, especially in primary migration routes and transitional zones like Marib. Nevertheless, the complexities of the situation require greater support to enhance institutional capabilities, especially with regards to addressing incidents resulting from the heightened precarity of refugees, asylum seekers, and migrants (ACAPS, 2023b; CIVIC, 2022).

1) For more information on these forms of hardships, which can include discrimination, challenges in accessing public services, recruitment by armed groups, and risks of sexual violence and exploitation, see IOM, 2022b and UNY, 2022.

The impacts of climate change, coupled with the environmental damage inflicted during the ongoing conflict, have fueled resource scarcity, and forced migration throughout Yemen with cascading effects. These dynamics have given rise to increased protection threats, inter-communal tensions over resources, and bouts of violence. Simultaneously, the war has constrained the population's access to essential water and sanitation services, with water facilities being either blocked or destroyed due to the conflict. One of the **significant consequences of climate change in Yemen is the displacement** of its population. Extreme weather events have already displaced tens of thousands of Yemenis. This displacement threatens livelihoods, especially in rural areas, strains critical resources in relocation areas, and provides armed groups with recruitment opportunities. Migration and displacement serve as a crucial nexus between climate change and conflict, with the potential to intensify various conflict drivers (OCHA, 2022). For example, a study led by the Center for Civilians in Conflict (CIVIC) identified direct links between climate change, environmental damage, resource shortages, **loss of livelihoods**, forced migration, and conflict in areas like Aden, Marib, and Taiz (CIVIC, 2022).

Amid these challenges, Yemen's dwindling renewable freshwater resources pose a severe problem. The country's water resources are strained due to factors such as population growth, urbanization, and the conflict's impact on water infrastructure. This exacerbates **the water crisis**, impacting the most vulnerable segments of the population, including women, children, and IDPs. While urban areas in Yemen enjoy better access to water compared to rural areas, the decline in water availability is more pronounced in urban settings. In Yemen's rural areas, the depletion of wells has dire consequences, leading to escalating social tensions that often erupt into local conflicts. Water scarcity, driving mass displacement, further amplifies the risk of broader conflicts (DCAF, 2022; NUPI & SIPRI, 2023). Moreover, densely populated urban centers, particularly among the urban poor, face heightened dangers from flash floods, adding to the environmental threats Yemen faces (Al-Aizari et al., 2022)satellite images, remote sensing data, essential geographic data, and various data sources and used as input data into four machine learning (ML. The following subsections highlight the migration history in Yemen, while later sections on vulnerability elaborate the risks to human mobility posed specifically by current trends in climate change and environmental degradation in the country.

1.2.1 Immigration and Emigration

The Horn of Africa and Yemen comprise one of the world's busiest and most perilous mixed migration routes, frequented by hundreds of thousands of migrants, the majority of whom undertake irregular journeys, often depending on smugglers to aid their movement along the Eastern Route which can put them at an increased risk of human trafficking. **Immigration** in Yemen is driven by a variety of factors, reflecting the complexity of the country's migration landscape. First, Yemen serves as a magnet for individuals in search of improved economic prospects. Immigrants are often enticed by the promise of job openings, trade prospects, or investment possibilities within the nation. Particularly in urban areas, Yemen's informal labor market can be an attractive draw for those seeking employment and better livelihoods. Among non-Yemeni migrant arrivals in 2022, 84% entered the country for economic reasons, while 16% did so for conflict reasons. Nearly all surveyed in a 2023 International Organization for Migration (IOM) study (97%) arrived in transit to Saudia Arabia. Migrants were either Ethiopian (92%) or Somali (8%) nationals (Binwaber, 2023; IOM, 2023a, 2023b).

Migrant arrivals in Yemen saw a substantial 87% increase between the first two quarters of 2023, marking the highest recorded figures to date. This surge in arrivals is indicative of the growing migration challenges faced by the region. Notably, there was a **significant shift in the demographic composition** of these migrants, with the number of boys arriving more than doubling, rising from 1,800 to 4,100 (IOM, 2023b).

The **increase in arrivals through specific coastal areas**, such as Lahj and Shabwah, reflects changing dynamics in migration patterns. This surge can be attributed to improved sea conditions, as well as smugglers adopting more efficient strategies, altering routes, and using larger boats. The occurrence of Ramadan affects migration flows as well, with eased patrols during this religious period making the journey to Saudi Arabia appear more attainable to migrants.

Figure 1: Governates of Yemen. From *Berghof Foundation and Political Development Forum Yemen: Resource Hub*

A noteworthy development in migration trends is the **emergence of a new route driven by reports of human rights violations and detention at the Saudi Arabian border**. Migrants are increasingly arriving in the Hadramaut and Al Mahrah governorates with the intention of accessing economic opportunities in Oman. These areas are seen as more hospitable, with fewer military checkpoints, relative stability, and better acceptance of migrants by the host communities. Furthermore, the reduced presence of the Yemeni Coast Guard along the coastal areas leading to Mukalla, Hadramaut, has made it a preferred transit point. However, while these areas offer relative safety, migrants still face severe limitations in terms of access to health and social services, and human rights violations continue to be a grave concern (IOM, 2023b).

In terms of **emigration**, the protracted conflict, exacerbated by the Saudi Arabian intervention in 2015, has driven a significant increase in migrant outflows, with Yemenis seeking refuge in neighboring and distant countries. While precise figures on Yemeni emigration are challenging to ascertain due to the lack of centralized data and the complexity of tracking irregular movement, multiple reports have shed light on this phenomenon. Approximately **190,000 Yemenis and foreign nationals have fled Yemen since the onset of the conflict**, signifying the scale of displacement and the dire conditions within the country. Djibouti, located merely 100 kilometers west of the Yemeni town of Taiz, received over 37,000 Yemeni arrivals as of 2020, highlighting its proximity and role as a refuge for those escaping the conflict (IHD, 2023).

Somalia, despite its own challenges, emerged as an unexpected haven for Yemeni refugees. **Over 14,000 Yemeni refugees sought shelter in Somalia**, driven by the need for safety amid Yemen's turmoil. Somalia's membership in the 1951 Refugee Convention obligated the country to accept asylum-seekers, but it also underscored the need for significant support and capacity building to provide proper care for the displaced population. Furthermore, **smaller but noteworthy numbers of Yemenis applied for asylum in Egypt (5,032) and Germany (3,992) in 2018** (IHD, 2023). These figures underscore the global reach of Yemeni emigration as individuals sought security and opportunities abroad, reflecting the profound impact of conflict-induced displacement on Yemen's population. However, analysts estimated that 2022 would see a net negative migration (>-100,000), indicating that more people were leaving the region than arriving (IHD, 2023).

1.2.2 Internal Migration

The economic landscape at the household level in Yemen has undergone significant transformations over the decades. Historically, prior to the 1970s, the majority of the population resided in rural areas, primarily engaged in the cultivation of crops such as coffee, qat, and vegetables. During this period, rural and urban areas exhibited minimal disparities in terms of architecture, lifestyle, and societal structure. The political elites inhabited the urban centers, while tribal influence held sway in rural regions. However, a crisis in Yemen's rural regions (due to delayed modernization of agricultural techniques and lack of arable land), and the opening up of the country's economy, sparked a pivotal shift in the 1990s, marking the commencement of **mass rural-to-urban migration, which has now become a defining characteristic of Yemen's urban milieu** (GSC, 2022; Stadnicki, 2014).

Presently, internal migration within the country plays a central role in shaping Yemen's urban dynamics. This phenomenon implicates several concurrent stressors, including escalating poverty rates in rural areas, the dearth of employment opportunities, and various climate-related challenges such as water scarcity, drought, and other natural hazards. Notably, **Sana'a City stands out as the primary destination for internal migrants**, signifying its magnetic pull for those seeking economic prospects and improved livelihoods. Houthi authorities cited internal migration and the influx of IDPs from various regions as the primary drivers behind the population surge in Sana'a, which witnessed a staggering increase from 2.9 million residents in 2015 to over 7 million by 2021 (ACAPS, 2023b). This demographic upswing has generated an immense demand for essential services, particularly in the realm of housing and accommodation (Al Monitor, 2022).

1.2.3 Displacement

Yemen faces a **significant internal displacement crisis**, with over 4.5 million IDPs, including 172,000 newly displaced in 2020 and nearly 160,000 in 2021 (IDMC, 2023). Most of the recent displacements occurred in Marib, Houdeida, Hajia, and Taizz Governorates (see Figure 1), and a substantial majority, over 70%, are women and children. Additionally, there has been an increase in female-headed households among displaced families, rising from 9% before the conflict escalated in 2015 to approximately 15% as of 2022. These IDPs are living in nearly 2,000 makeshift sites, but unfortunately, less than 25% of these sites receive assistance from humanitarian organizations. About 50% of these IDP sites are located within 5 kilometers of active conflict zones, disproportionately exposing them to the dangers of armed conflict (UNY, 2022). Displacement in Yemen **arises from both conflict and disasters triggered by natural hazards**, the latter causing repeated displacement for many. IDPs encounter significant obstacles in securing adequate housing and essential services, often exacerbated by discrimination against marginalized groups such as the Muhamasheen (detailed later on in this review) and individuals with disabilities, who face additional barriers to accessing housing and services in an already challenging Yemeni context (GSC, 2022).

The legal rights of IDPs are greatly affected by a weak judicial and administrative system in Yemen. The **absence of freedom of movement and civil documentation** further complicates the circumstances faced by displaced populations, impeding their access to vital services and protection (IAHE, 2020; OCHA, 2022). Traditional social and cultural norms often take precedence over basic human rights principles, including those established in international agreements to which Yemen is a signatory. Displaced individuals often require substantive legal aid to address intersecting economic and security issues, which often include family disputes, eviction threats, and difficulties in obtaining documentation. **Displaced and refugee women**, who constitute a significant portion of Yemen's internally displaced population, grapple with protection challenges and violence, further exacerbated by restrictive social norms (WFP, 2022).

Concerns also persist within the **response to the IDP crisis**, including inadequate livelihood support, deficiencies in assistance to IDP sites, and flawed monitoring and reporting systems. According to the September 2021 Camp Coordination and Camp Management (CCCM) cluster figures, only 22 percent of IDP sites are served by a management agency. Among these, merely 42 percent of households receive regular assistance (IAHE, 2020). Assessing coverage for IDPs outside of camps is even more challenging. When aid is provided, quality concerns can still remain – e.g., with malfunctioning hospital equipment, substandard school construction, and inadequate infrastructure projects. Water, sanitation, and hygiene (WASH) services and waste disposal are the weakest aspects of the humanitarian response in camps, except for livelihood support (OCHA, 2022).

Coordination and safety concerns have also posed challenges to humanitarian efforts, with the United Nations required to notify the Saudi-led Coalition of its movements to prevent staff from being hit by airstrikes. Marib exemplifies the difficulties of responding to emerging needs: at the beginning of 2021, Marib was under assault, causing a mass displacement. The United Nations Office for the Coordination of Humanitarian Affairs (OCHA) (2022) reported that Marib already hosted an estimated one million IDPs, the largest IDP population in Yemen. Responses were devastatingly slow, illustrating the challenges in responding to rapidly evolving crises in Yemen.

Sanitation and basic amenities also remain deficient in numerous IDP sites, exacerbating the living conditions of displaced individuals. The effectiveness of complaint mechanisms is questionable, with residents in IDP sites abandoning complaint boxes and hotline records indicating a systemic "no action taken" response to serious complaints. Additionally, the collective strategy for Accountability to Affected Populations (AAP) appears to have fallen by the wayside. Resource allocation for IDP services remains a persistent challenge and humanitarian actors struggle with funding gaps, hindering the full implementation of vital programs, including Quick Impact Projects (QIPs) aimed at enhancing access to basic services (IAHE, 2022).

And though internal displacement has long been noted to contribute substantively to unplanned urbanization, there is some evidence of an emerging contrasting trend with a "reverse" population movement from major urban centers to rural areas, turning rural regions into hosting areas for IDPs within Yemen's complex socioeconomic and political landscape (GSC, 2022).

