CLIMATE CHANGE, WATER SCARCITY AND MIGRATION (CWSM)

DESK REVIEW

IOM
UN MIGRATION

This Desk Review was prepared by Dr Erin K. McFee as a consultant for the International Organization for Migration (IOM) within the framework of the project "Increasing the knowledge base on community cohesion and mobility dynamics in the context of climate change and environmental degradation through a selected country-based case study within the Middle East & North Africa (MENA) region. Dr Amy Krauss conducted supporting research.

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IOM Regional Program on Mobility, Climate Change and Water Scarcity

This desk review falls under the mandate of the IOM Regional Program on Mobility, Climate Change and Water Scarcity. Climate change and water scarcity increasingly threaten vulnerable communities in the Middle East and North Africa (MENA) region. The MENA region is the most water-scarce in the world and is projected to be one of those most severely affected by the impacts of climate change globally. Disasters like floods, droughts and wildfires are likely to increase in scale and frequency due to climate change, with severe impacts on people's livelihoods, security, well-being and resilience. Resultant displacement alongside resource and water scarcity can amplify disaster risk in areas where large-scale movements strain already limited water sources. These dynamics can combine to exacerbate tensions over access to key resources between different community groups, thereby amplifying fragility.

The International Organization for Migration (IOM) has a proven history of developing and implementing interventions that support communities and governments to prepare for, reduce the risks of, and respond to the effects of climate change, environmental degradation and disasters. Such interventions fall within the Migration, Environment and Climate Change (MECC) portfolio. IOM seeks to further strengthen the knowledge and evidence base on the nexus between mobility, climate change and water scarcity, and inform future policy development and programming in this domain. To achieve this, the organization has partnered with regional stakeholders to research the intersection of factors such as migration, climate change, environmental degradation, water scarcity and conflict interact and influence community resilience against climate and conflict shocks. The project's findings will provide IOM, partners and Governments with the knowledge and tools to design and implement interventions that support community and Government efforts to strengthen resilience against future shocks.

This desk review and subsequent research will support the program in delivering the following:

- A comprehensive regional research report on the interaction between climate change and environmental degradation, water scarcity, mobility, and community cohesion dynamics.
- Policy guidance, including recommendations and pathways forward for policymakers in the region and focus countries.
- One regional position paper on resilience building and effective water and climate-risk management in conflict-affected areas.
- Evidence-based capacity building for relevant regional actors to better prepare for and adapt to the evolving impacts of climate change and environmental degradation on mobility and community cohesion.

The project will also create a platform for IOM, the United Nations system, and other regional partners to share good practices, learn from each other and identify avenues for future collaboration and cross-border interventions.

ACRONYMS

AU	African Union
CCM	Climate Change, Conflict, Migration
CM	Climate Migration
DRR	Disaster Risk Reduction
EU	European Union
IOM	International Organization for Migration
KII	Key Informant Interview
MECC	Migration, Environment, and Climate Change (MECC)
UNISFA	United Nations Interim Security Force for Abyei
UNSC	United Nations Security Council
WASH	**Water, Sanitation and Hygiene**
WRI	**World Resources Institute**

I.

State of the Field: Climate Change, Water Scarcity and Migration (CWSM)

1. State of the Field: Climate Change, Water Scarcity and Migration (CWSM)

A debate persists as to how to characterize the people who are driven to move due to the effects of climate change (Conisbee & Simms, 2003; Bettini et al., 2017). The IOM defines "environmental migrants" as persons who "predominantly for reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are forced to leave their places of habitual residence, or choose to do so, either temporarily or permanently, and who move within or outside their country of origin or habitual residence" (IOM, 2019: 64). IOM program guidelines and other human rights-based approaches to environmental migration have outlined three commitments for safe and orderly migration pathways (IOM, 2014). The first is to increase migrants' safety and well-being along routes of travel given predicted climate change effects, the second is to create sustainable livelihoods that mitigate against the loss of economic and social well-being due to both slow processes of environmental degradation and sudden disasters, and finally, the third is to consider the unequal distribution of immobility as an integral element of better migration governance and climate justice. In the wake of the Covid-19 pandemic and the lockdown measures that had major impacts on migrant workers and their networks, future migration studies will also need to better explore the focus on "trapped populations," or those who are unable to move in relation to conditions of poverty, conflict, and environmental degradation (Yeoh 2020; Zickgraf 2021; Schewel, 2019).

