

Human and Social Impacts of Global Warming and Resilience Building for Sustainable Development in Saharan African Countries

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Abstract

This paper examined the human and social impacts of global warming in the Sahel-Saharan African countries and as well proposed strategies for mitigation, adaptation and resilience building for sustainable development for countries in the region. The methodology employed an exploratory research design based on a systematic literature review obtained from searches in the Web of Science, Google Scholar, ResearchGate, Scopus, and institutional databases using key words including global warming, climate change, human impacts, resilience, and sustainable development from articles published in peer-review journals between 2010-2025 as well as reports from international development organizations including IPCC, WMO, FAO, UNEP using thematic synthesis to identify patterns across the relevant literature on human and social impacts of global warming in the region. The study revealed many critical challenges and highlighted some mitigation, and adaptation strategies as well as opportunities that could be leveraged for resilience building in the region. In addition, the paper highlighted how the abundant natural resources such as strong desert winds, prolonged sunlight hours, floods, and coastal waves could be harnessed to develop renewable energy sources, address persistent issues such as low agricultural productivity, water shortages, unemployment, poverty, migration and climate-related diseases for sustainable development in the region. The findings underscore the importance of integrated adaptation strategies, green technologies, and inclusive policies to build resilience and promote sustainable development.

Keywords: Global warming, Human and social impacts, Resilience building, Sahel-Sahara African Countries.

Introduction

Global warming, driven by greenhouse gas emissions from industrial activities, continues to escalate, resulting in a consistent rise in average global temperatures. The Intergovernmental Panel on Climate Change [IPCC] (2022) reports that global surface temperatures have increased by approximately 1.1°C above pre-industrial levels, with projections indicating a possible 1.5°C increase by 2040 under current emissions scenarios. Although Africa contributes less than 4% of global greenhouse gas emissions, it is one of the most vulnerable continents to the impacts of climate change due to its high exposure, low adaptive capacity, and fragile socioeconomic systems (World Meteorological Organization [WMO], 2022).

According to the African Climate Policy Centre [ACPC] (2021), over 80% of African countries already experience climate-induced stress, such as droughts, floods, and erratic rainfall patterns, which threaten agricultural productivity, water availability, and public health (United Nations Economic Commission for Africa [UNECA], 2021). These effects are particularly acute in

regions where the majority of the population relies on climate-sensitive sectors like rain-fed agriculture and pastoralism.

Causes of Global Warming and Climate Change

In the Saharan region of Africa, global warming is driven by a combination of factors, including human activities (anthropogenic) such as the burning of fossil fuels and other industrial activities (Asekome & Ogbu, 2021), as well as biogeographical (natural) factors. Naturally, the Sahara region experiences limited rainfall during most parts of the year, strong and fast-moving dust-laden winds, sand dunes, stunted grasses, and sparse vegetation, with a persistent shortage of water for both humans and livestock. Therefore, global warming and climate change in this region appear to be influenced more heavily by biogeographical factors.

Economic growth and environmental sustainability are both essential for human survival. The Kuznets theory, which suggests a relative compatibility between environmental quality and economic growth over time, assumes a world with advanced technology and institutional policies that minimize this incompatibility.

To meet economic needs, humans alter their environment through activities such as construction, deforestation, farming, mining, and industrial and vehicular emissions—all of which pollute and disrupt natural ecosystems. These actions have led to significant negative economic and social consequences, including health hazards, food and water shortages, social dislocation, conflicts, and forced migration (Asekome & Ogbu, 2021).

Impacts of Global Warming

Human Health

The direct impacts of global warming on human health in the Sahara include physical discomfort arising from higher temperatures, heat waves, heat stress, and shortage of clean water, with attendant incidences of diseases such as malaria, water- and air-borne diseases, and cholera, causing morbidity and mortality of vulnerable children and poor women in the region (Olivia, Adams et al., 2019).

Data on heat waves between 2000 and 2015 across the Sahel region, including areas bordering the Sahara, indicate that daily maximum temperatures at or above 41.1 °C elevate the risk of death from climate-sensitive diseases and malaria, with relative risks as high as 1.78 for all-age malaria and 1.67 for malaria in children under five (Arisco et al., 2023).