1.2.4 Relocation, Return and Local Integration

The protection of housing, land, and property (HLP) rights is crucial for IDPs in Yemen, as it directly impacts their ability to find durable solutions to displacement. These rights encompass the right to secure and dignified housing, recognized entitlements to land, and property ownership. However, several challenges hinder the protection of HLP rights in the Yemeni context and impede efforts to address displacement effectively. One major challenge is **the absence of civil documentation for IDPs, which complicates their relocation, integration, or return processes** (ACAPS, 2023b). Additionally, there is a scarcity of available land for IDP relocation, exacerbated by territorial disputes between returnees and new landowners, reluctance from landlords to provide land for durable solutions, and flood risks (ACAPS, 2023b; CIVIC, 2022). Particularly marginalized groups like the Muhamasheen, who confront societal prejudices and receive limited support, often find themselves compelled to seek refuge in informal settlements, compounding their vulnerability.

A significant concern in Yemen is the extensive contamination of areas by **unexploded ordnance (UXO),** where a substantial portion of the population now resides or has close proximity to. These areas include schools, hospitals, and agricultural lands, rendering them unsafe and unusable. This contamination adversely affects people's livelihoods and prevents IDPs from returning to their homes, directly endangering their safety and well-being (OCHA, 2022).

The **susceptibility to flooding** further restricts the land available for relocation and poses a re-displacement risk for IDPs in their current sites. In 2022 alone, 2 disaster incidents occurred linked to floods, resulting in over 170,000 displacements (IDMC, 2023). Approximately 40% of IDP sites in the country at risk of flooding (ACAPS, 2023b; CIVIC, 2022).

1.2.5 Refugees and Asylum Seekers

The collapse of Yemen's economy and public services, coupled with the ongoing COVID-19 pandemic, has had profound implications for refugees and asylum seekers in the country. This **multifaceted crisis** has significantly eroded the self-reliance of refugees, who have seen their livelihoods vanish, forcing them into harmful coping strategies and heightened reliance on humanitarian food assistance (OCHA, 2022; UNHCR, 2022). Concurrently, the dire state of shelter conditions in Yemen, characterized by **overcrowding and inadequate housing**, compounds vulnerabilities, escalating protection risks, and creating fertile ground for the spread of diseases (GSC, 2022). Yemen has historically been a nation of refuge, hosting individuals fleeing conflicts and persecution in neighboring countries. However, the severe humanitarian crisis in Yemen has led to growing intolerance and a shrinking asylum space for those seeking safety and protection. This situation has particularly affected refugees, asylum seekers, and migrants, with Yemen accommodating approximately 138,000 migrants and 140,000 refugees and asylum seekers, primarily in urban and semi-urban areas (IOM, 2022b; UNY, 2022).

Yemen remains a transit point for mixed movements and is also home to refugees and asylum seekers from various countries, including Somalis, Ethiopians, Syrians, Iraqis, Eritreans, Palestinians, and Sudanese. Among these, **Ethiopians constitute the majority of arrivals in Yemen**, primarily motivated by high unemployment rates and political instability, with the aim of reaching Gulf countries for employment opportunities (IHD, 2023; IOM, 2023a). Refugees in Yemen have **found employment primarily in the agriculture sector**, underscoring the importance of integrating immigrants and refugees into host nations' job markets (ACAPS, 2023b; CIVIC, 2022). The advent of COVID-19-related restrictions in 2020 led to a significant reduction in migrant arrivals in Yemen, leaving tens of thousands of Ethiopian migrants stranded without essential services or a means to return home. This dire situation exacerbated vulnerabilities for migrants, who were often blamed for carrying and transmitting the virus (IHD, 2023).

A **complex and challenging protection environment marks Yemen's approach to refugees and asylees**. Several factors, including mixed population movements from the Horn of Africa, have contributed to a restrictive atmosphere. Negative reactions from both authorities and the public have further complicated the situation. These factors, coupled with the ongoing global humanitarian crises and conditions in refugees' countries of origin, have limited opportunities for durable solutions (UNHCR, 2022). Despite Yemen being a signatory to the 1951 Refugee Convention and 1967 Protocol since 1980, it struggles to fulfil its international obligations effectively. This challenge is primarily due to the continuous humanitarian and protection crisis within the country (UNHCR, 2023a).

The United Nations High Commissioner for Refugees (UNHCR) operates the only refugee camp in Yemen, located in the Lahj governorate and opened in 2001. As of January 2023, the **Kharaz Refugee Camp shelters a population of 9,614 refugees and asylum seekers, primarily originating from Somalia, with approximately 10% coming from Ethiopia**. Of the registered refugees and asylum-seekers, women and girls make up 52%, while the elderly, aged over 60 years old, constitute a minimal 2% of the camp's population (UNHCR, 2023b). The most vulnerable populations within this camp require legal assistance for individuals in immigration detention and on civil and criminal matters. Education support for primary and secondary-aged children, primary and specialized healthcare for vulnerable refugees, and income-generation initiatives, including capacity building, are also offered, with the intent of enhancing self-reliance among the refugee population (UNHCR, 2023a).

In 2022, notable progress was made in advancing durable solutions for refugees, particularly in the context of **refugees voluntarily returning to their home countries**. This progress was primarily driven by the resumption of the assisted spontaneous return program (ASR) after the lifting of COVID-19-related travel restrictions and cross-border discussion involving relevant authorities and supporting international agencies. During the last quarter of 2022, for example, the ASR program successfully supported the spontaneous return of 602 Somali refugees (UNHCR, 2023a). Concurrently, the Voluntary Humanitarian Return (VHR) program, led by the IOM, facilitated the return of 160 refugees from Ethiopia, who had been referred and supported by UNHCR

following counseling. In total, 762 asylum seekers and refugees benefited from voluntary return assistance and support for their reintegration into their home countries (IOM, 2023b, 2022b; OCHA, 2022).

As individuals, particularly migrants and refugees, journey through Yemen, they encounter significant challenges to their human rights[1]. As is the case in most contexts, children, refugees, and female migrants —predominantly those originating from Ethiopia and Somalia—are particularly vulnerable to contextual adversity and have more acute risk profiles. Yemen's legislative framework includes provisions aimed at penalizing traffickers and smugglers who dominate migration routes. However, the ongoing conflict, among other dynamics, complicates the enforcement and oversight of these laws, revealing an opportunity for increased international collaboration to enhance protection capabilities

In 2022, UNHCR, in collaboration with the National Committee for Refugee Affairs (NACRA), initiated a **Participatory Assessment (PA) for refugees and asylum seekers** residing in Amanat Al-Asimah in Sana'a, marking the first such assessment in two years. This comprehensive evaluation also covered various refugee locations in the South, including Aden city, Kharaz refugee camp, and Mukalla, with the primary goal of tailoring interventions to the specific needs of displaced populations through meaningful participation. The PA exercise revealed several critical challenges faced by refugees and asylum seekers, including the **lack of livelihood opportunities, cash assistance, and income sources**, which significantly hindered their ability to meet basic needs and led to harmful coping practices. Young people expressed a strong desire for tertiary **education** opportunities, while refugees from Arab countries reported difficulties related to **civil documentation**, often obstructing their children's access to education. Additionally, refugees emphasized the pressing need for durable solutions, **including improved access to healthcare services to address psychosocial distress and mental disorders** across various age groups (UNHCR, 2023a).

1.2.6 Role of National and International Remittance

The drop in demand for food purchases in the local market in Yemen can be attributed to several factors, including the **decline in Yemeni migrants' remittances**. Remittances serve as the primary source of foreign currency for trade financing in Yemen and a major income source for most families. The reduction in migrant working incomes, limited employment space in Saudi Arabia, and an overvalued exchange rate in areas controlled by the De Facto Authorities have resulted in decreased remittances and reduced household net gains. Furthermore, there is a growing trend of migrants relocating their dependents to Saudi Arabia when possible (ACAPS, 2023b).

Remittances have historically been a crucial factor in maintaining economic stability in Yemen. According to the World Bank's estimation in 2022, remittances to Yemen amounted to $3.771 billion USD, accounting for 17.5% of the country's gross domestic product (GDP) (The World Bank, 2022). These remittances became even more significant during the conflict, playing a role in import financing, Yemen's balance of payments, and the provision of foreign currency (IAHE, 2022). The economic consequences of the COVID-19 pandemic have led to a decline in remittances globally, impacting food prices and causing variations depending on geographic areas of control (ACAPS, 2023c; HSA Group, 2022). The decrease in global fuel prices in 2020 further resulted in declining remittances to Yemen, especially as the majority of remittances originated from Saudi Arabia (IAHE, 2022). This has significantly affected **household incomes in Yemen, which are already precarious due to dependence on aid and remittances** (OCHA, 2022). Additionally, seasonal factors like flooding and locust infestations, coupled with continued economic challenges such as high unemployment and climate shocks, may further deteriorate the macroeconomic situation in Yemen, leading to high inflation, reduced purchasing power, and difficulty in securing food and livelihoods (IAHE, 2020; OCHA, 2022).

1) For more information on the challenges faced by migrants and refugees, such as human trafficking, kidnapping, torture, detention, gender-based violence, and the dangers associated with perilous sea voyages, see Binwaber, 2023; IHD, 2023; and IOM, 2022b, 2023c.

2.0 KEY CHALLENGES: THE MIGRATION, ENVIRONMENT, AND CLIMATE CHANGE (MECC) NEXUS

Yemen stands at the precipice of a climate crisis that threatens not only its environment but also its social and economic fabric. The impact of climate change in Yemen carries a stark and troubling dimension, underscored by the nation's precarious institutional landscape, which ranks among the lowest in the Middle East and North Africa (MENA) region. Against this backdrop, the intertwining issues of MECC take center stage, presenting a multifaceted challenge.

Yemen's socio-economic structure pivots heavily on **agriculture and fisheries**, sectors that not only constitute a significant portion of the country's GDP but also play an indispensable role in securing its food requirements. This profound reliance on climate-sensitive traditional livelihoods has, in turn, perpetuated a dearth of viable alternatives for the population, exacerbating the vulnerability of communities grappling with the adverse effects of climate change. Within Yemen's agricultural landscape, **small, subsistence farms form the backbone**, encompassing diverse farming systems such as crop cultivation, livestock rearing, and highland mixed farming. Yet, climate change has taken a devastating toll on agricultural yields, particularly for essential crops like wheat, maize, and vegetables, leading to diminished household incomes and an alarming rise in poverty levels. Moreover, the **environmental degradation** arising from climate change, coupled with the destructive forces of **storms and flash floods**, has further eroded agricultural landscapes and livelihoods.

One significant challenge to action in these domains is the **scarcity of recent and reliable climate data**. The country's struggle to access comprehensive national and localized climate statistics hampers efforts to fully grasp the scope of climate change's impact. The following subsections elaborate on the current state of knowledge on sudden-onset events in the country.

2.1 Sudden-onset events and their effects on human mobility patterns

Yemen, a nation already grappling with a range of complex challenges faces additional threats to life and livelihood from sudden-onset climate events, particularly extreme weather phenomena like droughts and floods. These climatic disturbances, though often overshadowed by more overt crises, play a pivotal role in perpetuating land degradation and disrupting agricultural systems across the country. According to data compiled by the Emergency Events Database (EM-DAT), Yemen experiences a staggering annual toll, with approximately 100,000 individuals affected by natural catastrophes. Among these calamities, floods feature prominently, leaving in their wake not only significant economic losses but also severe damage to crop yields (Al-Aizari et al., 2022)satellite images, remote sensing data, essential geographic data, and various data sources and used as input data into four machine learning (ML.

2.1.1 Cyclones

The effects of climate change have resulted in an increase in cyclones and changing rainfall patterns. When cyclones occur, they can result in major damage and flooding in coastal areas of the country, with subsequent reduction in crop varieties and fish stocks, as well as flash floods. For example, a rare 2015 cyclone that made landfall in Yemen caused heavy flooding and damage in the southeastern provinces of Hadramawt and Shabwa. According to the Ministry of Planning and International Cooperation, Cyclone Chapala forced 18,750 people to flee inland, caused 3 deaths, and injured over 200 people on the island of Socotra (Sana'a, 2022). The city

of Mukalla was described as being "underwater" and suffered severe damage to houses and roads (Aljazeera, 2015). Nevertheless, the current cyclone risk in Yemen is low (ThinkHazard, 2023b), though the Hadramawt government does face increasing risk (Zabara & Zumbrägel, 2022).

