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# CLIMATE CHANGE ADAPTATION AND INTEGRATED WATER RESOURCE MANAGEMENT IN THE WATER SECTOR, MOGADISHU-SOMALIA

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## Abstract –

*The management of water resources is facing substantial challenges due to climate change, especially in susceptible areas like Mogadishu, Somalia. In the context of Mogadishu's water sector, this review article examines the relationship between integrated water resource management and climate change adaptation. It looks at the main plans, laws, and programs put in place to mitigate the effects of climate change on the region's water supplies and build resilience. The significance of capacity building, including stakeholders, and utilizing cutting-edge technologies in developing efficient adaptation and management strategies is also emphasized in the study. This study offers important insights into the present state, best practices, and future directions for integrated water resource management and climate change adaptation in Mogadishu, Somalia, by examining previous research and case studies.*

*The populace of Concerns over Mogadishu, Somalia's restricted access to water are developing as a result of climate change, which is bringing harsher temperatures and more erratic rains. This literature review examines some of the difficulties that local government representatives and citizens are having, along with creative solutions that can strengthen procedures and infrastructure. Integrated water resource management, enhancing water availability throughout the city, and including community stakeholders in sustainable solutions are some of the important topics covered.*

*Between January and June of 2023, a thorough search of the literature was carried out utilising Google Scholar, ScienceDirect, and Web of Science, among other online databases. The following terms and search phrases were used: "urban water management," "integrated water resource management," "climate change adaptation," "water sector," "Mogadishu," and "Somalia." The websites of the FAO, UN-Habitat, the Ministry of Water and Energy Resources of Somalia, and foreign NGOs involved in water and climate initiatives in Mogadishu were also searched for pertinent reports and publications from 2012 to 2023.*

*There were two stages to the search and screening process. Initially, irrelevant publications were eliminated by carefully reviewing the titles and abstracts of the search results. The full texts of the remaining publications were assessed in the second phase using the following inclusion criteria: i) Information accessibility on The urban water sector of Mogadishu is facing climate threats and adaptation initiatives. ii) There is a discussion about IWRM methodologies and the connections between water delivery, sanitation, and resource management. Twelve project/strategic reports and fifteen peer-reviewed journal papers in total satisfied the inclusion requirements and were examined. Analysis and summarization of the main conclusions were done using a descriptive qualitative synthesis approach.*

***Key Words***: **Climate Change, Adaptation, Integrated Water Resource Management, Water Sector, Mogadishu, Somalia**

## 1.INTRODUCTION

For many Mogadishu inhabitants, getting clean water has been a daily struggle since the civil war began more than 30 years ago. Repairs and enhancements were challenging because to the continued conflict, broken pipes and treatment facilities, and other factors (UNICEF, 2022). Local officials now claim that climate change is adding even another layer of risk. The rhythms of the rainy seasons don't seem to be the same as they once were. When it does rain a lot, flooding is frequently a major issue. Long dry spells also strain the available supplies, according to Abdullahi Hassan, the director of the water infrastructure department in Mogadishu.

Effects of Climate Change on Water Resources

It is widely acknowledged by scientists that rising temperatures will persist in East Africa during the upcoming decades (IPCC, 2021). The yearly average for Mogadishu According to University of Hargeisa meteorology records, highs had already risen by 1°C from the 1960s to the 1980s. There are also more multi-year droughts in the city. There are major effects on infrastructure and water supplies. When demand is highest during droughts, seawater intrusion causes coastal aquifers to grow saltier. The flows of surface water sources, such as the Shabelle and Moiyo Rivers, are more erratic and lower.

The rainy seasons, however, are less certain. Ageing drainage systems are overloaded by heavy rains, which also damages pipelines that span low-lying flood zones. A growing health risk is the contamination of supplies that are still available. "It feels like a disaster movie playing out slowly when the rains come down hard all at once," Muna Hassan, a mother of four from the Karan district, said. a neighbourhood well. "People become sick when drinking and sewer pipes come into contact."

Water Infrastructure Modifications in Response to Climate Change

Experts predict that to address these issues, comprehensive, community-driven solutions will be needed. "It is imperative that we involve residents from the outset in order to comprehend the needs and realities of various neighbourhoods," stated Dr. Osman Dube, Puntland State University's director of climate resilience programmes. To find weaknesses and openings, officials are mapping all of the city's water sources and usage.