Research shows that exposure to Sahara dust is associated with increases in asthma, bronchitis, pneumonia, stroke, and neonatal mortality (Weil et al., 2024). Harmattan conditions, with humidity dropping below 15% and temperatures swinging between 9 °C and 35 °C, also lead to exacerbations of skin, eye, and lung conditions like conjunctivitis and silicosis.

Water scarcity caused by global warming also reduces access to safe drinking water in Saharan nations. Sudan has increasingly reported heatwaves and prolonged droughts, significantly reducing water availability and quality. These conditions drive outbreaks of water-borne diseases such as cholera, particularly among children and marginalized groups (Wikipedia, 2025). While comprehensive cholera figures for Saharan nations are limited, regional trends attribute significant outbreaks to drought and flash floods that degrade sanitation infrastructure and overwhelm water systems (Copernicus Atmosphere Monitoring Service, 2025; European Space Agency, 2025).

Agriculture

Agriculture remains the backbone of the economy across Saharan and Sahelian Africa, with over 90% of rural communities depending on rain-fed farming as a primary source of employment, income, and food security (World Bank, 2017). Persistent droughts, reduced precipitation, extreme heat, and erratic rainfall patterns have significantly lowered agricultural productivity and exacerbated water scarcity across the region. These climate-related stressors contribute to rising food insecurity, poverty, and social instability.

Data from the European Commission's Joint Research Centre [JRC] (2025) reveals that crop yields in Morocco fell by approximately 25% below average and by around 6% in Western Algeria during early 2025 due to prolonged drought and declining soil moisture. Similarly, the Sahelian belt including Niger, Mali, Chad, and Mauritania faces frequent droughts and desertification, affecting over 128 million hectares of rain-fed cropland and 656 million hectares of pastureland, while more than 60% of irrigated cropland is under high water stress. These conditions deepen socioeconomic hardships and spark communal conflicts over scarce land and water (JRC, 2025; World Bank, 2017). The United Nations Environmental Programme (UNEP, 2007) also highlights how desertification, extreme heatwaves, and drying wetlands across northern Sub-Saharan countries such as Nigeria, Chad, Mali, Niger, and Burkina Faso contribute to widespread crop failure, livestock mortality, and declining vegetation. Projections indicate that by mid-century, crop and livestock output in the region could fall by 17–22%, affecting over 230 million people and rendering large swaths of land unsuitable for traditional agriculture (JRC, 2025; Wikipedia, 2025).

Water Shortage and Drought

The landlocked countries of Chad, Mali, Niger, Mauritania, and Sudan as well as inland regions of Libya, Morocco, and Algeria are particularly vulnerable to severe water scarcity caused by heatwaves, prolonged droughts, and rising temperatures (IPCC, 2014; Lezzaik & Milewski, 2017). These shortages severely impact human consumption, agriculture, and livestock, leading to dehydration, disease outbreaks, mortality, reduced productivity, and loss of income.

In Libya, over four million people including 1.5 million children faced an imminent water crisis in 2021 due to damaged infrastructure and repeated attacks on the Great Man-Made River system, which supplies approximately 60–70% of the country's freshwater needs (United Nations Children's Fund [UNICEF], 2021). Much of the Saharan region receives less than 50 mm of annual rainfall, leaving communities dependent on deep fossil aquifers that are highly susceptible to overuse and contamination (UNICEF, 2021; Wikipedia, 2025).

Lake Chad, shared by Chad, Niger, Cameroon, and Nigeria, has lost nearly 90% of its surface area over the past six decades due to climate change, population growth, and increasing demands for irrigation. This dramatic shrinkage has affected the livelihoods of more than 30 million people, triggering widespread water stress, a collapse in fisheries, forced migration, reduced agricultural productivity, and heightened conflict over dwindling water resources (AP, 2023; Chicea & Olaru, 2023; Daily Trust, 2023; Global Tipping Points Report, 2023).