2.1.2 Hurricanes and Tropical Storms

Seasonally intense and short-lived heavy storms characterize rainfall in Yemen. Tropical storms and hurricanes, whose increasing frequency is linked to climate change, can cause flash floods and soil erosion. These floods have resulted in economic damage and crop loss in the past. For instance, a tropical storm in 2008 brought 90 mm of rainfall in just 30 hours, causing severe flooding and destruction in the Hadramawt and Al-Maharah governorates. The damage from this flood was estimated to be $1,638 million. Urban areas, with their concentrated population and physical assets, are particularly vulnerable to these floods, with the average annual loss in Sana'a estimated at $3.0 million. Broadly speaking, Yemen's coastal areas are exposed to annual monsoon cycles, resulting in devastating hurricanes that have impacted people, infrastructure, and livelihoods (GSC, 2022).

2.1.3 Storm Surges

Storm surges and sea level rise also render Yemen susceptible to coastal damage, with the intensification of these phenomena resulting in the deterioration of wetlands, coastal mangrove migration, land erosion, infrastructure damage, and seawater intrusion. Estimates suggest that more than 50% of Yemen´s coastal land areas are at risk, with significant effects anticipated for coastal populations and GDP, and over 105,000 internal displacements since 2008 (IDMC, 2023; Price, 2022; Republic of Yemen, 2015; USAID, 2016).

2.1.4 (Flash) Floods

Floods are the most important and recurring disaster in Yemen, occurring almost every year. Yemen is particularly susceptible to flooding due to its physical land features and rainfall patterns, with areas such as Sa'ada, Taiz, Aden, and Marib being particularly vulnerable (ACAPS, 2020). Climate change is predicted to increase the severity and frequency of (flash) floods in Yemen, as it alters rainfall patterns and exceeds the soil's capacity to absorb water. The increasing frequency and scale of flash floods are also attributed to illegal logging, groundwater depletion due to qat cultivation, the elimination of natural flood barriers due to urbanization, and the expansion of agro-investments (Acacia Water, 2021; Al-Aizari et al., 2022; FAO et al., 2021; IRW, 2022; Lackner & al Eryani, 2020; Zabara & Zumbrägel, 2022)2021; Al-Aizari et al., 2022; FAO et al., 2021; IRW, 2022; Lackner & al Eryani, 2020; Zabara & Zumbr\\uc0\\u228{}gel, 2022. In addition, the destruction of infrastructure (including houses, roads, bridges, and water and electricity networks) during heavy rainfall events and flash floods exacerbates the impact of flooding in these areas (GSC, 2022). For example, in April 2020, heavy rainfall in Yemen led to flooding, displacement, severe infrastructure damage, and casualties. The most affected governorates were Saada, Sana'a, Marib, Aden, and Lahj and at least 15 deaths and 89 injuries reported (ACAPS, 2020).

Flooding in Yemen has serious socioeconomic consequences and has significantly worsened livelihood conditions. **Floods exacerbate desertification and land degradation**, leading to agricultural losses, the death of livestock, reduced availability of housing materials, starvation, and increased food insecurity. Yemen's heavy reliance on agriculture and subsistence farming makes it particularly vulnerable to these climate hazards. Additionally, floods and other climate-related disasters hamper the ability to import sufficient quantities of food, further increasing the risk of famine (FAO et al., 2021; IAHE, 2022; NUPI & SIPRI, 2023; OCHA, 2022).

Floods also **heighten the risk of water contamination**, leading to potential outbreaks of diseases such as dengue fever, malaria, and cholera (ACAPS, 2020; CIVIC, 2022; FAO et al., 2021; IAHE, 2022; Tower, 2020). This occurred during the cholera outbreak of 2016, which spread to 19 governorates and affected 53,000

individuals (Gadain, 2023). In addition, flash floods often mix with waste and byproducts from the oil industry, further polluting water resources and damaging farmland and vegetation (Al-Dailami et al., 2022; UNDP, 2022; Zabara & Zumbrägel, 2022)"page":"96","publisher":"The United Nations Development Program (UNDP. These public health risks are worsened by the destruction of healthcare and WASH infrastructure due to disasters and conflict. The increasing frequency and intensity of flooding and precipitation due to climate change is expected to further exacerbate health and humanitarian crises in Yemen.

IDPs and refugees are particularly vulnerable to the effects of climate change and environmental degradation, with **their homes being more susceptible to flooding and limited access to safe water and food**. The majority of displaced individuals are women and girls, who encounter heightened vulnerabilities, such as an increased risk of violence and human trafficking (IHD, 2023; UNY, 2022). This will be further elaborated on in the gender section. During recent floods, thousands of IDP shelters were destroyed, at least 7000 people were displaced and supplies and non-food items (NFIs) were washed away (ACAPS, 2020). Since 2008, floods have led to over 507,000 internal disaster displacements (IDMC, 2023). Moreover, floods and the risk of floods make land unsuitable for IDP relocations, limiting the availability of relocation land and posing **risks of re-displacement**. The absence of a national cadastre system and the loss or damage of documentation through displacement and flooding complicate the resolution of territorial disputes and property rights issues (ACAPS, 2020; UNY, 2022).

The ongoing conflict in Yemen worsens the impact of flooding, exacerbating the vulnerability of various populations and undermining efforts to address the crisis. A lack of coordination and the existence of two parallel administrations at war with each other make it extremely difficult to centralize humanitarian efforts. Additionally, areas affected by flooding have also witnessed increased violence and clashes between different armed factions. Moreover, Yemen is heavily contaminated by landmines and explosive remnants of war (ERW), which are further aggravated by intense rainfall and flash floods (ACAPS, 2023b; FAO et al., 2021).

The lack of a national coordination mechanism for emergency management in Yemen makes it difficult for anticipatory action (AA) to be delivered in coordination with government plans and activities. This hinders the response to flood disasters. The government and international organizations like the World Food Programme (WFP) are implementing projects focused on disaster risk reduction and resilience-building, including the construction of flood protection infrastructure and the enhancement of water availability in local communities. However, Yemen's **limited resources and lack of preventive planning** pose significant challenges to effectively addressing the impacts of climate change. Flood susceptibility mapping is also a crucial tool for mitigating flood-related losses. While geographic information systems (GIS) and remote sensing (RS) can create flood susceptibility maps, their accuracy is limited due to the complexity of flood mechanisms.

In a case study of flash floods in Tarim City, Yemen, researchers used advanced machine learning methods and RS data to assess flash flood susceptibility and identify contributing factors (Al-Aizari et al., 2022)satellite images, remote sensing data, essential geographic data, and various data sources and used as input data into four machine learning (ML. The study identified **several factors influencing flood susceptibility, including rainfall, elevation, topographic characteristics, stream power, drainage density, vegetation status, soil, land use, and management measures**. The researchers found that the **distribution of flood incidents in Yemen is concentrated in low-lying areas**, locations with a high accumulation of water and topographic wetness index (TWI), areas with low stream power index (SPI), slopes facing east, northeast, southeast, flat slopes, areas with high drainage density, and areas with gravels and bare ground. Preliminary research showed that the Random Forest (RF) model performed the best in predicting flood susceptibility in Yemen. Flood susceptibility maps generated by the machine learning models also show that flood-prone areas are mainly located along the main Wadi River and tributary streams, and are influenced by distances from streams, drainage density, elevation, and slope. Taken together, climate change, combined with poor planning, ongoing conflict, and environmental degradation, has greatly increased flood risk in Yemen, leading to displacement, loss of livelihoods, and severe humanitarian issues in the country.

2.1.5 Landslides

Yemen has a high risk of landslides due to its mountainous terrain, rainfall patterns, terrain slope, geology, soil, land cover, and potential earthquakes (ThinkHazard, 2023d). The combination of climate variability, including excessive rainfall and floods, and unstable soil in Yemen can lead to landslides and the destruction of infrastructure, including mud houses and coastal constructions (Mustun, 2022). Heavy rainfall causes swelling of the soil, which provokes landslides, as was the case in Taiz city (Zaid et al., 2021). Sea-level rise threatens coastal infrastructures as well. The Hadramawt governorate is exposed to significant landslide risk as are the urban poor throughout Yemen, who live in informal settlements on marginal and environmentally sensitive land, are particularly vulnerable to rockslides and landslides (GSC, 2022; Zabara & Zumbrägel, 2022).

2.1.6 Wildfires

The wildfire risk in Yemen is classified as high in the western governates, which means that there is a greater than 50% chance of weather effects resulting in wildfires that would result in life and property loss each year (ThinkHazard, 2023e). In 2022 alone, wildfires in Yemen led to over 1200 cases of internal disaster displacement (IDMC, 2023).

2.1.7 Sand- and Dust Storms

Yemen is also subject to sand- and dust storms, which have triggered widespread concern about negative health effects resulting from exposure to the dusty air (Al-Maqtari, 2012). Sandstorms can also lead to abrupt increases in river flows, rainstorms, flooding, and agricultural damage, collectively contributing to environmental degradation, alongside the direct harm caused during the sand- and dust storms (SDSs) (Keynoush, 2022).

2.1.9 Volcanic Eruption

Volcanic eruptions can have significant impacts on the environment and climate. They release large amounts of gases, ash, and aerosols into the atmosphere. These emissions can cause changes in the composition of the atmosphere and potentially affect climate patterns.

Yemen is a country that has various regions with different geological formations, including volcanic rock. The Yemen Volcanics formation is present extensively throughout the country, particularly in the governorates of Al Bayda, Amran, Dhamar, and Lahij. These regions have mountains, plains, and plateaus, and their geology is dominated by volcanic rocks such as basalt, olivine basalt, lava flows, basalts, porphyries, and tuff. The Yemen Volcanics also include younger volcanic rocks known as Quaternary Volcanics, which are basaltic and often encased in tuff (FAO et al., 2021). The country rests within a highly active region known as the triple junction, which consists of the Gulf of Aden, the Red Sea, and the Eastern African Rift System (GSC, 2022). After a period of 124 years of inactivity, Jebel at Tair, the volcanic island, experienced an eruption on September 30, 2007 (Aziz Ali Nasser, 2010). Thus, while volcanic activity has been low over the last 15 years, presence of volcanoes and volcanic rocks in Yemen suggests that the country may be prone to volcanic activity.

2.2 Slow-onset processes and their effects on human mobility patterns

Yemen is also a nation highly vulnerable to slow-onset environmental degradation processes, experiencing significant challenges such as **droughts, aridity, heatwaves, land degradation, and desertification**. Climate change further manifests through **shifting weather patterns marked by temperature fluctuations and altered precipitation trends**. These changes have catalyzed a cascade of repercussions, including land degradation, soil erosion, and accelerated desertification. Consequently, the country grapples with the impact of these phenomena on its overall sanitary conditions and the spread of diseases in addition to the underlying economic consequences and impacts on human mobility. The following sections elaborate on the various slow-onset processes faced by different governorates in Yemen, including waste management, garbage pollution, soil pollution, destruction of arable land, maritime pollution, climate change-driven soil destruction, and pollution caused by human activities. These concerns contribute to the displacement of populations, agricultural losses, infrastructure damage, sanitary risks, and increased poverty and vulnerability in the country.

2.2.1 Increasing Temperatures

The different ecological zones in Yemen have varying temperatures and rainfall patterns. The coastal plain is arid with low rainfall and high temperatures, while the western mountains have a more hospitable climate with higher rainfall. The eastern highlands have a similar climate to the coast, with low rainfall and high temperatures (NUPI & SIPRI, 2023). Within these conditions, Yemen faces the consequences of rising temperatures like the rest of the world: a long-term warming trend has been observed in annual mean surface temperature across Asia, including Yemen, from 1960-2015 and accelerating after the 1970s. This warming trend is in line with global climate patterns and is mainly caused by the increased release of greenhouse gases, leading to heat-trapping within the Earth's atmosphere. Temperatures in Yemen have already increased by 1.8 degrees Celsius over the last 50 years and continue to rise. The mean annual temperature in Yemen is expected to increase by 1.2-3.3 degrees Celsius by 2060, leading to large-scale changes in the country's climate with irregular patterns of rain (NUPI & SIPRI, 2023). Projections show that the warming trend is likely to continue in the future, with more frequent and intense heat events by the end of the 21st century.

For example, one effect of this temperature rise is the occurrence of **heatwaves, which pose significant risks to public health, agriculture, and water resources in various regions of Yemen**. The country has a high-risk extreme heat hazard, which refers to the fact that, based on current trends, it is anticipated that there will be at least one occurrence of heat stress within the next five years due to prolonged exposure to extreme heat (ThinkHazard, 2023c). In terms of considerations for population health and governance, increased temperature extremes for extended periods can result in increased morbidity and mortality and necessitate the promotion of cooling strategies in building design and construction – a consideration that remains under addressed in the Yemeni context (GSC, 2022). Additionally, the adoption of cooling measures will be challenging given that approximately 25% of Yemen's total population does not have access to electricity (CIA, 2023).

