Eleventh year Folder: 11 N°:01 PP: 600-579
ISSN 2543-375X EISSN 2676-1645

Environmental Protection and Water Security in the Era of Climate Change: Towards Sustainable Development in the Arab Region

حماية البيئة والأمن المائي في عصر التغير المناخي: نحو تنمية مستدامة في المنطقة العربية

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Received: 2025/09/26 Accepted: 2025/11/01

Abstract:

This research highlights the complex interconnectedness of climate change, water security, and environmental protection. It poses a central problem: how to achieve sustainable development in the face of these escalating challenges. The analysis deconstructs the different dimensions of this problem, starting from the direct effects of climate change on the hydrological cycle and ecosystems, and extending to its economic and social repercussions, which may lead to conflicts and displacement. The research shows that while technological solutions, such as desalination and water reuse, are essential, they are insufficient without a comprehensive overhaul of environmental governance and public policies. The study reviews the changing geopolitical dynamics in shared water basins, highlighting opportunities for enhanced regional cooperation. This holistic approach is crucial, as it integrates innovative practices with ingrained ethical and legal frameworks to ensure environmental and social justice. The research concludes with a set of interconnected strategic recommendations that call for adopting a green-gray pathway that combines hard infrastructure with nature-based solutions, while focusing on building institutional capacity

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capable of turning challenges into opportunities, paving the way for a more resilient and sustainable future for the region.

Keywords: Climate Change; Water Security; Arab Region; Sustainable Development; Environmental Governance.

ملخص:

يسلط هذا البحث الضوء على الترابط المعقد بين تغير المناخ والأمن المائي وحماية البيئة. ويطرح إشكالية محورية، ألا وهي: كيف يمكن تحقيق التنمية المستدامة في ظل هذه التحديات المتصاعدة؟ يفكك التحليل الأبعاد المختلفة لهذه المشكلة، بدءا من الآثار المباشرة لتغير المناخ على الدورة الهيدرولوجية والنظم البيئية، وصولا إلى تداعياته الاقتصادية والاجتماعية، التي قد تؤدي إلى صراعات ونزوح. يبين البحث أنه على الرغم من أهمية الحلول التكنولوجية، مثل تحلية المياه وإعادة استخدامها، إلا أنها غير كافية دون إصلاح شامل للحوكمة البيئية والسياسات العامة. تستعرض الدراسة الديناميكيات الجيوسياسية المتغيرة في أحواض المياه المشتركة، مسلطة الضوء على فرص تعزيز التعاون الإقليمي. يعد هذا النهج الشامل بالغ الأهمية، إذ يدمج الممارسات المبتكرة مع الأطر الأخلاقية والقانونية الراسخة لضمان العدالة البيئية والاجتماعية. ويختتم البحث بمجموعة من التوصيات الاستراتيجية المترابطة التي تدعو إلى اعتماد مسار أخضر رمادي يجمع بين البنية التحتية الصلبة والحلول القائمة على الطبيعة، مع التركيز على بناء القدرات المؤسسية القادرة على تحويل التحديات إلى فرص، مما يمهد الطريق لمستقبل أكثر مرونة واستدامة للمنطقة.

الكلمات المفتاحية: تغير المناخ؛ الأمن المائي؛ المنطقة العربية؛ التنمية المستدامة؛ الحوكمة البيئية.

INTRODUCTION:

The Arab region is one of the driest and most water-scarce areas in the world, a geographical reality that is rapidly intensifying due to the effects of climate change. Many international reports classify the region as the world's poorest in terms of renewable water resources. This water scarcity is not a recent phenomenon; it is a natural feature of the region that has been exacerbated by rapid population growth and the expansion of economic activities like urbanization, industrialization, and irrigated agriculture over the past few decades, which have caused a huge increase in water demand.

The already fragile situation is compounded by the impacts of climate change. Temperatures in the Arab region are rising at nearly twice the global average, posing significant challenges to human livability, water

availability, and food security. Projections indicate that this rise in temperature, along with a projected decrease in rainfall and an increase in evaporation rates by the end of the century, will lead to a further reduction in food and water productivity by 2030. These alarming statistics confirm that water security in the region is not merely an environmental challenge but a fundamental component of food security, economic and social stability, and regional peace.

Research Problem and Questions

The central problem of this research revolves around the following fundamental question: How can sustainability be achieved in light of the increasing challenges facing the climate, water, and environment in the Arab region?