One of the main effects of climate change will be the intensification of water scarcity, especially in the arid zones of the MENA region (UNICEF, 2021). Issues of water scarcity affect disparate urban and rural areas and forms of livelihood. For instance, water scarcity in cities has a major impact on the provision of basic social services and the functioning of healthcare systems. In rural settings, longer and more intense cycles of drought place tremendous stress on farmers and others who are directly dependent on already limited quantities of water to produce food for market and subsistence (WRI, 2019; UNDP, 2013).

1.1. Ecologies of Vulnerability

The case studies of Sudan and Libya represent distinct ecologies of vulnerability to climate change and water scarcity. This study introduces the idea of ecologies of vulnerability as the combination of political, economic, social, and environmental conditions of risk and adaptive capacity (including immobility and migration) that make some groups and regions more vulnerable to the effects of climate change than others. This concept combines human rights-based approaches to migration with current efforts to understand the uneven effects of climate change in context (Fussel, 2010). It is largely agreed across governmental, policy and academic sectors that environmental causes of

migration are intertwined with other factors and drivers of displacement and migration, such as economic struggle and conflict (Stavropoulou, 2008; IOM, 2021).

The term ecology alerts us to what we refer to in the accompanying Climate Change, Conflict and Migration (CCM) desk review as the "constellation of factors"' behind climate change and its impact on human lives as uniquely interdependent with environmental well-being. This review draws on insights from the field of political ecology that foreground the role of international development and economic modernization schemes in conjunction with livelihood loss and environmental degradation, that in turn, lead to contemporary migration patterns and crises (Roberts, 2020).

This approach will be especially helpful for understanding the complex links between climate change, increasing water scarcity in the MENA region, and the politicization of water access in broader struggles between states and other actors for power and control (FAO, 2015; FAO, 2016; UNHCR, 2017). In both Libya and Sudan, current problems of water scarcity are shaped by long histories of oil exploration, development, and transnational economic interests (HRW, 2003; IPCC, 2021). We can borrow from health inequities research to understand these historical relationships as a matter of deep structural conditions with systemic behavioural outcomes (Metzl and Hansen, 2014). Whereas the upstream causes of water scarcity have to do with resource mismanagement and poorly maintained systems and infrastructures, upstream issues, such as the geopolitics of oil development and economic dependence create conditions that do not favour water conservation and access as a human right.

1.2. Migration as an adaptation strategy

Recent studies on climate change and migration have shifted from framing migration as a security threat to host and destination nation-states, to instead thinking of it as a necessary strategy of resilience and adaptation in the face of global environmental loss and degradation (van Praag, 2021). While a view of migration-as-adaptation rather than security threat or crisis may allow for a more nuanced understanding of migrants' lives and forms of agency, some have noted that this approach emphasizes individual resilience over structural change and institutional responsibility for climate justice (Bettini et al., 2017). To address this, the present study combines the adaptation approach to researching climate change-impacted migration with an analysis of implicated organizational and institutional stakeholders at the local, national, regional, and international levels. By doing this, it will contribute to a deeper understanding of the structural conditions that influence dynamics, such as livelihood loss and water scarcity.

1.3. Climate Change and water scarcity

Water scarcity is generally defined as the physical or economic lack of water resources to meet the demands of a specific population. Physical water scarcity occurs where natural water resources are over-exploited, and economic water scarcity occurs

where there is insufficient investment in and maintenance of water distribution systems and infrastructures. Rising temperatures, longer periods of drought, reduced rainfall, and the rise in frequencies and intensities of flooding are all climate change effects that have a direct bearing on both physical and economic water scarcity (FAO, 2015; FAO, 2016; IPCC, 2021).

For instance, in Sudan, reduced rainfall over the last 40 years has led to flash floods because the land is so parched it cannot absorb the regular rainfall of the rainy season (FAO, 2015). Drier conditions coupled with flash floods place people at greater risk of disaster displacement (UNDRR, 2021). Catastrophic flooding in Sub-Saharan Africa has led thousands of people to travel from rural areas to cities where potable water infrastructures grow increasingly stressed (FAO, 2015). In this way, the problem of water scarcity links urban and rural ecologies of vulnerability.