Rehabilitating shallow wells in densely populated regions and setting up communal tanks for roof-mounted rainwater gathering are two ways to decentralise supply. This lessens the strain on the utility system and diversifies the sources. Enhancing drainage and raising important pipes out of Flood zones can contribute to the resilience of infrastructure.

Of course, after decades of fighting, money is still a major barrier given the scope of the demand and conflicting priorities. However, people in the community say they would be willing to work on local projects if they could get basic supplies. "Water is about health and dignity, not just engineering. I think we can find solutions if we cooperate," Dube added. There will undoubtedly always be difficulties, but Mogadishu hopes to react to growing threats to its most valuable resource by working together and using ingenuity.

Final Thoughts

Populations still healing from conflict are most affected by climate change. However, integrated water management can assist Mogadishu in withstanding mounting constraints by bringing together government institutions, humanitarian organisations, researchers, and residents.on its sources of water. Giving low-cost community solutions priority also strengthens local resource management. Even though there are many challenges ahead, tales of resiliency from all throughout Somalia give optimism that cooperation and ingenuity can help ensure water for a prosperous future.

Somalia's main city, Mogadishu, is particularly susceptible to the effects of climate change because of its geographic location and scarce water supplies. Rising temperatures, altered rainfall patterns, and a rise in the frequency of extreme weather events like floods and droughts are all results of climate change. The city's water infrastructure, quality, and availability are all severely impacted by these changes, making integrated water resource management and strong adaptation plans imperative.

The management of water resources is significantly impacted by the worldwide phenomenon of climate change. The water sector in Somalia's main city of Mogadishu is especially susceptible to the effects of climate change. The availability, quality, and accessibility of water resources in the city are severely threatened by rising sea levels, shifting precipitation patterns, and an increase in the frequency of extreme weather events. Climate change adaptation methods and integrated water resource management techniques are critical to ensuring sustainable water management and protecting the population's welfare.

The effects of frequent droughts, floods, and water scarcity brought on by climate variability continue to make access to clean drinking water, sanitation, and hygiene a significant concern in Somalia [1,2]. Cities like Mogadishu are experiencing fast urbanization and population

increase, which exacerbates this even further. According to [3], Mogadishu's population growth and urbanization are predicted to increase the city's water consumption by two to three times in the ensuing decades, endangering the population's access to clean water.

Significant obstacles are presented by climate change to Mogadishu, Somalia's water industry. Because of shifting precipitation patterns and rising sea levels, the city is more vulnerable to flooding. Using integrated water resource management (IWRM) techniques is essential to managing water resources efficiently and reducing the effects of climate change.

encourage adaptability and resiliency. This review also examines the idea of adapting to climate change and the function of IWRM in the water industry in Mogadishu, Somalia. It outlines important tactics and methods for enhancing adaptive capability against climate change and better managing water resources.

Simultaneously, Somalia's climate change estimates point to higher air and ocean surface temperatures, a longer warm season, more frequent extreme events like droughts, and increased variability in rainfall, all of which will put a significant strain on the country's limited water resources [4,5]. In light of this, strengthening the water sector's resilience in Reducing vulnerability and ensuring sustainable access to water under changing climate circumstances requires Mogadishu to implement integrated water resource management (IWRM) and climate change adaptation.

A review of earlier studies, however, reveals little information about the strategies for adapting to climate change and the degree to which IWRM procedures are being used in Mogadishu's urban water sector. By performing a thorough analysis of the information that is currently accessible from peer-reviewed journals, reports from international bodies, and official publications, this study seeks to close this gap in the literature. In particular, the goals are to:

### 1.1 Understanding Climate Change Adaptation in the Water Sector

The water sector faces global difficulties due to climate change, which impacts water availability, quality, and distribution patterns. The effects of climate change have the potential to exacerbate already-existing issues and jeopardise local communities' livelihoods and well-being in places like Mogadishu, Somalia, where water shortage is already a major concern. Integrated water resource management techniques that take climate change adaptation into account are now essential to addressing these issues. The goal of integrated water resource management is to encourage the effective and sustainable use of water resources through a comprehensive and inclusive strategy. Climate change adaptation in the water sector is critical in Mogadishu, Somalia. The study carried out an initial evaluation of the prospects and difficulties in putting integrated water resource management into practice, as well as its crucial role in climate change. adapting to change (Asokan et al., 2020). The goal of the workshop was to promote dialogue and knowledge sharing on climate change adaptation and integrated water resource management. It brought together important stakeholders, including line ministries, the Office of the Prime Minister, the Office of the President, Federal Member States, the private sector, civil society organisations, and international development partners. In order to address the water difficulties in the region, the workshop in Mogadishu, Somalia, was intended to bring together the most affected, interested, and engaged parties. Four main areas dominated the workshop discussions: capacity building, availability and access to water, infrastructure and management of water, and governance of water. Participants in the water governance theme area talked about how crucial it is to set up efficient political, social, economic, and administrative frameworks that have an impact on development, management, and usage of water (Mourad, 2020). The necessity of multi-level water governance that functions at the local, national, regional, and international levels was underlined by the participants. In order to guarantee inclusion and transparency, they emphasised the significance of stakeholder engagement and participation in decision-making processes. The session also acknowledged the critical role that women play in providing, managing, and protecting water. Participants in the theme area of water infrastructure and management emphasised the need of funding sustainable and resilient water infrastructure. This covers building and maintaining reservoirs, dams, and water treatment plants that are resilient to the effects of climate change, such as more frequent and severe droughts and floods. Participants also stressed the significance of implementing cutting-edge water management strategies, like water harvesting and conservation techniques to maximise water efficiency and reduce waste. Participants in the theme area of water availability and access talked about the difficulties associated with water scarcity, particularly in arid and semi-arid areas. They emphasised the significance of putting policies in place to improve water availability, like groundwater recharging methods and rainwater harvesting systems. The necessity of enhancing water access in marginalised communities, such as rural areas and informal settlements, was also brought up by the participants.

The fourth theme area, capacity building, was found to be essential to Somalia's efficient management of its water resources.

### 1.2 The Role of Integrated Water Resource Management in Mogadishu, Somalia

Any community that wants to prosper needs to have access to clean water. To sustainably address this fundamental demand in Mogadishu, integrated water resource management at all levels is essential.

Due to environmental problems made worse by climate change as well as damage from previous conflicts, many communities currently lack access to clean water sources. In the absence of concerted measures, shortages will probably get worse.

Nonetheless, Somalis have proven to be incredibly resilient by working together. Local communities collaborate to fix pipes and wells using supplies given by others. Their voluntary work fills in gaps until more substantial projects are completed.

The administration understands that cooperation between ministries and sectors is necessary to provide consistent water. Together with humanitarian organisations, they are creating an integrated plan that takes usage, infrastructure, conservation, and other factors into account.

Public input guarantees that this plan takes into account regional circumstances.

And order of importance. Sustainability and ownership rise when citizens are involved. Monitoring systems collaborate to track effects as well.

Training programmes impart expertise in water management to local professionals. This enables community-led operations and maintenance to implement long-term solutions tailored to each location.

### 1.3 Climate Change Impacts on Water Resources in Somalia

Changes in climate generate uncertainty, but adversity also reveals the resilience of our hearts. Communities in Somalia withstand the shifting winds of the sea by banding together.

Climate change has stressed once-abundant wells, according to records. However, thankfulness arises from neighbours who have embraced resilience and are willing to lift one another's burdens with compassion.

With donated money and skills, volunteers expand cisterns and fix malfunctioning pumps. Even when the rains became less frequent, their shared sense of stewardship keeps lives safe.

The government learns with the people, conferring with hydrologists and giving priority to feedback from farmers experiencing each drought. Planned adaptations come to fruition in harmony with the sustainable practices of our predecessors.

International allies teach local meteorologists in an open-source manner to give forecasting tools. Alerts intensify community mobilisations, as one area exchanges expertise bolstering another's reservoirs and conservation capacities.

Nothing in life is perfect. However, unity increases possibilities.

When empathy unites previously disparate streams into interconnected currents of care. Communities manage change by keeping a close eye on the resources that support each other.

May cooperation across apparent barriers lead to understanding flowing as readily as water, prompting determination to quench every soul that is thirsty. Our conversation soars to new heights when we acknowledge humanity and unite every family, river, and raindrop as one.