This primary question gives rise to several sub-problems that address different dimensions, most notably:

- What are the most significant challenges and impacts resulting from the organic link between climate, water, and the environment?
- How does climate change affect the water cycle and ecosystems, and what are the resulting consequences?
- What are the shared threats and incorrect environmental practices that exacerbate food, water, and climate security crises?
- What are the possible integrated and innovative solutions for achieving sustainable water management, smart agriculture, and developing health policies that are in harmony with climate strategies?
- How can technology and innovation, including geomatics, artificial intelligence, and renewable energy sources, contribute to serving sustainability and protecting ecosystems?
- What are the effective strategies for enhancing adaptation to climate change and building regional resilience in the face of environmental crises?
- What is the role of governance and environmental policies in confronting these challenges, and what are the most prominent international efforts made in this context?

Research Objectives and Importance

This research seeks to achieve several main objectives. First, to analyze the interconnectedness of climate, water, and the environment, and to identify the key challenges facing the Arab region in this context. Second, to study the impacts of climate change on the water cycle and ecosystems and propose scientific and practical solutions to mitigate their negative repercussions. Third, to explore integrated and innovative solutions to enhance sustainability, including sustainable water management, adopting smart agriculture, and utilizing technology. Fourth, to discuss adaptation strategies and promote regional resilience

in the face of crises. Finally, to evaluate the effectiveness of environmental governance and policies in addressing these challenges, while highlighting the role of ethical and religious principles like *Istikhlaf* in Islamic Sharia.

The importance of this study lies in its ability to go beyond a superficial analysis of the region's challenges to present a comprehensive and interconnected framework that integrates technological, policy, social, and ethical dimensions. This research helps fill a gap in the literature that often focuses on the technical aspects of water without giving sufficient attention to the social and policy dimensions. It also serves as a key reference for policymakers, researchers, and regional and international institutions by providing actionable insights that support efforts to achieve sustainable development in the Arab region.

Literature Review and Study Structure

The available literature shows that there are extensive research efforts in the Arab region, especially in the field of water management and desalination technology. Studies that combine the multiple dimensions of the crisis—between technology, policy, governance, geopolitics, and ethics—are still relatively few. This research aims to provide this integrated approach.

The structure of this research consists of eight main sections: the first provides the general framework for the topic, the second analyzes the interconnectedness of climate, water, and the environment and its impacts, the third reviews integrated solutions and technological innovation, the fourth discusses adaptation strategies and regional cooperation, the fifth evaluates the role of governance and policies, the sixth links environmental protection to Islamic Sharia and international law, the seventh reviews tangible Arab efforts, and the eighth and final section provides a conclusion and strategic recommendations.

2. The Climate-Water-Environment Nexus: Challenges and Impacts

2.1 Climate Change and Hydrological Changes

Climate change has a direct and profound effect on the hydrological cycle in the Arab region, as rising temperatures lead to increased evaporation rates from water bodies and soil. This rise in temperatures, coupled with a projected decrease in rainfall of up to 25% by the end of the century, leads to the depletion of both surface and groundwater resources (Shabbir & Behnassi, 2014, 15-38). The problem of water scarcity is exacerbated by salinization, which occurs when low groundwater levels allow saltwater from the sea to seep into freshwater aquifers, reducing the availability of water suitable for drinking and agriculture (Gamal et al., 2013, 157).

In addition to drought, climate change leads to an increase in the frequency and intensity of extreme weather events, such as flash floods (Ahmed et al., 2024). While floods may seem to be the opposite of drought, they are in fact a result of the same phenomenon: a disturbed water cycle. Long periods of drought make the soil unable to absorb water during heavy rainfall, leading to devastating floods that increase soil erosion and contaminate water resources. These changes in the hydrological cycle led to a decline in water quality, posing a double threat to water and environmental security in the region.

2.2 Environmental and Ecological Consequences

The effects of hydrological changes extend to vital ecosystems, where natural systems such as wetlands and forests are subject to degradation or complete collapse. These ecosystems are not merely natural areas; they are vital stations that provide "essential services" such as water purification, flood and drought mitigation, soil protection from erosion, and carbon storage (Maniar, 2025, 51-64). The loss of biodiversity and the degradation of these systems directly reduce the region's ability to naturally adapt to climate change, which exacerbates the environmental crisis. The more ecosystems degrade, the lower their ability to regulate the water cycle, leading to more drought or floods, in a vicious cycle of environmental degradation.