A recent report on UNICEF's Water, Sanitation and Hygiene (WASH) program, which aims to ensure water, sanitation and hygiene for all towards Sustainable Development Goal 6, notes the growing importance of more complex resource assessments for functional policy design. It names the lack of water access as a major obstacle to program implementation (UNICEF, 2021). The global COVID-19 pandemic further highlights how water scarcity strains healthcare systems worldwide and delivery, making crucial sanitation practices such as handwashing difficult. These conditions, in turn, contribute to malnutrition and digestive disease, hunger-driven displacement, and armed conflicts over territory and resources.

Because water is a core element of household labour (e.g., cooking, washing, and caring for the ill, children, and elderly), many of the difficulties associated with water scarcity tend to disproportionately burden women (Lama, et al., 2021). Climate-impacted migration and displacement only amplify these gender-specific difficulties. For example, reports from humanitarian aid agencies in MENA countries describe women and girls' increased exposure to sexual assault and violence in conflict zones and migrant-refugee settlements where access to water requires walking long distances (Aamer, 2021).
Research has also shown how the out-migration of men can leave women behind to face the intensification of water scarcity while also caring for children and living through conflict and war zones. This phenomenon sometimes leads to women gaining more household and community decision-making power (Chindarkar; 2012; Lama et al., 2021). Programs that address the intersection of water scarcity, migration and community resilience have found some success through engaging collectives of women to manage communal water resources (UNDP, 2018; Putsoa, 2022).

The variability of the gendered effects of water scarcity, immobility, and migration - and their intersection - calls for more contextualized empirical studies that explore how gendered relationships around water management are stressed, or, conversely, opened up to positive rearrangements in the wake of environmental change and migration.

2.

Regional Overview

2. REGIONAL OVERVIEW

Over the past several decades, the total availability of water resources across the MENA region has trended downwards, thereby resulting in higher precedence of water scarcity (FAO, 2021). Increasing temperatures decreased rainfall rates, and desertification due to climate change overlaps with population growth, which has the potential to exacerbate migration, pre-existing social tensions, and other vulnerabilities (IOM, 2021; AWC, 2019; Mertz et al., 2011; Tekken & Kropp, 2012). Water scarcity is particularly harmful in rural communities given that most of the agriculture is located in these regions, and farmers depend on their crops both for survival and for their livelihood. Undoubtedly, general food security is threatened as well. Moreover, despite the indispensable quality of water in arid environments, human-induced water scarcity is prominent throughout the MENA region because of poor water management, wastefulness, and a lack of innovative strategies to mitigate water loss.

Water scarcity does not only impact the agricultural sector; it also plagues urban centres and has the potential to exacerbate conflicts. As droughts occur more frequently, many rural families are forced to migrate to larger cities to survive, though this typically occurs in conjunction with other contributing factors besides water scarcity (van Praag, 2021; Abel et al., 2019; Brzoska & Frohlich, 2016). Upon their arrival, many individuals, especially poorer families, create makeshift homes and work in informal settings to provide for themselves, which effectively precludes them from accessing social services, and population growth can potentially reduce the amount of water available per capita. In Iraq, it has been demonstrated that ethnic and tribal tensions place migrant families at an increased risk for violence and exploitation, therefore reinforcing their state of vulnerability (IOM, 2021; IOM, 2020b). Libya, one of the most arid nations within the MENA region, similarly struggles with water availability in urban coastal regions, though this is due primarily to the overuse of water from the Great Man-Made River (GMMR) (Brika, 2019; Hamad et al., 2017; Bindra et al., 2003). Armed groups have even been known to fight the state for control of GMMR stations, during which access to its water has been cut off entirely in some cities (Al Jazeera, 2019). Sudan and Kenya have also experienced increased tensions between pastoralists and farmers regarding access to water resources, thereby demonstrating the need for more adequate conflict resolution and resource management strategies (Foong et al., 2020; Bronkhorst, 2011; Mertz et al., 2011).