Flooding

Global warming is believed to be a major factor contributing to frequent flooding along North Africa's Mediterranean coast, affecting countries such as Libya, Morocco, Tunisia, Algeria, and Egypt. In Libya, Storm Daniel a Mediterranean hurricane-like storm struck in September 2023,

delivering an equivalent annual worth of rainfall within just 24 hours. This extreme weather event caused the collapse of two dams upstream of Derna, unleashing a catastrophic wall of water that destroyed the city, killed between 5,923 and 11,300 people, and left thousands missing (World Weather Attribution, 2023; “Derna Dam Collapses,” 2025). Contemporary analyses confirm that climate change made the storm up to 50 times more likely and increased its intensity by 50% (AP News, 2023; *Scientific American*, 2023). Poor infrastructure and decades of neglected dam maintenance exacerbated by long-term conflict also contributed significantly to the scale of the disaster (CEOBS, 2023; Libya Floods, 2023).

In Egypt, the coastal city of Alexandria home to over 5 million residents faces escalating flood risks due to sea-level rise and land subsidence. Since 2015, torrential rains and coastal flooding have resulted in fatalities, damaged vital infrastructure, and worsened groundwater salinity through seawater intrusion (Egypt Today, 2021; Voice of America [VOA] News, 2023). Scientists estimate that sea levels have been rising at 3.2 mm annually since 2012, with projections suggesting a rise of up to 0.74 meters by 2100. This could submerge up to 30% of Alexandria’s landmass and necessitate the relocation of 1.5 million residents (Carnegie Endowment, 2025). Despite the construction of protective barriers and seawalls, there are ongoing concerns about their long-term effectiveness and durability (The Guardian, 2025).

Social Impacts

Some of the consequences of global warming, such as water and food shortages, unemployment, poverty, conflicts for competitive resources, and human insecurity in some parts of Sudan, Mali, and Chad are readily discernable in many parts of the region. Desertification, water and food insecurity, resource inadequacy, underemployment or total unemployment, poverty, conflicts in Sudan, Mali and Chad have greatly impacted on the social setting in those countries. These unfavorable social impacts have lots of negative effects on individuals and their families leading to frequent conflicts, displacements, relocations and forced migrations (Price, 2017).

The repercussions of climate change in Saharan and Sahel regions particularly Sudan, Mali, and Chad are creating cascading social crises marked by food and water scarcity, economic instability, and escalating conflicts. In the Sahel, around 33 million people faced food insecurity in 2022, a crisis exacerbated by erratic weather and dwindling agricultural yields (Bushara, 2024). In Chad alone, 2.7 million individuals experienced acute food shortages during the 2024 lean season, and over 1.3 million refugees and returnees were residing in the country, placing stress on local resources and services (International Organization for Migration [IOM], 2025).

In Sudan, climate-driven resource competition further overlaps with violence and mass displacement. The Blue Nile clashes (2022–2023) over land and water displaced up to 235,000 people, while the broader civil war that began in 2023 has internally displaced more than 8.8 million and forced an additional 3.5 million to seek refuge abroad, many after their livelihoods collapsed amid drought and agricultural failure (UNHCR, 2025; Wikipedia, 2025). Climate variability such as repeated floods and dry spells has been identified as an exacerbating condition for communal conflicts, with water-point disputes in North Darfur serving as frequent flashpoints (NUPI, 2023).

In summary, global warming in Sahara-Sahel regions is not only a physical and ecological crisis, it is deeply humanitarian and developmental. With food shortages, mass displacement, and community fragmentation increasing, climate impacts are directly entwined with violence,

insecurity, and entrenched poverty. Meeting this challenge requires integrated responses that address ecological sustainability and social resilience together.

Migration

Migration from Saharan countries including Algeria, Chad, Libya, Mali, Morocco, Tunisia, and Sudan is increasingly driven by environmental stressors such as drought, water scarcity, land degradation, and community tensions. In May 2025, seven Sudanese migrants died of dehydration after being left in the desert near Kufra, while 22 survivors, including five children, were rescued after 11 days (Blackburn & Associated Press [AP], 2025). According to the International Organization for Migration (IOM), approximately 787,000 migrants and refugees currently reside in Libya, many of whom endure perilous conditions due to armed smuggling networks and desert abandonment (IOM, 2025).