Rising temperatures also aggravate water scarcity by accelerating evaporation rates and adding strain to already depleted water resources due to over-extraction of groundwater and reduced rainfall. These dynamics contribute substantively to a general drying trend in Yemen that is also linked to reduced precipitation. Furthermore, increased evaporation rates of water threaten the operation and utility of hydropower facilities. As a result, the water levels in the country's basins have significantly declined, leading to the drying up of numerous wells (FAO, 2023b).

Rising temperatures and erratic water availability in Yemen have also led to the drying up of wells, affecting livestock production. The agricultural sector, important for food security, is also negatively impacted, experiencing changes in growing seasons, reduced crop yields, and increased vulnerability to pests and diseases.

Separately, rising temperatures combine with floods to threaten Yemen's wetlands, saltwater wetlands, and biodiversity. Higher sea temperatures also combine with the rising sea levels, further degrading the coastal and marine environment, including coral bleaching and the disappearance of fish species (GSC, 2022).

2.2.2 Salinization

Salinization refers to the increasing levels of salt in groundwater, particularly in coastal areas where aquifers are becoming increasingly saline. This phenomenon has negative consequences, particularly for the poorest populations who will struggle to afford access to clean water. In Yemen, **groundwater salinity is increasing along the coast due to farmers' overreliance on inefficient water management methods** such as flood and furrow irrigation (Gwinner, 2021). In Wadi Hadhramaut, increased salinity levels in the principal aquifer system occur due to downward leakage from abstraction, leading to the abandonment of water wells. Farmers in the Abyan Delta areas are observing a growing issue of soil salinity caused by the intrusion of saltwater and the utilization of irrigation water with high salt content (i.e., 25% of the farms in Abyan Delta reported moderate to high soil salinity). When irrigation with high salinity water occurs, this causes the formation of salt crusts on the topsoil. Additionally, increasing salinization is likely to become a problem for farmers in the coastal plain of Wadi Hassan (Acacia Water, 2021).

Desalinating water to address Yemen's water crisis is a proposed solution, but it is costly and could increase dependence on fossil fuels. It also poses environmental and health risks due to the discharge of brine and the use of chemicals. The country had two desalination stations – one in Aden (Al-Haswah Electricity Station), and one in Al-Mokha – though the latter was reported destroyed by an airstrike in 2016 and it is unknown whether it has been restored (Clifford & Triebert, 2016).

2.2.3 Coastal Erosion

In tandem with salinization concerns, **saltwater intrusion into freshwater aquifers due to coastal erosion poses contamination risks for drinking water and agriculture**, further jeopardizing access to clean water and the viability of coastal agriculture. In this and other ways, coastal erosion is a critical issue in Yemen, leading to the gradual loss of valuable land along the extensive coastline. This has dire consequences for communities living along the coast, threatening their livelihoods and displacing people. Vulnerable groups, such as fishermen and those reliant on coastal agriculture, are particularly affected and face constant risks from encroaching seas (Bahakim, 2022). The erosion also damages critical infrastructure, disrupts transportation networks, and hampers economic activities and trade, hindering the country's overall development. All but one of the country's coastal governorates rank as high-risk areas for coastal flooding (with the one exception, Hajjah, having a medium-risk ranking) (ThinkHazard, 2023a).

2.2.4 Sea-level Rise

Rising sea levels and more **frequent storm surges render Yemen particularly vulnerable to coastal destruction** (GSC, 2022). Estimates suggest that the governorate of Aden will experience sea-level rise, the consequences of which will be flooding of key infrastructures – e.g., hospitals, schools, and mosques – as well as the airport, which is surrounded by water on both sides (al Saafani et al., 2015). Sea-level rise, coupled with Yemen's acute water shortage along the coast of Aden, additionally **creates risks for water intrusion and salinization of aquifers**, which will further threaten water quality and drinkability in the country (Mustun, 2022). Furthermore, the anticipated increase in storm surge intensity could lead to higher death rates among fish species that are in high demand commercially, thereby decreasing the fisheries industry's contribution of 2.4 percent to the GDP and posing a greater risk to approximately 80,000 reliant fishermen (Bahakim, 2022).

2.2.5 Drought and Desertification

Yemen is prone to drought, and the problem of desertification in current agricultural areas, which currently impacts 3-5% of land each year, will likely continue or worsen (Lackner & al Eryani, 2020). Frequently, heavy rainfall is followed by extended periods of dryness, which often lead to widespread drought, desertification, and degradation of land. These dry periods may be further lengthened by climate change and worsened by weak water and natural resource governance systems, leading to the **degradation of groundwater resources and increased vulnerability to drought**. The period between January and June 2022 was the third driest period in Yemen in nearly 40 years, leading to crop loss and reduced availability of forage for livestock. Heavy rainfall later caused floods in several areas, affecting over 300,000 people by the end of August 2022 (NUPI & SIPRI, 2023).

Variability in rainfall patterns may also result in prolonged drought periods. Drought in Yemen is a critical and recurring environmental crisis that exacerbates the already dire humanitarian situation in the country. Yemen's susceptibility is primarily driven by its arid climate, erratic rainfall patterns, and unsustainable water resource management practices (Anticipatory Action in the MENA Region, 2022; Price, 2022). **Prolonged droughts have severely impacted agriculture**, which is a major source of livelihood for the population, **leading to food insecurity and economic instability** (FAO et al., 2021). Livestock production has also seen negative effects from rising temperatures and erratic water availability, impacting reproduction, health, forage, and water quantity and quality (Price, 2022; UNY, 2022). Furthermore, the unregulated drilling of tube wells since the 1970s has resulted in overdrawing groundwater and deepened the national water crisis in one of the most water-scarce countries in the world (Varisco, 2019).

Increased desertification in Yemen has resulted from the scarcity of monsoon rains, droughts, erosion caused by flash floods, and other factors. Desertification leads to the degradation of agricultural land, including soil erosion, sand encroachment, and deterioration of soil fertility, and exacerbates the humanitarian crisis, armed conflict, and economic collapse in the country. In Yemen, this has led to the loss of vast areas of cultivable land, leaving only a small percentage of arable land available. A study prepared by the Yemeni government and the UN has warned that climate change will increase desertification in Yemen to 86% of the country's total area (al Awsat, 2022). According to the General Directorate of Forestry and Desertification, desertification poses a threat to nearly 97% of agricultural land in Yemen, affecting approximately 90 percent of the country's farming area (Thamer et al., 2023).

2.2.6 Deforestation

The effects of climate change and environmental degradation have substantively accelerated deforestation in Yemen, exacerbating existing challenges and contributing to the country's humanitarian crisis. The impacts of deforestation include a decrease in available agricultural and pastureland over the course of many years. **Among the primary drivers of deforestation are fuel shortages**, which result in a broader turn to the use of wood to cook and logging as a source of work (Aljazeera, 2021). Furthermore, Yemen lacks a legal framework regulating forest land and forest resources, amplifying the negative impacts of unchecked activity in this domain. Additionally, trees and shrubs often perish due to drought conditions (Lackner & al Eryani, 2020).

2.2.7 Changing Rainfall Patterns

The rainy season in Yemen spans from March to October, with the southern uplands (Ibb, Al Bayda, Ad Dali, and Lahj) receiving the highest average rainfall of 561 mm annually. The central highlands (Amran, Sana'a, Dhamar, and the western parts of Saada, Hajjah, Al Mahwit, and Marib) experience the most precipitation between March to May and July to August (ACAPS, 2020). **However, climate change has disrupted the typical rainfall pattern, leading to intense rainfall in short periods of time and exceeding the soil's**

ability to absorb water, resulting in floods (Al-Aizari et al., 2022)satellite images, remote sensing data, essential geographic data, and various data sources and used as input data into four machine learning (ML. Rain-fed agriculture is the most common farming system in Yemen, practiced on more than half of all arable land. And though precipitation benefits this approach, the intense precipitation events in the summer months often lead to soil erosion and flooding resulting in massive displacement, crop destruction, and loss of human life (FloodList, 2023). Furthermore, these rainfall patterns have led to the proliferation of locusts through sudden increases in vegetation and plant growth and moisture retention, which destroys crops and pastoral lands (Lackner, 2020)2020.

2.2.8 Pollution and Solid Waste

Pollution in Yemen poses significant concerns for both the environment and public health. The primary issues include water pollution from untreated sewage, industrial discharges, and agricultural runoff, leading to a lack of safe drinking water and increased waterborne diseases. In Yemen, the quantity of municipal solid waste per capita is high, particularly in urban areas, contributing to the challenges of management and disposal. Issues in Yemen's waste management systems are also tied to the scale of the conflict and humanitarian crisis in the country, with local authorities facing damaged equipment and a reduced capacity to provide essential services due to financial constraints. Addressing the widespread absence of comprehensive solid and liquid waste management is imperative as an integral component of recovery and rehabilitation plans across various governorates. The predominant method of waste disposal in Yemen is landfilling, which raises long-term issues such as leachate pollution, greenhouse gas emissions, odor problems, and health risks for nearby communities (Al-Dailami et al., 2022)urbanization, economic progress, and changing lifestyles all contributed to an increase in resource consumption and waste generation. Global solid waste generation was about 1.3 BT/year and was predicted to further increase to a tremendous amount of 2.2 BT/year by 2030. Municipal solid waste generation is increasing at a high rate, creating immense pressure on municipalities and pollution concerns for the environment. In Yemen, the quantity of municipal solid waste per capita in urban areas is 0.6 kg/day, while in rural areas it is 0.35 kg/day and the increase in the generation of Municipal solid waste is about 3%. Municipal solid waste is characterized by its diverse nature and therefore requires immediate attention for its effective management and disposal. Like most developing countries, the solid waste generated in Yemen is disposed into the landfills due to its simplicity and economical aspects while composting and incineration are rarely utilized. The disposal of waste at landfills is associated with long-term problems, such as leachate pollution, the release of greenhouse gases (GHGs. **Air pollution from solid waste burning, diesel generators, inappropriate pesticide application, hydrocarbon extraction inland, and industrial emissions cause respiratory problems**, especially in densely populated cities (FAO et al., 2021; Lackner & al Eryani, 2020). In addition to the public health impacts, these pollutants have significant economic consequences such as reduced agricultural productivity and increased healthcare costs. The high generation of solid waste, including plastic bags, in Yemen poses severe environmental issues, harming marine animals and birds. Hospital waste also contributes to the overall waste generation in the country.

Pollution, particularly in the governorate of Aden, has posed substantial challenges. Despite being a major transportation hub with numerous ports, Aden faces issues such as **ship sewage discharge and waste disposal**, which accompany the financial benefits of port activities. The region has witnessed several oil tanker disasters, with the most prominent being the sinking of an abandoned oil tanker in the summer of 2021, resulting in a significant oil slick along the southern coast. Additionally, waste from electricity plants is regularly discharged into the sea, negatively impacting the natural environment and marine life. Contaminated fish from these waters have far-reaching consequences, affecting food security, public health, and the country's economy, given the importance of the fishing industry for both domestic consumption and exports. Unfortunately, much of this pollution remains unnoticed, as fishermen are often unaware of invisible contamination, such as heavy metals, and consumers prioritize price over the purity of fish (Al-Dailami et al., 2022)urbanization, economic

progress, and changing lifestyles all contributed to an increase in resource consumption and waste generation. Global solid waste generation was about 1.3 BT/year and was predicted to further increase to a tremendous amount of 2.2 BT/year by 2030. Municipal solid waste generation is increasing at a high rate, creating immense pressure on municipalities and pollution concerns for the environment. In Yemen, the quantity of municipal solid waste per capita in urban areas is 0.6 kg/day, while in rural areas it is 0.35 kg/day and the increase in the generation of Municipal solid waste is about 3%. Municipal solid waste is characterized by its diverse nature and therefore requires immediate attention for its effective management and disposal. Like most developing countries, the solid waste generated in Yemen is disposed into the landfills due to its simplicity and economical aspects while composting and incineration are rarely utilized. The disposal of waste at landfills is associated with long-term problems, such as leachate pollution, the release of greenhouse gases (GHGs.