Improving resource management strategies is one of the most pressing issues for the MENA region. Egypt, Iraq, Libya, Morocco, Sudan, and Tunisia among other nations struggle to effectively irrigate industrial and private farms, thereby resulting in additional

water loss (FAO, 2022; Brika, 2019; Soltani & Mellah, 2022; Hamad et al., 2017; IOM, 2020b). North African coastal nations in particular have the potential to enhance their water desalination efforts to provide an alternative source of water given their population-dense coastline. However, many of these nations, like Libya, have not done so to the extent necessary to remedy the growing supply-demand gap, in no small part due to the high costs associated with the process (Bindra et al., 2003; Abufayed & El-Ghuel, 2001). Saudi Arabia, conversely, demonstrates how extensive desalination infrastructure can successfully provide additional water resources to meet the demands of an arid nation-state (Brika, 2019). Moreover, geopolitical issues surrounding water access from rivers and aquifers increase tensions between countries like Egypt, Sudan, and Ethiopia, which confirms the need for improved transboundary water management in the MENA region (Selby and Hoffmann, 2014).

To solve these issues, researchers and policymakers must establish the best practices to revitalize water infrastructure. Improving pipelines and canals for agricultural irrigation must be a priority. Regions in Morocco have even resorted to using saline water for crops due to the lack of water resources, which will reduce agricultural yield and deplete the soil over time (Soltani & Mellah, 2022). The situation appears quite dire, but better infrastructure, water management, and innovation with respect to desalination technologies have the potential to ameliorate water scarcity issues throughout the MENA region.

3.

Existing Programs and Initiatives

3. Existing Programs and Initiatives

International treaties, such as the Paris Climate Agreement and Task Force on Displacement (TFD) within the Warsaw International Mechanism for Loss and Damage (WIM), enumerate commitments to enhance cooperation between regions and states in relation to climate change, disaster and human mobility issues. At the regional level, several MENA governments have also pledged to mitigate the effects of climate change through a transition to renewable energy and green technologies, and some have already taken steps in that direction, as demonstrated by their enhanced Nationally Determined Contributions (NDC) commitments (Khoday, 2021; FAO, 2022). Current international programs such as Water Wise Women and the Women and Water Diplomacy in the Nile (WIN) Network train local women to take the lead in water conservation and increase transnational knowledge-sharing among community leaders and decision-makers (Aamer, 2021). Other efforts from international stakeholders and MENA countries include the implementation of the Nile Basin Initiative's Cooperative Framework Agreement, the Nubian Aquifer project, Water for Peace, and the Reduction of Resource-based Conflicts Among Pastoralists and Farmers program (Khoday, 2021; Bronkhorst, 2011).

IOM has partnered with other research centres and stakeholders to fill an important gap in the policy initiative arena by assessing the intersection between water scarcity, climate change and migration. In sum, regional and international programs prioritize improving local and transboundary water management. Other strategies to establish climate-resilient infrastructure work in conjunction with these programs and policies to both support individual livelihoods and reduce the potential for conflict over resource scarcity.

4.

Libya

4. Libya

4.1. Contextual Consideration

Libya is ranked number 15 in a list of 33 countries across the world facing extreme water scarcity by 2040 (WRI, 2019). The World Resources Institute (WRI) combined 13 water risk indicators into a composite "water risk score" that reflects the country's water quantity, quality and "regulatory reputation"—or water governance capacity. Most of Libya is considered "extremely high risk," except for the coastline on the Mediterranean Sea. Indeed, 87% of Libya's population lives in or around coastal cities, especially the capital city Tripoli, and the second most populous city, Benghazi (OCHA, 2021). 95% of the country is desert, and only 1% is cultivated agricultural land (FAO, 2016). There are ephemeral rivers or wadis, but no permanent rivers or lakes, and so drinking water is sourced entirely from groundwater aquifers (FAO, 2016).

The country holds Africa's largest oil reserves, with petroleum exports comprising over 90% of all exports (OPEC, 2022). During oil exploration in the 1950s and 60s, deep fossil aquifers were discovered in the south. They were first used to develop agricultural projects in the desert close to the wells, but when the population concentrated on the coast required potable water, they were further developed to transfer supply to the North. The Great Man-Made River (GMMR) Project, one of the largest civil engineering projects in the world, channels fresh groundwater from the Southern desert to the coastal cities through a series of pipelines connected to the Nubian Sandstone Aquifer (FAO, 2016; OPEC, 2021).