Internal and cross-border movements are also significant in Algeria, where migrants from Mali, Niger, and other Sub-Saharan countries live in informal settlements amid persistent insecurity. Between August 2023 and mid-2024, thousands were deported or disengaged often into desert regions. In 2023, approximately 350 migrants were stranded near Ras Jedir before Tunisia and Libya reached an agreement to share responsibility for about 300 people, relocating them to reception centers in Tatouine and Medenine (Info Migrants, 2024).

These precarious journeys reflect broader European Union (EU)-backed policies that funnel migrants into North African deserts. Since 2015, Morocco, Tunisia, and Mauritania have received over €400 million through the European Emergency Trust Fund to curb arrivals. Despite these efforts, reports continue to surface of desert abandonments and human rights abuses (Le Monde, 2024).

The human toll is immense as migrants face torture, forced labor, and extortion in Libya's detention centers, which hold thousands in inhumane conditions (The Guardian, 2024; Info Migrants, 2024). Hundreds die yearly enroute to Europe. In 2024 alone, over 674 migrants perished at sea off Libya's coast, with many more missing or unaccounted for (AP News, 2024).

These migration patterns create complex social challenges in host areas, including urban slums in Nouakchott, Rabat, Algiers, Tunis, Tripoli, and Benghazi. Cultural differences, strained infrastructure, and scarce resources often fuel xenophobia, community tensions, and localized violence (Price, 2017). Migrants frequently reside in overcrowded camps, lacking access to healthcare, shelter, and sanitation, deepening their vulnerability and inflames grievances among host communities. In some cases, such as the forced mass deportations from Algeria these actions further exacerbate trauma and social fragmentation (Info Migrants, 2024).

Potential Opportunities Derivable from Global Warming

Renewable Energy Potential

North Africa's geographic advantages—vast desert lands, long hours of sunlight, and strong wind corridors position the region as a renewable energy powerhouse. The Sahara Desert, with over 3,500 hours of sunlight annually, has unmatched solar potential that can support some of the world's largest solar farms (IRENA, 2023). Morocco's Noor Ouarzazate Solar Complex, one of the largest concentrated solar power facilities globally, generates over 580 MW of electricity, providing power to more than 2 million people and significantly reducing carbon emissions (African Development Bank [AfDB], 2023). Similarly, Egypt's Benban Solar Park produces

approximately 1.8 GW, contributing substantially to the government's goal of deriving 42% of its electricity from renewable sources by 2035 (World Bank, 2022).

The potential does not end with solar energy. Wind power in the region is also promising, particularly along the Atlantic coast and Red Sea corridors. Morocco's Tarfaya Wind Farm and Egypt's Gabal El-Zeit Wind Farm each generate over 300 MW (Nareva, n.d.; United Nations Sustainable Development [UNSD], n.d.). Beyond domestic energy supply, Algeria, Tunisia, and Libya are advancing projects in green hydrogen production using solar and wind power for export to Europe a move expected to generate new revenue streams and foster international climate cooperation (IRENA, 2024).

Employment Opportunities

The shift to a green economy presents major employment prospects across diverse sectors such as construction, maintenance, manufacturing, research, and green entrepreneurship. Renewable energy projects are inherently labor-intensive during construction and operation phases. Morocco's solar energy sector alone has created over 11,000 direct and indirect jobs, while projections indicate that the broader green economy could add 270,000 jobs by 2030 (Global Center on Adaptation [GCA], 2023). Egypt's renewable energy expansion has equally driven job creation in areas like solar panel installation, power grid integration, and clean technology innovation (IRENA & International Labour Organization [ILO], 2023).

Furthermore, initiatives such as climate-smart agriculture, agroforestry, and reforestation including the Great Green Wall Initiative are engaging thousands of youths and women in land restoration and environmental conservation across the Sahel and North Africa (Food and Agriculture Organization [FAO], 2023).

Technological Innovations

Rapid technological advances in climate adaptation and mitigation are reshaping North Africa's response to global warming. Governments and private actors are investing in drought-resistant irrigation systems, solar-powered cold chains, blockchain-based carbon markets, and mobile applications for real-time weather forecasting. In Tunisia and Egypt, digital platforms such as CLIMVEST and Agri Predict leverage artificial intelligence and predictive analytics to deliver localized weather updates, pest alerts, and soil health data to farmers, enabling data-driven agricultural decision-making (GSMA, 2024).