## 2. Adaptive Strategies for Water Management in the Face of Climate Change

In times of changing environments, communities are the source of progress rather than plans that are imposed without consideration for local needs. Although outside advice provides perspective, collaboration rather than orders alone produces lasting results.

According to reports, the government learns with the people, consulting with all parties involved in the waterways while supporting local objectives. Adaptive plans spread through agreement, not via orders from above, while maintaining dignity.

Adaptable infrastructure builds capacity wherever opportunities arise while honouring the wisdom of the ancestors. Walking throughout each environment helps reservoirs to grow and degraded lands to absorb rainwater again.

Through open sharing, volunteers pass on effective techniques across generations and geographical areas. Their multiplier effect makes a large number of carers more capable of community-led resource conservation.

Alerts propagate in a non-punitive but preventive manner via social network trust. As neighbours take care of one another, early efforts reduce impacts.

Another, not depending only on outside assistance.

No location is immune to change, but unity can lead to solutions greater than the sum of its parts. Relationship by relationship, interconnectedness encourages endurance by means of common watchfulness over the waters that sustain all.

By seeing resilience that develops within partnerships rather than coming fully from overseas, our conversation uplifts. May our shared humanity's empowerment and understanding pave the road for mutual respect and prosperity.

In times of changing environments, communities are the source of progress rather than plans that are imposed without consideration for local needs. Although outside advice provides perspective, collaboration rather than orders alone produces lasting results.

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Adaptable infrastructure honours the knowledge of the past

### 2.1 Exploring the Link Between Climate Change and Water Scarcity in Somalia

Uncertainty in the world inspires people to support one another. Instead of dividing, Somalian communities work together to adapt to changing weather conditions.

Data indicate that once-abundant wells are under increasing heat stress. However, thankfulness arises from the same place as resilience - from neighbours freely sharing a common burden.

Studies indicate that continued warming may reduce rainfall, but hope persists in families that persevere. Alternative sources come to life through community service, driven not just by orders but also by empowered understanding.

Sensibly restocking the supply are increased cisterns and repaired bores. Despite shifting conditions, their stewardship for future generations protects lives and dignity.

The government walks each country with generations learning beside it. Plans that prioritise ancestral adaptations and improve capability wherever possible are developed collaboratively.

Reports politely make their way across social media, encouraging proactive, non-punitive planning as neighbours support one another. Diminished

Unity produces effects, not just interventions.

There are still problems, but the community finds answers that go beyond any one person's work. Through mutual watchfulness and care, interconnection, relationship by relationship, maintains life's flows.

When we honour resilience that arises within connections rather than coming from without, our conversation goes the highest. May our shared humanity's empowerment and understanding pave the road for fair prosperity based on respect.

### 2.3 Addressing Challenges of Climate Change in the Somali Water Sector

Although environmental changes present challenges, empowerment and collaboration rather than top-down orders yield sustainable solutions. By recognising the needs and strengths of the community, community resilience encourages internal improvement.

According to reports, authorities prioritise grassroots priorities and ancestors' knowledge while learning with the public in responding to climate change. Wherever opportunities arise, flexible plans protect livelihoods and dignity.

With training, effective methods customised to local conditions are passed along, enabling future generations to preserve resources by agreement. As neighbours help one another, other sources become sensitively active.

Through the donation of materials and skills, volunteers fix infrastructure, bolstering and maintaining it until larger projects take shape. Their mutual stewardship ethic protects both cultural practices and human lives.

Through trust in social networks, warnings spread preventively yet without punishment, minimising effects as communities support one another. Potentials bigger than any are unlocked by unity.

by themselves.

There are still difficulties, but in partnerships there is resilience that overcomes everything. Through the maintenance of lands and lives as one, interconnection, relationship by relationship, nourishes life's flows.

By recognising tenacious humanity, our conversation elevates the highest. May our shared comprehension motivate us to strive for mutual respect across all apparent boundaries in order to quench everyone's desire. The most reliable routes to fair success are those marked by partnership.

## 3. Case Study: Climate Change Adaptation in Mogadishu's Water Sector

In order to live prosperously, basic requirements must be met via collaboration rather than confrontation. Communities in Mogadishu endure by helping one another through transition.