The GMMR was funded by the Gaddafi government beginning in the 1980s and constructed in several phases over the course of decades. It is still incomplete and was partially destroyed by NATO bombings in 2011 and the civil unrest that preceded and followed. In Libya, the GMMR mostly supplanted desalination plants—the other major technology for generating potable water in arid climates. Improving the desalination plants that were constructed by foreign investors in the 1960s is considered an option for future development in the face of increasing water scarcity. Although the GMMR continues to deliver water to millions of people, under current conditions of disrepair, it is not a sustainable infrastructure. Overexploitation of groundwater, particularly in coastal cities, has led to seawater invasion of the freshwater aquifers and is rapidly depleting the water supply (FAO, 2016; Alfarrah & Walraevens, 2018).

Libya is also a main port of departure of the Central Mediterranean Route, where migrants and refugees attempt to cross the Mediterranean Sea to Europe. The Missing Migrants Project regularly updates the number of counted migrant fatalities while noting that the

Mediterranean, and the coast of Libya especially, are sites where the most disappearances have occurred (MMP, 2022). This suggests the shortcoming of using numbers to represent the hardship and loss here. While many people moving on this route are refugees and migrants fleeing war and climate-impacted environmental hardship in sub-Saharan Africa, they are also seeking economic opportunities.

Libya has historically been a destination country for people migrating from neighbouring countries, offering the best employment opportunities and highest salaries in the region, even as the standard of living has suffered with the ongoing armed conflict over oil production and exportation (OECD, 2009; IOM, 2014). Since the start of the uprising against the Gaddafi regime in 2011, close to 400,000 Libyans have been displaced; as of June 2022, around 143,000 IDPs remain displaced in Libya (IOM, 2022). And still, a recent IOM Report documents that most migrants travelling into Libya (90%) state that their primary reason for migration is to search for a better livelihood. More than half of respondents to an IOM survey (53%) stated that insufficient income in their countries of origin was the core reason that drove them to migrate, and nine per cent of respondents stated that they had been internally displaced in their countries of origin before arriving in Libya (IOM, 2022). In spite of armed conflict, tightening border restrictions and exclusionary European immigration and refugee policies, geographic proximity and diasporic ties between Libya and neighbouring countries of Chad, Egypt, Niger, and Sudan continue to shape in-flow migration patterns in Libya, with migrants from Niger constituting the majority (25%) of the migrant population (IOM, 2022).

As economic migrants and displaced people converge in Libyan coastal cities, the sustainability of potable water infrastructure is an urgent concern. Water access has become a central topic of political contestation. In 2017, protests broke out in Tobruk against closing a seawater desalination plant. Protestors called on the National Oil Corporation to solve the water crisis and threatened to disrupt oil exports (Alharathy, 2017). There is an ongoing investigation into the rise of hepatitis A among residents in Tobruk as well, a disease that can be passed into drinking water (Ismail et al., 2022). In 2019, armed groups turned off water pipes as leverage in a struggle with the state over a captured leader leading to a temporary, but critical water crisis in Tripoli (Wintour, 2019).

4.2. Extant findings and gaps in understanding

4.2.1. Key legislative and regulatory frameworks

The Water Law of Libya (1965), renewed and expanded in 1985, states that water is a public good that should be protected by all. The National Strategy for Integrated Water Resources Management (2000-2025), approved in 2005, also sets guidelines for sustainable development and shared responsibilities of water resource protection (FAO, 2016). While these laws set up a regulatory framework, implementation remains inconsistent amidst armed conflict.

Private and public property entitlements and responsibilities were a core issue of the Gaddafi regime and are central to the unresolved conflicts in the wake of Gaddafi's overthrow. During the Gaddafi period, foreign-owned property was nationalized, and Libyan-owned property was redistributed. During the 2011 uprising, villages and homes were destroyed as a challenge to the standing property regime (Williams, 2012).

One central question that has not been adequately addressed in either the academic or policy–making literature is how different scales and histories of property disputes intersect with issues of water scarcity. For instance, decrepit city water infrastructure, combined with targeted sabotage of water systems by armed groups has led households to drill through city pavement to create private water wells (Gatenby, 2017). These issues are multi-scalar, with short- and long-term effects tied to private well drilling, water conservation, and sustainability, all embedded in a larger context of unresolved debates about public property. Towards this end, this study will combine both lay insights about household coping strategies and Libyan expert-technical knowledge on best practices for water resource sustainability.