These technological solutions narrow the information gap between large-scale and smallholder farmers, allowing for more resilient agricultural systems and increased productivity. According to International Renewable Energy Agency [IRENA] (2023), innovation in renewable and digital technologies has become central to Africa's climate adaptation strategy, with renewable energy investments catalyzing parallel growth in digital entrepreneurship. Such innovations exemplify how climate challenges are being converted into technological opportunities that stimulate green growth.

Development of SMART Agricultural Practices

Sustainable Management and Resilient Technologies (SMART) agriculture is gaining ground across North Africa as an effective adaptation strategy to global warming. Practices such as conservation agriculture, drip irrigation, vertical farming, and agroforestry have been widely adopted to enhance soil fertility and optimize water use. In Morocco, solar-powered drip irrigation systems and compost-based soil regeneration have reportedly increased farm yields by

up to 60% while reducing water use by 40% (FAO, 2023). Similarly, Algeria's adoption of water-efficient greenhouse technologies and Egypt's experiments with AI-enhanced vertical farming in arid zones demonstrate region-wide commitment to SMART agriculture (UN Convention to Combat Desertification [UNCCD], 2024).

These sustainable approaches not only enhance agricultural productivity but also support ecosystem restoration, biodiversity protection, and long-term food security. As a result, SMART farming techniques are transforming global warming's threats into opportunities for climate-resilient agriculture and sustainable rural development.

New Skills Acquisition by Migrants

Migrants in transit or host countries are increasingly acquiring green skills that enhance employability and resilience. In Libya and Tunisia, UNDP and IOM have implemented programs offering vocational training in solar panel installation, waste recycling, sustainable construction, and green entrepreneurship (International Organization for Migration [IOM], 2023). These initiatives empower migrants with transferable competencies that can be utilized across borders whether they return home, remain in host countries, or continue onward migration.

In Tunisia, vocational training centers are open to both migrants and local youth, fostering social cohesion and labor market integration. This inclusive model transforms migration from a vulnerability into an opportunity for skill development and sustainable livelihoods. As noted by the Global Center on Adaptation (2023), such programs not only contribute to individual empowerment but also help bridge the regional skills gap in emerging green sectors.

Development of New Varieties of Disease-Resistant Crops and Livestock

Research institutions across North Africa are pioneering the development of climate-resilient crops and livestock capable of thriving under harsh environmental conditions. In collaboration with the International Center for Agricultural Research in the Dry Areas (ICARDA), Egypt's Ministry of Agriculture has developed salt- and heat-tolerant wheat, sorghum, and barley varieties suited to desert environments (ICARDA, 2024). These resilient strains require less water and withstand rising soil salinity critical for sustaining yields in semi-arid regions.

Flood Water Harvesting and Preservation

As flooding becomes more frequent due to climate change, North African countries are implementing floodwater harvesting and preservation systems to mitigate losses and enhance water security. In Morocco's Tiznit and Tata provinces, catchment systems have been constructed to capture runoff for agricultural use, while Tunisia has rehabilitated urban wetlands to manage flash floods (UN Environment Programme [UNEP], 2023). In Sudan and Chad, Food and Agricultural organization [FAO]-led initiatives support the construction of small dams and sand storage systems to preserve floodwaters for dry-season irrigation (FAO, 2023).

These measures transform destructive floods into valuable water resources, supporting agriculture, recharging aquifers, and improving community resilience. With appropriate scaling, floodwater harvesting can serve as both an adaptation and economic opportunity, reinforcing regional strategies for sustainable water management under a changing climate.

Adaptation and Resilience Building Policy Implications

Sahara Africa is highly vulnerable to the harsh effects of global warming that have severely impacted human health, agricultural and livestock productivity, income capacity, and the

socioeconomic development of the region (UNEP, 2023; IPCC, 2022). These impacts necessitate urgent mitigation, adaptability, behavioral change and resilience building through appropriate policy mainstreaming that promotes efficient water and land use management, reforestation and coastal shore protection (FAO, 2023). Governments must also strengthen local adaptive capacities by integrating climate resilience into national planning and resource allocation frameworks.