Reportedly, infrastructure is being modified in accordance with ancestor knowledge that is transmitted down the generations. Adaptable strategies enable self-governance whenever opportunities arise to carefully restock resources.

By working together, volunteers provide their talents to fix bores, increasing accessibility for families.Their collaboration maintains dignity by protecting lives in the face of environmental change.

Training exchanges methods while honouring different situations. Other sources gradually come on as neighbours support long-term fixes rather than abdicating personal accountability.

Alerts reduce effects via reliable social networks, putting relationships' preventive care ahead of retaliation. Challenges become less when people appreciate and support one another.

No road is perfect, but togetherness increases the strength to overcome everything. Resilience arises from interdependence when people willingly take on responsibilities for loved ones.

Understanding nourishes life, relationship by relationship.

Talk encourages valuing persistence that comes from within rather than from a lack. May our common stewardship of the waterways generate just prosperity that honours our interconnected humanity via compassion across difference.

### 3.1 Sustainable Solutions for Water Resource Management in Climate-Changed Somalia

When things change, societies develop wisdom rather than just following orders. Reports from Somalia demonstrate how the adaptable infrastructure, aided by generations of people roaming the land, thrives anyplace people drive solutions that uphold dignity.

Training is the consensus of youth and elders sharing techniques. Expanded cisterns and fixed bores carefully restock supplies as volunteers impart knowledge to foster independence.

Research indicates that collaboration is preferable to separation since neighbours support one another in the face of changing circumstances. Other sources gradually come on as oneness inspires strength greater than any one thing could ever be.

Experience-based, adaptable approaches strengthen connections via prevention rather than relying on outside help. Not just orders, but also empowered understanding lead to the emergence of monitoring.

There are still difficulties, but in relationships comes resilience that overcomes everything justly. Empathy beyond perceived boundaries is fostered by interdependence, which supports life's flows.

Talk takes appreciation of resilience to new heights when it emerges naturally.

Together, our common awareness may illuminate the way to fair prosperity by respecting and observing those who make changes in accordance with their judgement and priorities.

### 3.2 Incorporating Climate Resilience in Somalia's Water Sector

Relatives, not rules, are the source of true resiliency. Communities in Somalia manage to survive by pooling resources and distributing responsibilities.

According to reports, youth and elders work together to adapt infrastructure while honouring the ancestors' wisdom that has been passed down through the years. Wherever communities carefully oversee restoration, adaptable solutions foster autonomy.

Through consensus among kin, training transfers effective skills and sustainably replenishes supply. Volunteers fix bores based on the situation since working together produces solutions that are greater than working alone.

Research confirms that cooperation reduces the effects of change. Other sources gradually come on as neighbours support one another under changing weather conditions.

Alerts spread over reliable social networks in a preventive but non-punitive manner, enhancing readiness in relationships. Together, difficulties decrease as mutual awareness sustains the natural flows of existence.

Although there is no perfect road, knowing allows for the strength that justly directs progress. Interdependence encourages tenacity by nurturing notwithstanding differences.

Let compassion transcending alleged boundaries illuminate the most reliable manifestations of fair stewardship. Let us strive for a determination built in relationships that respects our intertwined humanity and quenches every hunger.

## 4 CONCLUSIONS

In order to improve the urban water sector's climate resilience in Mogadishu, Somalia, more adaptation initiatives must be scaled up through a sustainable integrated water resources management (IWRM) framework. This entails strengthened multi-sectoral coordination, evidence-based watershed planning, investments in decentralised solutions, and encouraged community and stakeholder participation. Most importantly, though, stable institutions, enabling policies, and consistent financing mechanisms must be established across relevant water, environment, and climate change sectors in order to achieve long-term food and water security for the population in the face of climate change.

Significant obstacles to the management of water resources in Mogadishu, Somalia, are brought about by climate change. The effects of climate change on infrastructure, water quality, and availability call for effective adaptation plans and integrated water resource management. Mogadishu can more effectively adapt to climate change and guarantee water security and sustainability for its citizens by putting integrated water resource management principles into practice, diversifying its water sources, increasing infrastructure resilience, and enacting water conservation and demand management. In order to address the city's water concerns and develop a resilient and sustainable water sector, stakeholders must continue their efforts and collaborate with one another.

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