Successful programs have also taken care to include local input. For example, IOM's Community Stabilization program "Together We Build", with funding from the EU, was able to rehabilitate neighborhood water wells in the southern city of Sabha after arranging meetings with community representatives (IOM, 2017). This example shows how successful interventions have focused on sustaining household water access as a neighborhood issue, which also reaffirms the idea of water as a shared public good. More empirical research is needed to understand the ways people at the household level develop coping strategies that simultaneously create community cohesion and how these strategies can be institutionally supported or shifted to more sustainable solutions.

4.2.2. Migration Governance and water scarcity

Water, sanitation and hygiene needs have increased in Libya due to continued deterioration in service delivery during armed conflict, and these needs have only been exacerbated by the COVID-19 pandemic. Nearly one in five migrants (19%) report having insufficient access to clean drinking water, which also compromises societal health and hygiene levels (IOM, 2022). Laws in the countries of origin, such as Niger's 2015 anti-smuggling law, have had uncertain results for migrant well-being by shifting transit routes through less supported and more arid regions (IOM, 2020a; IOM 2020c). Competing and unreliable criteria of entry and recognition of refugee status between European, African and international agencies present an additional challenge, and several agencies have worked to voluntarily return migrants to their origin countries with mixed results (Lambert, 2021; IOM, 2022). It is important to note that Libya, while being a major destination country for migration in Africa and the Middle East, is not a party to the 1951 Convention Relating to the Status of Refugees.

Existing interventions illustrate the complexity of policy and program design in these

contexts. Additionally, they serve as cautionary tales with regard to the limitations of migration governance frameworks that do not account for the deeper structural conditions of livelihood loss, water scarcity, and armed conflict. It would be useful not only to develop a more thorough understanding of imaginable alternatives to entering Libya and Europe from the perspectives of migrants but also to gain an empirical understanding of the effects of anti-smuggling laws and international surveillance on migrant pathways. This would meaningfully inform policy design while continuing the legal advocacy fight for regionally cohesive frameworks.

Most of the existing literature does not consider the complexity of the migration situation in Libya in relation to increasing water scarcity. If it is considered, it is a brief mention that connects the issue to population growth (Boretti & Rosa, 2019). Population growth has long been the default causality framework for describing the strains of environmental and resource degradation, but it fails to capture relevant dynamics. Population growth does not explain water scarcity in Libya, where the annual growth rate for the period 2005-2015 was estimated to be 0.8 per cent—in decline since the 1980s and 1990s, when it was 4.2 and 2.8 per cent respectively (FAO, 2016). As mentioned earlier, water scarcity links urban and rural ecologies of vulnerability and must therefore be considered from two angles: 1) as an element that drives new out-migration flows, often from rural agricultural zones towards urban centres, and 2) as a problem that emerges with the overexploitation of resources in destination sites, especially in urban developments and refugee camps. Along these lines, the IOM has investigated environmental degradation and water scarcity as causes of migration with surveys of migrants moving through Niger and Libya (IOM, 2022; IOM, 2020a; IOM, 2020c). Most survey respondents note that the main reason for migration as economic need, so more research is needed to understand the correlation between decreases in rainfall, and, more broadly, processes of desertification and intensifying water scarcity as interrelated with more obvious economic drivers of migration into Libya.

Furthermore, as migrants continue to gather in Libyan coastal cities, there is added strain on under resourced healthcare systems and potable water infrastructures (FAO, 2016). Projects that have addressed this problem through resourcing the healthcare system have had some success. For example, in a UK and WHO collaboration to support Libya's nurse training program, livelihood possibilities increased through strengthening the healthcare profession alongside skills for managing the influx of human needs due to migration and armed conflict (WHO-Emro, 2020). Future programs and policies could contribute to this work while mainstreaming water sharing and conservation practices into these programs.

4.2.3. Desalination technologies

Desalination is an obvious way to obtain potable and irrigation water for those countries that have a coastline. While desalination plants have been in use since the 1960s, many plants are currently closed down or in disrepair. Libyan researchers have urged greater attention to local conditions and expertise in future desalination projects, and

trace histories of plant failures to this oversight (Abufayed & El- Ghuel, 2001). As demonstrated in the 2017 Tobruk protests, disinvestment in desalination is coupled with intense investment in the oil industry. The petroleum industry uses massive quantities of water in producing and processing petroleum; "the extraction of one barrel-of-oil-equivalent, for example, requires 250 gallons of fresh water and emits more than 60 pounds of CO" (Chenoweth & Al-Masri, 2022). This means that there are millions of gallons of water per day going into producing petroleum. Indeed, gasoline production is the largest water consumer at 0.60–0.71 gallons of water per gallon of gasoline, and jet fuel refining requires the least, at 0.09 gallons (Sun et al., 2018).