Resilience building according to Folke et al (2016) includes both coping strategies (immediate response to climate stresses) and adaptive capacities (long term adjustments in institutions, technological innovations and behavioral changes) based on a socio-ecological resilience framework which posits that vulnerability is not only determined by exposure to climate change hazards but also by the capacity of social and ecological systems to absorb shocks, adapt, adopt and transform (Folke et al, 2016)

Despite the harsh environmental weather characteristics in the Sahara, the region can take advantage of the immense potential opportunities for developing renewable energy resources that can be derived from solar, wind, and coastal waves (IRENA, 2024). Policies encouraging investment in large-scale solar power plants such as Morocco's Noor Ouarzazate and Egypt's Benban Solar Park should be replicated across other North African states to ensure energy diversification and reduce dependence on fossil fuels. Regional energy cooperation, supported by the African Continental Free Trade Area (AfCFTA), can facilitate cross-border renewable energy exchange, thus, contributing to energy security and supporting industrialization (World Bank, 2022; GCA, 2023).

Furthermore, the green economy transition provides opportunities for job creation and skills development, especially among youth and women. Governments should introduce incentives for private sector participation in green innovation, research, and sustainable infrastructural development (ILO: 2023). Policy frameworks like Morocco's Green Jobs Strategy and Egypt's Sustainable Development Strategy 2030 offer replicable models that link renewable energy expansion with vocational training programs for solar, wind, and recycling industries (UNDP, 2024).

To address human health impacts, public health care policies must incorporate climate adaptation measures such as disease surveillance systems, community awareness programs, and improved water sanitation management to prevent outbreaks of vector-borne and water-borne diseases exacerbated by changing climatic conditions (World Health Organization [WHO], 2024).

Agricultural and food insecurity should be tackled through policy measures that promote efficient land use, climate-smart irrigation, and integrated water management systems. Governments should encourage floodwater harvesting, channelization into artificial lakes, and the adoption of sustainable soil regeneration practices, including composting and reforestation to combat desertification (FAO, 2023; ICARDA, 2024). Promoting climate-resilient crops, such as salt-tolerant wheat and drought-resistant sorghum, could strengthen food systems and enhance nutrition security across arid regions (ICARDA, 2024).

To minimize migration pressures, policies should target the root causes of displacement mainly declining agricultural productivity and resource scarcity. Investments in local employment, renewable energy enterprises, and sustainable farming will not only stabilize livelihoods but also make migration less necessary (IOM, 2023). Integrating migrants into green training programs will foster inclusion and strengthen host-migrant relations through shared economic participation

Preventive measures against flooding including dam construction, urban drainage systems, and vegetative cover should be prioritized under national adaptation plans. Countries like Tunisia and Morocco have demonstrated success through catchment systems and wetland restoration projects (UNEP, 2023).

To combat acute water shortages, national water strategies must prioritize efficient treatment and reuse technologies, deep borehole drilling, protection of aquifers, and the construction of micro-dams for irrigation (GWP, 2023). Public-private partnerships can enhance investment in water infrastructure while integrating digital monitoring tools for efficient allocation.

Finally, the social dimensions of climate change require a participatory policy approach that promotes community engagement, peacebuilding, and social cohesion between migrants and host populations. Environmental education and awareness programs can further strengthen local adaptive behavior, fostering collective responsibility in addressing the global warming challenge.

Conclusion

For several decades, there have been serious concerns about the negative impacts of global warming in the African Sahara. This paper examined the various human and social effects and found that the major consequences of global warming such as water scarcity, soil degradation, low agricultural productivity, migration, flooding, and health challenges can be mitigated through integrated adaptation and innovation strategies. The region's vast natural resource endowments hold great renewable energy potentials and provide opportunities for resilience building for sustainable transformation. Harnessing these natural endowments could propel green industrialization and energy independence. Addressing climate challenges in the Sahara region is not only a continental priority but a global imperative for achieving sustainable development in the region.

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