2.2.9 Land Degradation

Land degradation and environmental conditions in Yemen are closely linked, with climate change exacerbating the existing economic under-development in the country. **The reduction in the size of agricultural land due to environmental problems is particularly concerning** as it affects Yemen's most vital source of work and income. Land degradation, erosion, and flooding in the agriculture and fisheries sector, which contribute significantly to the country's GDP and food requirements, further compound the issue. Land degradation weakens the land's ability to support vegetation and retain moisture. This, in turn, heightens susceptibility to erosion and reduced fertility, paving the way for desertification as the land transitions towards more arid conditions(Bowyer et al., 2008).

Furthermore, the cultivation of qat, a crop that is highly water-intensive, has increased in Yemen due to its profitability compared to other crops and caused significant land degradation, particularly in the highlands of the country, and left farmers vulnerable to the effects of climate change (FAO et al., 2021). The widespread cultivation of the water-intensive narcotic consumes almost half of underground water sources in the country (Acacia Water, 2021). In addition, **the water crisis in Yemen has severe consequences, including decreased agricultural productivity, reduced food security, increased conflict over resources, accelerated land degradation, and heightened vulnerability for livelihoods**. These factors combined with the abovementioned sudden- and slow-onset processes are projected to increase instances of land degradation, posing additional threats to crop production (Price, 2022).

2.2.10 Loss of Biodiversity

Yemen has been grappling with **significant challenges regarding the loss of biodiversity**. Its susceptibility to climate change, including rising temperatures, changing precipitation patterns, and more frequent extreme weather events, threatens the survival of many species. For example, Yemen's wetlands, including the saltwater wetlands, face heavy threats from floods and rising temperatures, as well as from livestock, agricultural production, waste disposal, tourism, and port activities (Al-Mahfadi & Dakki, 2019). Separately, the Socotra archipelago, a unique ecosystem in Yemen, is also suffering from the impacts of climate change, soil erosion, increased aridity, and cyclones. Consequently, the endemic Dragon Blood Tree teeters on the brink of extinction (Saraf, 2021).

Habitat destruction, primarily driven by deforestation, land degradation, and habitat fragmentation stemming from activities like agricultural expansion, infrastructure development, and uncontrolled logging, has also played a critical role in the loss of biodiversity (FAO et al., 2021). The **overexploitation of natural resources such as timber, marine resources, and non-renewable resources like oil, alongside unregulated fishing practices and wildlife hunting for trade and consumption, has further contributed to the decline of various species** (UNEP, 2023).

The **misuse of pesticides by farmers** – often used randomly and without consultation with specialists - results in the death of animals and bees, community health problems such as poisoning and cancer, and pollution of pastures, food, fodder, soil, and water resources. Furthermore, pests in Yemen are gaining immunity against pesticides, making them harder to control. In the aggregate, the **lack of conservation measures** resulting from political instability and limited resources, as well as the rampant **illegal wildlife trade**, which uses Yemen as a transit and destination point for trafficking endangered species and their products, pose significant threats to vulnerable species (FAO et al., 2021).

2.2.11 Declining Soil Fertility

The national soil map of Yemen, compiled in 2006, categorizes soil types into groups such as dry soil, dry sedimentary soil, limestone soil, and shallow calcareous soil. Several factors have contributed to the loss of soil fertility in Yemen, including topography, soil type, waste management practices, and climate change. Climate change processes such as desertification and changing rainfall patterns have particularly impacted soil fertility in the Hadramawt governorate (Zabara & Zumbrägel, 2022).

Soil fertility also relates to flooding potential. The variables with the highest importance in flood susceptibility modeling are slope, drainage density, elevation, and soil. Declining soil fertility can affect water infiltration and increase the risk of flooding (Al-Aizari et al., 2022)satellite images, remote sensing data, essential geographic data, and various data sources and used as input data into four machine learning (ML. **Flash floods, unplanned urbanization, and damaging agro-industry practices combine to significantly degrade soil quality**. Thus, declining soil fertility and flooding create a negatively reinforcing loop: as each condition worsens, it accelerates the deterioration of the other. Relatedly, water scarcity also plays a significant role in Yemen's soil fertility: excessive groundwater extraction for irrigation purposes, often without proper management, can cause the intrusion of saltwater into freshwater aquifers. This intrusion leads to the salinization of soils, further reducing their fertility (Broussard, 2020)desertification and subsequently food insecurity.","container-title":"International Atomic Energy Agency (IAEA.

Several factors have contributed to the loss of soil fertility in Yemen, including **overgrazing of livestock and improper solid waste management** – e.g., burning plastic waste and accumulation of waste (Al-Dailami et al., 2022)urbanization, economic progress, and changing lifestyles all contributed to an increase in resource consumption and waste generation. Global solid waste generation was about 1.3 BT/year and was predicted to further increase to a tremendous amount of 2.2 BT/year by 2030. Municipal solid waste generation is increasing at a high rate, creating immense pressure on municipalities and pollution concerns for the environment. In Yemen, the quantity of municipal solid waste per capita in urban areas is 0.6 kg/day, while in rural areas it is 0.35 kg/day and the increase in the generation of Municipal solid waste is about 3%. Municipal solid waste is characterized by its diverse nature and therefore requires immediate attention for its effective management and disposal. Like most developing countries, the solid waste generated in Yemen is disposed into the landfills due to its simplicity and economical aspects while composting and incineration are rarely utilized. The disposal of waste at landfills is associated with long-term problems, such as leachate pollution, the release of greenhouse gases (GHGs. Another contributing factor is **deforestation**. The clearance of forests and vegetation for agriculture and other purposes has resulted in soil erosion and decreased soil fertility. Trees and vegetation play a crucial role in protecting the soil from erosion and maintaining its organic matter content. Additionally, the ongoing conflict in Yemen has further exacerbated the loss of soil fertility. By disrupting agricultural activities and displaced communities, making it even more challenging to manage and maintain healthy soils (Zabara & Zumbrägel, 2022). Other climate change-related factors, including increased temperatures and changing precipitation patterns, also worsen soil fertility issues in Yemen. These climate impacts affect the availability of water and nutrients for crops, further jeopardizing soil health, threatening agricultural productivity and exacerbating food insecurity and poverty (Price, 2022).

A major contributor to loss of soil fertility is **the overuse of chemical fertilizers without proper soil testing and nutrient management** (FAO et al., 2021). This excessive use has caused nutrient imbalances, ultimately affecting crop yields and overall soil health over time. For example, a United Nations Development Programme (UNDP)-led study found that farmers engage in random use of pesticides without consulting specialists, often combining multiple types of pesticides without considering the potential risks to soil and plant health (FAO et al., 2021). Furthermore, there is a prevalent lack of awareness concerning the dangers of excessive pesticide usage, including the utilization of expired and illicitly obtained pesticides. The farm's inadequate storage of these harmful substances and the failure to follow proper instructions for their use only exacerbate the issue. The same study found that farmers apply pesticides with little concern for personal protective equipment, even in the presence of children and pregnant women. They frequently mix pesticides with their bare hands and combine different varieties, leading to detrimental consequences for soil fertility as these chemicals accumulate within it. The repercussions of pesticide usage extend beyond the farms and impact neighboring communities, polluting pastures, food, fodder, soil, and water resources while also causing the death of animals and bees. **Other traditional and unsustainable farming practices, such as shifting cultivation and the lack of crop rotation, which deplete soil nutrients and lead to a decline in fertility, have contributed to soil degradation**. These practices deplete soil nutrients and lead to a decline in fertility. Furthermore, much of the topsoil in Yemen is considered of poor quality due to the presence of salts from agricultural fertilizers (GSC, 2022).

3.0 VULNERABILITY MAPPING

3.1 Geography

Multiple aspects of Yemen's unique geographical features give rise to vulnerabilities to climate change and environmental degradation. The country's extreme aridity, with over 80% of its land classified as desert, exacerbates its water scarcity. Its population relies heavily on underground aquifers for its freshwater supply, but over-extraction and unsustainable practices have led to their rapid depletion. The limited surface water sources make the country particularly vulnerable to droughts and water shortages. Additionally, Yemen's mountainous terrain poses challenges for transportation and infrastructure development, while deforestation and soil erosion worsen the impacts of climate-related events (Acacia Water, 2021; FAO et al., 2021).

The long coastline along the Red Sea and Arabian Sea faces threats from rising sea levels and increased storm intensity, impacting coastal communities' livelihoods and agriculture. The country's geographical location in the Arabian Peninsula exposes it to regional climate patterns, leading to irregular and unpredictable weather events. Furthermore, the lack of adaptation infrastructure, compounded by the ongoing conflict, hampers Yemen's ability to effectively respond to climate-related disasters.

3.2 Livelihoods

The **protracted conflict** and climate extremes have severely impacted households' resilience and livelihoods, pushing families to exhaust coping strategies to meet basic needs. The **conflict has disrupted the labor market and economic opportunities**, leading to high unemployment rates and severe poverty, eroding the livelihoods of many Yemenis. Industries have collapsed, resulting in severe unemployment, and disrupting public services, including access to essential staples like food and water, to the verge of collapse due to conflict and inflation, further exacerbating the precariousness of livelihoods (FAO, 2023b). **Conflict-induced displacement** has forced people from their agricultural lands, depriving them of their primary source of livelihood. Displaced populations, including women and children, often endure vulnerability to recruitment by armed groups as they search for alternative means to sustain themselves and their families. Even if individuals or households manage to escape conflict zones or displacement, they often lack the necessary income, funds, or alternative income-generation options to rebuild their livelihoods, perpetuating poverty (ACAPS, 2023b).

In 2022, progress towards achieving SDG 2 (Zero hunger) in Yemen remained fragile due to the ongoing conflict and its impact on lives and livelihoods. Around 17 million people faced acute hunger, while over 23 million people needed some form of humanitarian assistance. Funding shortfalls led to reductions and suspensions of WFP activities, including general food assistance, resilience and livelihoods programs, and nutrition interventions (WFP, 2022). A household survey, although not fully representative due to its limited sample size and geographic scope, revealed that only 38% of respondents reported being employed, with 20% employed by someone else and 18% engaged in farming or self-employment. Unemployment accounted for 15% of the total respondents, while 43% identified themselves as housewives, representing 77% of all female respondents. Moreover, the survey highlighted that in 69% of households (with an average size of six members), only one member received an income, and merely 18% had two members earning income. Among those households where no one received an income (9% of the total), 86% relied on humanitarian assistance. Additionally, the survey indicated that in 65% of households, it was the male head who earned income, and this same individual made decisions regarding household spending for 67% of the respondents (OCHA, 2022).

Environmental degradation further compounds the challenges faced by Yemeni livelihoods. Critical resources are scarce, freshwater scarcity is prevalent, and farmland and water sources are contaminated with landmines, significantly reducing the capacity for local food production and access to suitable land and water resources. The impacts of seasonal flooding, exacerbated by climate change, further heighten the vulnerability of affected families by causing the loss of assets, shelter, and livelihoods, as well as the death of economically active household members.

Moreover, **insecure tenure arrangements, including the risk of forced eviction and lack of formal land occupancy agreements, represent other forms of insecurity**, making it difficult to invest in sustainable agriculture or other income-generating activities. These cycles have left the population struggling to secure their livelihoods, with women and vulnerable populations facing additional gender-based barriers and insecurity (ACAPS, 2023b; Camacho et al., 2018; FAO et al., 2021; OCHA, 2022).

3.3 Internal Migration and Displacement Dynamics Due to Environmental Factors

As **internal migration continues to rise**, it has led to **a complex situation in Yemen's villages**, where cohabiting tribes with divergent economic interests vie for access to increasingly scarce water resources. This situation has heightened the potential for disputes and conflicts, with historical resentments and ancient feuds being reignited. Water-related disputes are often intertwined with land disputes, creating a volatile backdrop for conflicts to emerge, especially when combined with other underlying grievances (Acacia Water, 2021). This dynamic underscores the intricate relationship between migration, housing, resource scarcity, and the potential for conflict in Yemen's urban and rural areas.

Since 2008, the protracted conflict in Yemen has **displaced approximately 4.5 million people (14% of the population),** placing immense strain on already limited resources (IDMC, 2023). Historical tensions over resources, particularly water and land, have fueled conflicts for generations and continue to be significant drivers of unrest. The displacement crisis exacerbates these drivers, leading to heightened competition for critical resources, loss of livelihoods, and increased recruitment opportunities for armed groups. Internally displaced families endure substandard living conditions due to restricted access to essential services like clean water, sanitation, education, and healthcare (IAHE, 2022).