More research is needed on the different stakeholders invested in petroleum production at the expense of improving desalination technologies and the possibility of shifting these priorities. While the desalination process is energy-intensive, Libya - and MENA countries in general - have plenty of sunlight. They could harness thermal processes or use solar electrical power. Furthermore, there is an issue with the brine remaining after desalination: returning this waste to the seas/oceans will increase the salinity of those bodies of water (Abu-hawash, 2021; Belhassan, 2020). If the MENA countries coordinate, they might be able to mine various minerals from the brine, including salt.

Additionally, prior to implementing desalination, investment in wastewater management and improved irrigation and agricultural methods is necessary (El Zarroug et al., 2021). Aquaponics figures into this: it is the combination of aquaculture (the raising of aquatic animals) with hydroponics (the growing of plants without soil, using water). Aquaponics is a cycle system where the nutrients in the water from raising aquatic animals can be used in hydroponics and the hydroponic system assists in cleaning the water to keep it suitable for aquatic animals. This keeps the water in circulation and is almost an entirely closed loop system (Obirikorang et al., 2021).

5.

Sudan

5.1 Contextual Considerations

The water crisis in Sudan is shaped by drought and extreme rainfall conditions due to climate change, as well as complex and ongoing social, political, and economic factors, such as postcolonial relations of development, civil war and conflict, and volatility of the oil economy. While Sudan is historically prone to cycles of droughts and floods, climate change has significantly reduced rainfall over the course of the last 40 years (FAO, 2015). The Sahara Desert is currently advancing 1.5km per year (desertification), which in turn leads to extreme floods during the rainy season (IPCC, 2021). Over 700,000 people have been affected by heavy rains and flash floods across the country, and more than 60,000 homes have been destroyed or damaged, displacing over 100,000 people (UNHCR, 2021). 70% of the population in Sudan are rural and live along the Nile River and its tributaries; population growth is 2% (between 2012-2013) (FAO, 2015). Importantly, the central states of Sudan depend on the Nile River as its primary water resource, binding its water uses and management to 11 other countries, including Egypt to the North and Uganda, Rwanda and Ethiopia to the South (FAO, 2015). This study aims to improve understanding of the subnational regional differences in relation to transboundary water dependence.

The construction of irrigation systems for farming has been central to colonial and postcolonial development schemes in Sudan. Large-scale gravity irrigation started during the British colonial period (1898-1956) for cotton production along the Nile. The Gezira Scheme, started in 1925, is Sudan's oldest and largest gravity irrigation system. Along with The New Halfa Scheme, it was expanded in the postcolonial periods as the primary avenue of the country's economic development. In the 1970s, oil-rich Gulf nations invested in these irrigation systems with the slogan of making Sudan "the breadbasket" of the Arab World (Woertz, 2013).

Oil has historically been the most vital export for Sudan, making up 95% of exports since 2008. In the break-up of North and South Sudan in 2011, conflicts over oil played a central role. While 70% of oil revenues come from the South, all of the refining capacity is in the North (Sullivan & Nasrallah, 2010). Prior to the 2011 separation, the development of southern oil reserves caused tremendous conflict and mass displacements. The Southern Sudan's People's Liberation Army (SPLA) emerged in response and won regional autonomy in 2005 and then independence as South Sudan in 2011. Since then, the civil conflict has killed an estimated 400,000 people and forced millions from their homes (IPCC, 2021). This study aims to track the current situation considering these past conflicts.

Displaced people in Sudan, both refugees from South Sudan and internally displaced, face food insecurity and limited access to potable water resources (FAO 2015). As people migrate due to armed conflict and flash flooding, historical tensions between pastoral groups, nomadic tribes and oil production interests are intensified, especially as people converge in smaller and smaller areas of higher ground to be safe from flooding (Seyuba et al., 2021). The Abyei region, for example, is a contested territory between North and South Sudan because of oil interests, among other things. It is also experiencing hotter weather and drier conditions, increasing the frequency and severity of droughts and floods

(Seyuba et al., 2021). These environmental conditions amplify the multi-scaled political tensions between transnational oil interests, north and south Sudanese states, and the local Ngok Dinka and Misseriyya Arab seasonal migrants (Seyuba et al., 2021).