These dire circumstances are **exacerbated by the ongoing climate crisis**, which is forcing more families to abandon their homes. While there was a decrease in conflict-related displacement in 2022, displacement triggered by disasters related to weather-related hazards increased. Weather related hazards, such as floods and heavy rains, disproportionately affect poor people, especially IDPs and small-scale farmers. Environmental pollution compounds the already dire hygiene and sanitation situation for IDPs, while inadequate infrastructure leaves their shelters and food stocks vulnerable to flooding. Furthermore, these individuals are often experiencing secondary displacement following previous instances tied to the ongoing conflict. However, the lack of reliable monitoring systems made it challenging to track displacements associated with drought and other extreme weather events (IAHE, 2022; OCHA, 2022).

Furthermore, environmental degradation and the impacts of climate change have introduced a new layer of problems, including water contamination and the accumulation of garbage. These **environmental issues disproportionately affect vulnerable populations**, including IDPs. For example, Ta'iz faces environmental challenges related to waste management, pollution, and water scarcity, exacerbated by an increasing number of IDPs residing in the governorate. Coastal regions like Aden face specific environmental issues, including sewage pollution, uncontrolled sewage discharge into the sea, and threats posed by sea level rise. These issues

significantly impact public health, particularly in IDP camps and slums (al-Akwa & Zumbragel, 2021). The compounding effects of conflict, displacement, and environmental stressors intensify the struggles faced by these marginalized communities.

3.4 Intersection with Conflicts and Fragility

The conflict in Yemen, which has been ongoing since 2015, has exacerbated existing environmental stress, leading to potential conflicts over vital resources such as water, arable land, and biomass. The conflict primarily involves forces affiliated with Ansar Allah ("Houthis") and the Government of Yemen, supported by a coalition led by Saudi Arabia. However, there have also been clashes between the Government of Yemen and the Southern Transitional Council, as well as attacks by Al Qaida in the Arabian Peninsula (AQAP) and Islamic State of Iraq and the Levant (ISIL). An initially promising UN-mediated truce expired in October 2022, and renewed fighting in March 2023 resulted in at least 16 casualties (IAHE, 2020).

Existing traditional informal dispute resolution mechanisms have been degraded by armed conflict and marginalization and have thus proven insufficient to address the problem. Furthermore, politicization, obstructions, restrictions, and interference with humanitarian aid by the parties to the conflict have made it extremely challenging to provide assistance to those in need. Together with the existing economic crisis and the COVID-19 pandemic, Yemen's internal conflict has also erected significant **hurdles for data collection** efforts in these domains (ACAPS, 2023b).

Yemen's multifaceted crisis - in which the conflict is heavily implicated - has resulted in acute food insecurity, and economic collapse. Over 80% of the population needs assistance and protection. Despite a slight decrease in the number of people requiring assistance and protection in 2023, estimated at 21.6 million, the situation remains dire. **Traditional issues related to armed conflict, such as the identification and safe removal of ERW, are compounded in severity by the effects of slow and sudden-onset climate-related events**. For example, risks associated with ERW are further intensified during the rainy season, as heavy rains and flooding can displace devices and wash away warning signs, posing a threat to the safety of the population. The risks are particularly high in areas recently affected by the conflict, hindering the safe return of internally displaced people to their homes (ACAPS, 2023b; OCHA, 2022).

Efforts to address climate change and environmental degradation are crucial in promoting stability and preventing future conflicts over resources in Yemen. However, **the severe effects of climate change**, including droughts, flooding, and rising sea levels, have further exacerbated the security situation. Furthermore, soil fertility degradation, soil erosion, desertification, and unequal access to water resources have led to conflicts over land and water. Different governorates in Yemen face varying environmental threats, including waste management and garbage pollution, soil pollution, maritime pollution, and soil destruction driven by climate change and human-caused pollution. These environmental threats have a high potential for violence, as the fight over resources is a crucial driver of conflict behavior (UNY, 2022; WFP, 2022).

In turn, **the ongoing armed conflict continues to accelerate environmental degradation**, including the destruction of water sources and infrastructure worsening resource shortages caused by climate change. Violent actions have hindered conservation efforts by disrupting environmental laws, halting environmental projects, and depleting the resources of environmental institutions. They have also resulted in pollution from military equipment, destroyed habitats, and displaced local communities (FAO et al., 2021; GSC, 2022; UNDP, 2022).

Importantly, vulnerability to the impacts of climate change and environmental degradation are not exclusively tied to a single conflict at the national level. Historical and ongoing conflicts at the local levels over resources, particularly water and land, are major sources of tension. Contributing factors to the persistence of these localized escalations include land ownership disputes, weak rule of law institutions, and gender inequality. In general, the conflict has led to an increase in land disputes and inheritance issues, which in turn has created tensions and potential new displacements. An increase in land-grabbing incidents has posed serious challenges to ordering migration flows as a result (ACAPS, 2023b). Local authorities have limited capacity to address these disputes, and tribal influence over land-related decision-making can escalate into violent conflict. These are particularly acute in contested areas, such as Marib and the south (Acacia Water, 2021; CIVIC, 2022; IAHE, 2022).

Furthermore, the **decline in agricultural production** is a direct consequence of farmers being forced to take sides in the conflict, with implications for the ownership and productive use of land (FAO et al., 2021; ICRC, 2021). The ongoing war has severely impacted Yemen's agriculture and fisheries sectors, two significant contributors to the country's GDP and food supply, as well as major employers. The decline in these sectors has further intensified land disputes and competition for dwindling water resources as different tribes with diverging economic interests vie for access. The lands that remain productive are also tied to Yemen's conflict and fragility dynamics as they intersect with environmental and climate change concerns. For example, the cultivation of water-intensive crops like fruits, vegetables, and qat, as well as the connection between qat cultivation and political and economic patronage networks, **contribute to the conflict economy** in Yemen while simultaneously posing distinct threats to the country's water supply (NUPI & SIPRI, 2023).

Access to water foregrounds as a critical factor in mapping the vulnerability of Yemenis at the intersection of armed conflict, climate change, and environmental degradation. Water scarcity is already a pressing issue, but the conflict makes it more challenging for humanitarian organizations to provide aid and support to vulnerable communities. Moreover, water is being used as a weapon of war in Yemen, disrupting supply chains and leading to brain drain as people flee areas with limited water access. The risk of running out of potable water and conflicts over water disputes further threaten Yemen, as climate change-fueled drought and water scarcity increase the likelihood of more conflict (ACAPS, 2023a, 2023b; Suter, 2018; Zabara & Zumbrägel, 2022).

The **intercommunal conflicts** over water and land that have emerged have become increasingly deadly, worsened by the civil war. Disputes related to water account for 70-80% of rural conflicts and result in a large number of deaths annually and can range from local disputes between individuals to larger-scale conflicts between tribes or villages (Acacia Water, 2021). For example, the Abyan Governorate, particularly the Khanfar district, has been deeply affected by the conflict, resulting in displacement, destruction, and loss of livelihoods. The floods of 1982 damaged irrigation infrastructure and delayed repair efforts, while ongoing conflicts have hindered the rehabilitation of the irrigation system. The Abyan Delta region has a history of water distribution conflicts between powerful regional tribes, and the absence of a strong national government has made resolving these conflicts challenging.

Conflict actions have also heavily affected water and sanitation services. For example, the water systems in Al Hodeidah Governorate and Marib city have been heavily affected by the conflict, with multiple incidents damaging water facilities, resulting in water shortages and increased prices for water trucking services (Acacia Water, 2021; ACAPS, 2023c; WFP, 2022). Furthermore, the conflict has impacted water resources management, leading to a need for external support for recovery, as **traditional rules and laws do not address conflicts of interest between agricultural and urban water use** (ACAPS, 2023b; FAO et al., 2021; UNDP, 2022). Local water authorities would greatly benefit from capacity building in order to provide water to both host and IDP communities, allowing them to move away from the costly and unsustainable practice of water trucking. Rising fuel prices and competition over biomass have only heightened the crisis (ACAPS, 2023c; OCHA, 2022; Tarnas et al., 2023). Taken together, these dynamics and conditions converge to perpetuate the country's contemporary cycles of violence and further exacerbate the country's socio-economic and environmental challenges.

Yemen's conflict has also had a profound impact on **gender dynamics** in the country. It has **deepened gender inequalities and discrimination against women and girls**. They encounter heightened barriers to accessing education, employment, and political participation, further marginalizing them in an already challenging environment. Gender-based violence, including sexual assault, domestic violence, and child marriage, has increased significantly during the conflict. Unfortunately, the COVID-19 pandemic has further limited access to support services for survivors of gender-based violence. Women in Yemen are often underrepresented in formal employment while being overrepresented in informal and low-wage work sectors. Traditional social norms and stigmas surrounding women working outside the home persist, affecting not only Yemeni women but also refugee women and marginalized groups. Paradoxically, the conflict has also led to shifts in gender roles, with women assuming more responsibilities in humanitarian and peace-building initiatives, as well as taking on paid and subsistence labor. Their presence in conflicts can sometimes contribute to violence mitigation, as combatants are less likely to use violence in the presence of women (ACAPS, 2023a, 2023c, 2023b; FAO et al., 2021; IOM, 2022b; UNHCR, 2023a). These shifts reflect the adaptability of women in the face of adversity but also underscore the need for gender-sensitive approaches to support their changing roles.

3.5 Cross-Border Movements

The interplay between the conflict, economic and public service collapses, the pandemic, and environmental issues has had significant consequences for cross-border movements in Yemen. Climate change and environmental degradation have exacerbated resource scarcity, contributing to the overall humanitarian crisis. The challenges related to resource access, particularly **water scarcity and limited livelihood opportunities**, are particularly acute for refugees and asylum seekers in Yemen. Many of them reside in camps without sufficient water sources, relying on costly water deliveries or alternative, often unsafe, sources. Surrounding communities additionally grow increasingly dependent on external assistance (CIVIC, 2022; IHD, 2023). Tensions with host communities further exacerbate the challenges, with IDPs and refugees often bearing the blame for resource strains and rising rent prices (OCHA, 2022).

This situation is exacerbated by the loss of livelihoods, especially for those displaced from rural areas who depend on farming for their income. Social tensions with host communities can further strain resource access. Climate change compounds these issues by displacing more people, making resource access even more challenging and increasing the risk of repeated displacement due to extreme weather events.

The **widespread use of landmines** in Yemen, particularly around water sources, poses a severe threat to civilians and disrupts access to vital resources like water. Landmines have destroyed water pipelines, leading to disruptions in water supply in certain areas. The ongoing conflict in Yemen has significantly worsened the availability and accessibility of water resources, further exacerbating the already dire humanitarian crisis (ACAPS, 2023b; CIVIC, 2022; OCHA, 2022). Thus, climate-related factors are not only driving displacement but also intensifying vulnerabilities for those who have been forcibly uprooted.

3.6 Gender Implications

The protracted conflict in Yemen has amplified the adverse effects of climate change, with women bearing a disproportionate burden. Women are differentially by conflicts over land and resources, climate-induced displacement, and gender-based violence. While the Women, Peace, and Security (WPS) Agenda has spurred support for Women's Rights Organizations (WROs) in peace processes, the intersection of gender and climate advocacy remains underemphasized in Yemen (DCAF, 2022).

Climate change exacerbates resource disputes, intensifying **protection risks, early marriage, and gender-based violence**, which disproportionately impact vulnerable groups such as women, IDPs, refugees, and children. Poverty, weak governance, political marginalization, and corruption are pervasive challenges in Yemen. Notably, poverty is more prevalent among women, contributing to their heightened vulnerability. Among displaced populations, 73% are women and girls, especially women of reproductive age and adolescent girls (UNY, 2022). Displaced and refugee women are particularly susceptible to violence and **human trafficking**, underscoring the multiple layers of hardship they face (FAO et al., 2021; IHD, 2023; IOM, 2022b; OCHA, 2022). Additionally, restrictions on their rights, such as male guardian requirements imposed in areas controlled by Ansar Allah, further exacerbate existing structural inequalities (IAHE, 2022).

Environmental degradation and climate change have introduced additional challenges because of issues like water contamination and garbage accumulation. Regrettably, these problems disproportionately affect women. As a result of these and other effects, women's health overall has been differentially impacted by environmental degradation and climate change (DCAF, 2022; Mustun, 2022). For example, it has been shown that these dynamics increase psychopathologies, such as distress and trauma (Cianconi et al., 2020). Rising temperatures can also lead to shorter gestation periods and stillbirths, further endangering women and children in arid regions (Mustun, 2022).