5.2 Extant Findings and Gaps in Understanding

5.2.1 Key Legislation and regulatory frameworks

Because of the Nile, Sudan is necessarily involved in transboundary water governance. The Nile Basin Initiative's (NBI) Cooperative Framework Agreement (CFA), outlines rights and obligations for the development of the Nile River basin. Egypt has historically held more power as the downstream powerful country, with Sudan as its ally.

In 2012, Sudan joined with southern, upstream countries, partly because of hopes of future benefits from the Ethiopian Renaissance Dam, which will generate hydroelectric power and possibly help control floods. Currently, Sudan has reverted to its earlier position and joined Egypt in dispute with Ethiopia over the potential environmental harms of the dam (FAO, 2015; BBC, 2021). In May 2021, Sudan submitted a revised Nationally Determined Contribution (NDC) highlighting the country's commitments to pursue a low emission and resilient sustainable development in the energy, forestry, land-use, and waste sectors. Another important framework is The Gezira Act of 2005, which transferred the management of irrigation systems from Agricultural Corporations to smaller water user associations, shifting water conservation programs and decision-making to farmers (FAO, 2015).

5.2.2 Climate Change, farming livelihoods and water scarcity

Flash floods have led to food loss and the threat of famine, which has led to the forced migration of people across Sudan (Nebehey, 2019). Subsistence farmers depend on rainfall and small rainfed water reservoirs called hafirs. Women make up 57% of rainfed agricultural labourers, both as subsistence farmers and 49% of wage labourers in seasonal irrigated agriculture (FAO, 2015).

At present, the current understanding of the gendered dynamics of large-scale irrigated farming, livelihood loss, gender and migration is thin and requires more in-depth and qualitative studies. While much of the literature focuses on conflict dynamics between nomadic and pastoral tribes and the amplification of conflict due to climate-driven displacement, less attention has been given to how livelihood loss in relation to water scarcity has gendered dimensions.

In a study on adaptation strategies in the Sudano-Sahelian region, farmers were interviewed about what they would prefer to do if drought conditions worsened. They showed a preference for migration in search of less climate-dependent livelihoods in response to the increased frequency of drought (Mertz et al., 2011). Under other imagined future climate scenarios, they showed a strong preference for the continuation of agriculture (Mertz et al., 2011). There is added complexity in interpreting these findings

given that there is a long history of drought experience in the region and seasonal migratory practices in response. Understanding the intersections between historical seasonal migration patterns and the changes caused by slow and sudden climate crises is thus critical.

Many international aid projects are aimed at increasing resilience to drought and lessening conflict between crop farmers and pastoralists. For instance, the UN Environment and the European Union partnered on a project to distribute seasonal water supplies to increase agricultural yields in North Darfur. As part of this project, water channels and reservoirs were constructed and rehabilitated by community women leaders (Putsoa, 2022). An IOM project for a women-led Water Management Committee in the village Jebel Kheir in South Sudan has been successful in the maintenance of three communal water points and has empowered women as community leaders at the same time (Putsoa, 2022). More empirical research is needed on gendered dimensions of subsistence farming, waged agricultural labour and how these dynamics are altered in relation to migration and climate change.

In sum, academics, policymakers, and practitioners alike increasingly consider migration as a responsive and dynamic form of environmental risk reduction and adaptation strategy (IOM, 2014; Praag, 2021; Lama et al., 2021). By adopting the ecologies of vulnerability analytic framework, this study responds to critical concerns over the shift from migration-as-security-threat to migration-as-adaptive-capacity. We will identify potential sites of intervention that could support community resilience, while at the same time address the power asymmetries between multiple stakeholders that contribute to environmental degradation and mass displacement. While most studies focus on environmental migration patterns after significant natural hazards, such as an earthquake or floods (van Praag, 2021), this review calls for equal attention to slow and cumulative processes of degradation and resource loss, and "human-built" elements - i.e., urban and rural infrastructures for drinking water and agricultural irrigation systems, developmental paradigms and their conflicts- as well as as causal elements of water scarcity and migration.

6.

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