The confluence of climate change and conflict additionally intensifies existing gender-based risks as water becomes both a weapon and a casualty of war. Within this context of **water scarcity and weaponization**, women and girls are particularly affected as they are often tasked with collecting water, putting them at risk of landmines. Additionally, they must increasingly travel longer distances to fetch water, exposing them to sexual abuse and human trafficking (Suter, 2018). Taken together, the above highlights the intersectionality of crises, as climate change compounds existing vulnerabilities and further threatens the security of women in the country.

Simultaneously, women have played pivotal roles as first responders and informal peacemakers by mediating disputes, facilitating the release of detainees, negotiating access to natural resources, and preventing the recruitment of children into armed groups. Despite being excluded from formal negotiations, women, often leveraging Yemeni tribal principles, navigate their position as "du'afa" to engage in mediation efforts, frequently achieving significant success. This includes addressing issues such as the limited water supply in conflict-ridden Taiz, where a female mediator, Ola Al-Aghbari, brought together a committee of local leaders to negotiate civilian access to water tanks, showcasing the crucial role women play in conflict resolution and resource access in Yemen (UN Women, 2022) (UN Women, 2022). Women's successful role in navigating (resource) disputes clearly demonstrates the benefit of encouraging the participation of women in water user associations (WUAs) and other related groups dealing with water resource management and other causes of tension in communities.

3.7 Life-Cycle Implications

Environmental degradation and climate change effects in Yemen have brought about numerous challenges that disproportionately affect children, including **water contamination and garbage accumulation**. In Yemen, these phenomena have led to alarmingly high rates of malnutrition, exacerbated by the declining availability of clean water and food. The **poverty**, displacement, and family separation intensified by these environmental challenges have contributed to alarming rates of child recruitment into armed groups and early marriages. As a result, many children are forced to abandon their education in order to support their families. Children's vulnerability becomes especially evident in the face of **increasing levels of malnutrition. Children with disabilities** are particularly vulnerable, facing physical, communication, information, and attitudinal barriers exacerbated by the conflict (Aisha Thawab & Wafa M. Al Madhagi, n.d.; Michelle Di Benedetto, n.d.).

The education system in Yemen has suffered severe disruptions, with thousands of schools damaged or destroyed since 2015. **The conflict's toll on education is evident in the collapse of the system, irregular or unpaid teacher salaries, and a lack of qualified educators and resources**. Weather-related hazards, such as floods in 2022, have added to the challenges, affecting nearly 1.5 million school-age children. The scale of the problem is staggering, with more than 8.6 million school-aged children needing education assistance in 2023. Additionally, despite efforts to integrate IDP children into nearby schools, irregular attendance and a lack of participation in exams often discourage schools from accepting newly arrived IDP students (IAHE, 2022; UNY, 2022; WFP, 2022).

Armed conflict further compounds the difficulties children face, subjecting them to grave violations and lasting effects. **Attacks on schools, students, and teachers have been rampant, discouraging parents from sending their children to school**. In some cases, schools are occupied by military forces or used for purposes other than education. The conflict has disrupted the education system in other ways, with teachers often going unpaid, schools being damaged or destroyed, and students facing risks of recruitment by armed groups on their way to school. IDP children, in particular, encounter significant barriers to education, compounding the challenges faced by Muhamasheen and disabled children. These dynamics have left Yemeni youth with limited skills for employment, perpetuating poor labor market opportunities (CIVIC, 2022; OCHA, 2022; UNDP, 2022; UNY, 2022).

The conflict has also led to an increase in child trafficking. Yemeni children, mainly boys, have been forced to work in various capacities, including domestic service, begging, and small shops, with some experiencing sex trafficking in Saudi Arabia. Furthermore, girls as young as 15 were reportedly exploited in commercial sex in hotels and clubs in Sana'a, Aden, and Taiz. Child sex tourism was primarily associated with Saudi Arabian men, some of whom used "temporary marriages" authorized by Islamic authorities to sexually exploit Yemeni girls as young as 10 years old (IHD, 2023). Efforts to combat trafficking were hampered by the conflict, which also affected the implementation of a 2014 bill aimed at preventing the recruitment and use of child soldiers. While Yemen's laws prescribe penalties for human trafficking, arrests and convictions remained low, with indications of government officials' complicity in trafficking. In January 2020, an agreement was reached through the UN on a roadmap for implementing an existing action plan to prevent child soldier recruitment and use (IHD, 2023).

The impact of these environmental challenges extends to **labor practices**, as child labor becomes more prevalent, with thousands of children, including those as young as five, involved in unpaid labor. Yemeni legislation attempts to address child labor through various decrees and laws, but discrepancies exist regarding the minimum working age, creating uncertainty in its application. Nevertheless, efforts have been made to combat child labor, including the creation of child protection focal points and the ratification of international labor conventions. However, the ongoing conflict and economic instability continue to pose challenges to effectively addressing the issue (IAHE, 2020, 2022; UNY, 2022; WFP, 2022).

The **impact of these factors on girls** in Yemen is particularly distressing. Their already limited access to education and livelihoods has worsened due to displacement, disrupted livelihoods, and inadequate access to public services. Gender-based violence, including sexual assault, domestic violence, and child marriage, has surged, and the COVID-19 pandemic has further restricted support services for survivors. Furthermore, both women and girls face significant barriers in accessing justice and legal aid, compounding their vulnerability (FAO et al., 2021; IOM, 2022b; OCHA, 2022).

The situation is further complicated by **Yemen's inadequate legal framework**, which exhibits gaps in both norms and implementation and results in a reduction in the protection of children's rights. In the absence of effective accountability mechanisms, these gaps lead to rights violations and increased exposure to protection risks, affecting physical safety, well-being, and access to critical services. Climate change exacerbates the above elaborated problems, making it even more challenging for children to thrive (OCHA, 2022).

Among the segments of society exposed to heightened risks stemming from the adverse health impacts of climate change, **the elderly are notable**. In 2023, an estimated 7.5 million people in Yemen require shelter and NFI assistance, with a breakdown of over 1.8 million women, 1.9 million men, 1.9 million girls, and 1.9 million boys. **This includes approximately 0.6 million elderly individuals and 1.1 million persons with disabilities**. The greatest needs are concentrated in Al Hodeidah, Ta'iz, and Marib governorates (OCHA, 2022).

Older individuals and persons with disabilities additionally grapple with the hardships of stigma and social isolation during displacement (OCHA, 2022). Residents of informal displacement sites encounter notably challenging circumstances concerning WASH. Individuals newly displaced require tailored and immediate WASH support. **Persons with disabilities and the elderly, among others, confront diverse constraints and protection risks when endeavoring to access WASH services**. The compounding effects of these crises leave Yemenis at an elevated risk of necessitating medical assistance. Climate change is additionally projected to amplify the prevalence of vector-borne diseases such as malaria, as well as fuel a surge in heat-related illnesses and waterborne diseases. The elderly, among other vulnerable groups, stand particularly susceptible to the adverse health consequences associated with climate change (Price, 2022).

3.8 The Muhamasheen

The historical context surrounding Yemen's Muhamasheen community illustrates their enduring poverty and caste-based exclusion. Initially derogatorily referred to as "Akhdam," (servants) they later adopted the name "Al-Muhamasheen" (the marginalized) to reclaim their identity. Debate about their ethnic origins adds complexity, whether descended from African slaves, Ethiopian soldiers, or Yemeni roots (Minority Rights Group, 2018). In the 2011 uprising for social change, some Muhamasheen participated, but their representation in the National Dialogue Conference (NDC) was minimal, with just one delegate among 565. Promises of equitable access to housing, services, healthcare, and employment during the NDC remained unfulfilled due to Yemen's subsequent conflict, perpetuating their historical marginalization (Kali Robinson, 2023).

The intensification of Yemen's civil conflict since 2015 has worsened the Muhamasheen's precarious situation, particularly in conflict-affected cities like Aden, Taiz, and Hodeida, where significant Muhamasheen populations reside. Displacement has been especially challenging for them due to discrimination within Yemeni society. They lack access to traditional support networks, making it hard to secure basic services and aid during the humanitarian crisis. Discrimination even extends to aid distribution, with some local leaders denying them assistance. Muhamasheen often reside in makeshift shelters, with young girls coerced into early marriages, and boys forcibly recruited by armed groups, highlighting the vulnerability of Muhamasheen youth (CIVIC, 2022; IAHE, 2020; UNHCR, 2023a).

The challenges faced by the Muhamasheen in accessing HLP rights in Yemen are further compounded. Yemeni property ownership traditions, primarily restricted to men, disproportionately affect them. This situation is particularly dire for displaced Muhamasheen individuals, who encounter increased obstacles in accessing housing and resolving land disputes (ACAPS, 2023b).

4.0 POTENTIAL EFFECTS OF (ENVIRONMENTAL) MIGRATION ON VULNERABILITY

4.1 Environmental Degradation

As populations are forced to migrate due to environmental challenges such as water scarcity, desertification, and soil erosion – exacerbated by climate change – environmental degradation features as an area of increasing concern. Unplanned resettlement and the influx of IDPs into host communities exerts pressure on already fragile ecosystems and strain available resources like arable land, and forests, leading to overexploitation and degradation. As elaborated in the previous sections, water scarcity as a resource concern is paramount in Yemen, driven by climate change-induced droughts and over-extraction of groundwater. Environmental migrants, in search of water sources and arable land, may settle in areas with limited access to water infrastructure.1 This can lead to increased competition for water resources, illegal drilling, and the unsustainable extraction of groundwater. As a result, groundwater levels continue to decline, exacerbating water scarcity and causing long-term damage to aquifers. Additionally, the establishment of new settlements often leads to deforestation as trees are cleared for construction and fuelwood, further intensifying environmental degradation and soil erosion (IRW, 2022; Lackner & al Eryani, 2020; Zabara & Zumbrägel, 2022).

Furthermore, environmental migrants in Yemen often engage in livelihood activities that can harm the environment. For instance, in their struggle to secure food and shelter, some may resort to unsustainable agricultural practices, contributing to soil degradation and reduced agricultural productivity. Others may rely on the unsustainable harvesting of natural resources such as firewood and animal grazing, which can lead to deforestation and accelerate desertification (FAO et al., 2021).

4.2 Health and Human Security

Logistical challenges, supply shortages, and increased fuel prices compromise access to health services in Yemen. The healthcare system itself is under strain, marked by privatization, high medicine costs, and an urban-rural healthcare divide (Lackner & al Eryani, 2020). The conflict and additional drivers of large unplanned migration flows have additionally exacerbated vulnerabilities in healthcare, food security, and WASH sectors – an estimated 15.4 million people are in need of WASH assistance - making the population more susceptible to cholera. As a result of the conflict, only 50% of health facilities remain fully functional, and healthcare worker capacity is severely depleted, making it difficult for people to access safe drinking **water and sanitation services**. This has led to an increase in infectious diseases, malnutrition, and a decline in maternal and child health (OCHA, 2022).

Malnutrition rates are expected to rise, and refugees, asylum seekers, migrants, and displaced people face serious protection risks. **Mental health is also a major concern, particularly for women and girls, given the scarcity of mental healthcare services and the stigma associated with mental illness**. Despite an estimated 7 million people needing mental health treatment, only 120,000 have uninterrupted access to these services (DCAF, 2022). Additionally, conflict-induced civilian casualties, internal displacement, and high

1) "Environmental migrants are persons or groups of persons who, predominantly for reasons of sudden or progressive change in the environment that adversely affects their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad" (IOM, 2007, p. 33).

humanitarian needs have strained the country's resources, while landmines and ERW continue to pose a threat to civilians. Compounding that, climate-induced natural hazards prompt further displacement, deepening issues surrounding fundamental health and human security (ACAPS, 2023b; CIVIC, 2022).

4.3 Food Insecurity

Multiple factors drive Yemen's food insecurity, with approximately 17.3 million people expected to experience high levels of acute food insecurity in 2023: the **fragile economy, currency depreciation, macroeconomic instability, and the de facto separation of economic institutions** (FSIN, 2022; WFP, 2022). Yemen's reliance on imported food makes it vulnerable to global price fluctuations, further exacerbated by the crisis in Ukraine affecting global supply chains. Approximately 70% of the food supply in Yemen consists of imported food commodities, which highlights the country's significant vulnerability to external shocks and global factors. This vulnerability is further complicated by internal conflict, which results in displacement, loss of lives and livelihoods, food supply disruptions, and reduced access to basic services. Climatic shocks, including droughts and floods, worsen food insecurity, while health risks and limited healthcare access compound the problem (ACAPS, 2023c; FAO et al., 2021; HSA Group, 2022).

The primary tool employed in Yemen to assess food insecurity trends is the **Integrated Food Security Phase Classification (IPC),** a collaborative analysis led by the Food Security and Agriculture Cluster (FSAC). A closer examination of the IPC process and its outputs suggests that as of 2021, 45% of Yemen's population faced high levels of acute food insecurity. A November 2022 update to the IPC projection showed that positive mitigating factors, such as WFP's food assistance efforts, helped contain food insecurity and prevent famine. This stabilization resulted from the large-scale provision of food assistance (CIVIC, 2022; FAO, 2023b; WFP, 2022).

Climate change intensifies Yemen's food insecurity by **reducing agricultural productivity, increasing sea levels, leading to climatic variability, and impacting coastal zones**. Water scarcity, exacerbated by climate change and population growth, affects agriculture and living standards (e.g., through the spread of diseases). Furthermore, the country experienced significant climate shocks in 2022 - severe drought followed by flooding - further exacerbating its vulnerability. Yemen's lack of preventive planning and constrained resources make it one of the most vulnerable yet least prepared countries to face the impacts of climate change. The convergence of conflict, climate change, displacement, and food insecurity has placed millions of Yemenis at the brink of starvation, and groups such as displaced people, Muhamasheen, and female-led households, are among the most affected (FAO et al., 2021; IAHE, 2020; Rahman, 2023; UNHCR, 2023a; UNY, 2022; WFP, 2022).

4.4 Urbanization

The lack of affordable housing in Yemen's urban areas has significant implications, particularly for IDPs with limited or no income. Even before the onset of armed conflict in 2014, Yemen's urbanization was rapidly increasing, driven by factors like rising poverty, unemployment, water scarcity, drought, and natural hazards. This **urbanization trend resulted in a substantial shortage of housing, with an estimated 60% of the urban population residing in informal settlements**. For instance, Sana'a witnessed a remarkable population increase from 2.9 million in 2015 to over 7 million in 2021, largely due to internal migration and an influx of IDPs from other regions. Consequently, the demand for services, including housing, has surged significantly (ACAPS, 2023b; FAO et al., 2021; NUPI & SIPRI, 2023; Rahman, 2023).

As rural conditions deteriorate, rural-to-urban migration has increased, placing additional strain on resources in host communities. **The ongoing urbanization is a defining feature of Yemen's urban landscape**, especially for urban centers like Sana'a. **Several factors drive this migration, including increased poverty in rural regions, the absence of employment opportunities, and climate-related challenges such as water scarcity, droughts, and natural disasters**. As a result, urban areas have become a magnet for individuals seeking better economic prospects and improved living conditions, further exacerbating the housing shortage and affordability issues (Acacia Water, 2021; Aziz Ali Nasser, 2010; FAO et al., 2021; GSC, 2022; Mustun, 2022; Zabara & Zumbrägel, 2022).

Unfortunately, population growth, urbanization, and conflict-related displacements put immense pressure on existing water supply networks. Urbanization, especially in cities like Sanaa, Aden, Mukalla, and Taiz, has led to an increasing deficit between water demand and availability. This overexploitation of groundwater has caused a continuous drop in the water table, making water more expensive and less accessible to urban residents. In response to these resource strains, urban residents in Taiz city began to look outwards for solutions, exploring water sources in nearby rural areas. However, projects to bring water from rural areas to the city faced challenges such as limited compensation to rural communities and resultant conflicts. The ongoing conflict has further deteriorated the water and sanitation situation in Taiz, with decreased water supply network coverage and reliance on costly water vendors (Lackner & al Eryani, 2020; UNDP, 2022).

In addition to strains on host community resources, large inflows of populations into urban centers have also led to an increase in solid waste generation, posing environmental and health risks. Yemen faces significant issues related to solid waste management, with a significant portion of waste ending up in landfills, causing pollution, greenhouse gas emissions, groundwater and surface water contamination, environmental degradation, and health concerns (Al-Dailami et al., 2022; FAO et al., 2021)urbanization, economic progress, and changing lifestyles all contributed to an increase in resource consumption and waste generation. Global solid waste generation was about 1.3 BT/year and was predicted to further increase to a tremendous amount of 2.2 BT/year by 2030. Municipal solid waste generation is increasing at a high rate, creating immense pressure on municipalities and pollution concerns for the environment. In Yemen, the quantity of municipal solid waste per capita in urban areas is 0.6 kg/day, while in rural areas it is 0.35 kg/day and the increase in the generation of Municipal solid waste is about 3%. Municipal solid waste is characterized by its diverse nature and therefore requires immediate attention for its effective management and disposal. Like most developing countries, the solid waste generated in Yemen is disposed into the landfills due to its simplicity and economical aspects while composting and incineration are rarely utilized. The disposal of waste at landfills is associated with long-term problems, such as leachate pollution, the release of greenhouse gases (GHGs. Furthermore, unplanned urban expansion has resulted in the destruction of natural flood barriers, leading to more frequent and severe floods, sometimes mixing with hazardous waste from the oil industry (e.g., in Hadhramawt governorate), posing environmental and health risks (Zabara & Zumbrägel, 2022).

5.0 POLICY AND PROGRAM RECOMMENDATIONS

5.1 Existing Policies and Programs

IHRL remains applicable during armed conflicts, as stated in the Universal Declaration of Human Rights (UDHR), which Yemen must uphold as a UN member. The UDHR emphasizes the right to a standard of living that ensures health and well-being, including access to food. It also highlights the need for special care and assistance for children and mothers. The UDHR also affirms the non-derogable right to life, which necessitates access to food and water. Yemen is also a signatory to the International Covenant on Economic, Social and Cultural Rights (ICESCR), which recognizes the right to an adequate standard of living, including sufficient food. The ICESCR implicitly includes the right to water as well. Furthermore, the Saudi-led Coalition is bound by their human rights obligations under ICESCR to avoid activities that may directly and predictably deprive the civilian population in Yemen of food and water (CIVIC, 2022).

Below are the applicable and binding international agreements to which Yemen is a signatory that relate to climate change and environmental protection.1

Conventions / Agreements	Date of adoption or ratification
Climate and Atmosphere	
The Montreal Protocol on Substances that Deplete the Ozone Layer and its amendments	16 September 1987
United-Nations Framework Convention on Climate Change (UNFCCC)	30 June 30, 1994
Stockholm Convention on Persistent Organic Pollutants (i.e. a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically and accumulate in the fatty tissue of humans and wildlife).	5 December 2001 9 January 2004
Vienna Convention for the Protection of the Ozone Layer	19 December 1994
Kyoto Protocol to the UNFCCC	11 December 1997; 16 February 2005
Civil Responsibility for Damage from Oil Pollution,	14 April 1979
Paris Agreement	22 April 2016; 4 November 2016
Land and Physical Cultural Resources	
The Convention on the Protection of World Cultural and Natural Heritage	14 September 1982
Biodiversity and Natural Habitats	

1) This table was originally elaborated as it is presented here in (FAO et al., 2021).

Conventions / Agreements	Date of adoption or ratification
Climate and Atmosphere	
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	3 March 1973; 22 June 1979
Convention on Biological Diversity (CBD)	1 December 2005
Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitats	24 January 2000
Convention on the Conservation of Migratory Species of Wild Animals (CMS) à (P#100)	1 December 2006
Others: Environmental Modification, Hazardous Wastes, Law of the Sea, the Rio Declaration on Environment and Development, The Universal Declaration of Human Rights, and The International Labour Organization (ILO) Conventions.	

Source: CATS – October 2020

Based on the research conducted for this desk review, the following are the minimum recommended stakeholders to include in the stakeholder interview phase of the project:

1. General Directorate of Forestry and Desertification
2. Council of Ministers (National Food Security Strategy)
3. Ministry of Water and Environment (Environment Emergencies Unit, National Biodiversity Strategy and Action Plan)
4. Ministry of Planning and International Cooperation
5. UNHCR (IDP, refugee, and asylee initiatives)
6. Ministry of the Interior (National Plan for Disaster Management)
7. World Bank and Food and Agriculture Organization (Food Security Preparedness Plan)
8. Ministry of Agriculture and Irrigation (Agricultural Research and Extension Authority)
9. Women's grassroots organization/council
10. Muhamasheen grassroots organization/council
11. Youth grassroots organization/council

5.3 Data Gaps and Research Priorities: Some Initial Suggestions

Based on the desk review, these are some of the identified gaps in data and information that underscore the need for additional data collection in shaping the development of the country report:

1. **Research and develop recommendations for addressing qat cultivation**. Qat cultivation consumes arable land and water resources, hampers productivity, exacerbates health issues, and contributes to social disparities. The income from qat farming plays a significant role in Yemen's economy, so researching potential policies to transition farmers into alternative livelihoods could help mitigate economic shocks and stimulate growth in other sectors. Furthermore, qat cultivation is linked to political instability, and researching policies to curtail production would likely help contribute to conflict prevention and peace-building efforts as well as improve public health outcomes and societal well-being. Given the intersectionality of qat cultivation with MECC dynamics, internal conflict, and stability in Yemen, the topic is well-positioned to benefit from further attention and data collection.

2. **Identify opportunities to strengthen, support, and extend multi-institutional responses in disaster response and recovery and climate change that remain dormant or are otherwise underdeveloped**. To address the multiple challenges posed by climate change and environmental degradation, it is essential to conduct additional research into existing initiatives that encompass all these objectives. Gathering this data would help with identifying opportunities for enhancing existing initiatives and developing comprehensive solutions to bridge any existing gaps. This can be achieved through conducting an analysis of current climate change and environmental degradation trends to assess potential security risks. Based on this analysis, an action plan for climate adaptation could be formulated in collaboration with relevant ministries, civil society organizations (CSOs), community leaders, and non-governmental organizations (NGOs). To ensure effective coordination and communication, there should be clear channels established between these bodies and CSOs, NGOs, and other entities working on climate change adaptation.

3. **Identify and strengthen local conflict resolution mechanisms, especially as they relate to tensions around land and water access**. To address civilian harm and combat land and water scarcity caused by landmines, additional data and review of the adaptation of the mine action plan would be greatly beneficial. Moreover, additional data would help to develop a mechanism to address conflicts at the community level concerning resource-sharing, particularly focusing on water-related disputes. Environmental mediation can play a crucial role in environmental peace-building efforts by establishing dialogue platforms and convening meetings of these various actors. Efforts to strengthen these partnerships would need to be built upon a better understanding of the needs and conditions of local authorities as well as local communities. Better understanding and enhancing the role of women in the environmental sector is crucial, and empowering local organizations could help mitigate growing social tensions and conflict linked to environmental stress by increasing awareness and fostering environmental education. Another important avenue for further data collection is investigating how women in Yemen can make use of tribal norms to mediate resource disputes and contribute to conflict resolution, and how their role in these processes can be strengthened.

4. **It is crucial to establish a strategy for supporting NGOs and CSOs engaged in climate work, water, and food management, and to develop a pathway for providing them with necessary approvals, partnerships, and timely support.** Furthermore, facilitating the passage of NGOs, CSOs, and government agencies through checkpoints becomes pivotal, especially when they are working to improve water infrastructure and mitigate harm resulting from climate change and environmental degradation. By conducting additional research on existing initiatives, identifying areas for improvement, and filling in any gaps, a comprehensive strategy can be developed to strengthen climate adaptation efforts, resource management, conflict resolution at the community level, and support for NGOs and CSOs.

5. **Deepen the understanding of current trends in climate change and environmental degradation and nuance available data on potential security risks as they relate to human mobility patterns**. To fill existing data gaps, it would be greatly beneficial to conduct an extensive analysis of current trends in climate change and environmental degradation to identify potential security risks. Based on this analysis, an action plan for climate adaptation can be developed in coordination with relevant ministries, CSOs, community leaders, and NGOs. This data would also serve to enhance protection-related interventions with security forces to improve the safety and well-being of all migrants. This plan would need to include dedicated elements of the research that address the differential needs of women, the Muhamasheen, children, and the elderly.

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