2.3 The Vicious Cycle of Climate-Induced Conflict and Displacement

The relationship between climate change and stability in the Arab region is not a linear one; rather, it is a complex vicious cycle where environmental degradation acts as a multiplier of social and political threats. This process begins with the immense pressure the region already faces due to natural water scarcity and rapid population growth. Climate change intensifies this pressure by reducing water availability (Gamal et al., 2013, 157), which leads to increased competition over scarce resources.

This competition can lead to social unrest and collective violence, as some research indicates that climate change is causally associated with collective violence when combined with other factors. In turn, armed conflicts lead to severe environmental degradation, as vital water infrastructure, including treatment plants and distribution networks, is damaged, which leads to the contamination and degradation of water resources (Khalifa & Al-Zu'bi, 2025, 671-684).

This degradation of water supplies exacerbates the original environmental crisis, leading to waves of internal and external displacement of populations who have lost their livelihoods or are no longer able to live in their affected areas (Chougrani & Behnassi, 2022, 129-148). Thus, the conflict sparked by water scarcity returns to exacerbate this scarcity, in a continuous cycle of degradation,

instability, and human suffering. Breaking this vicious cycle requires an integrated and multi-sectoral response.

2.4 Threats to Food and Socio-Economic Security

The impacts of these challenges go beyond environmental aspects to directly affect food security and livelihoods. Water scarcity linked to climate change is expected to lead to a drop in agricultural productivity by up to 60% in some countries by 2050 (Hejazi et al., 2023). This decline exacerbates the food security problem in a region that is already the most dependent on food imports in the world. Climate change also negatively affects economic growth in Arab countries, as economic losses associated with decreasing water availability are estimated at about 14% of the region's GDP by 2050 (Hilmi et al., 2023).

Additionally, about 45% of the agricultural land in the region is susceptible to salinization and soil degradation. These economic and environmental damages threaten the financial stability of countries, lead to an increase in the prices of basic goods, and increase poverty and population displacement rates.

Table 1: Key Indicators on the Climate-Water-Environment Nexus in the Arab Region

Indicator	Value
Per capita share of renewable water in the region	Less than 1,000 m³ per year (poverty line) and less than 500 m³ per year (extreme poverty line)
Expected temperature increase	May rise by 5°C by the end of the century
Expected rainfall decrease	May decrease by 25% by the end of the century
Expected economic losses	May reach 14% of the region's GDP by 2050
Expected decrease in agricultural productivity	May decrease by 60% in some countries by 2050
Percentage of agricultural land susceptible to degradation	About 45% of the total land area

Sources: (Hejazi, 2023), (Twining, 2018), (Hilmi, 2023), (Gamal, 2013)

3. Integrated Solutions and Technology in the Service of Sustainability

3.1 Integrated Water and Agriculture Management

In the face of scarce water resources, traditional solutions are not enough. It requires adopting innovative models for water management in arid and semi-arid regions. A large part of these models relies on developing non-conventional water resources, such as desalination and the reuse of treated wastewater. For example, Saudi Arabia relies heavily on desalination plants to meet more than 95% of their drinking water needs. The reuse of treated water, especially in the agricultural

and industrial sectors, also contributes significantly to relieving pressure on fresh water resources. (Laaouimri & Ourbak, 2024). In Algeria, these practices support a strong economy despite severe water stress

At the same time, adopting the concept of "climate-smart agriculture" is a crucial strategy. This concept is not limited to increasing agricultural productivity but also aims to build resilience in the agricultural sector and reduce greenhouse gas emissions. Examples include projects in Djibouti, Sudan, and Somalia that focus on building the capacity of farmers in rain-fed agriculture and pastoral practices, as well as providing micro-finance and weather-based index insurance services to protect farmers from the effects of climate change. The Global Environment Facility (GEF) supports these efforts by investing in climate-smart agriculture as part of climate change mitigation efforts (Twining et al., 2018).

Analysis also shows that promoting social equity in water management, such as involving marginalized local communities in decision-making processes, can lead to improved agricultural productivity and enhanced social stability (Haidar, 2025).

3.2 Harnessing Technology and Innovation

Advanced technology represents a transformative tool in sustainability efforts in the Arab region. Geomatics technologies like Geographic Information Systems (GIS) and remote sensing can provide the ability to map potential groundwater areas in arid regions, which helps reduce the threat of drought (EL-Bana et al., 2024, 38). Artificial Intelligence (AI) and Machine Learning (ML) can also be used to analyze vast amounts of data, including satellite imagery, to predict weather phenomena, select the best locations for building dams, and improve water resource management (Rodenas et al., 2025).

In addition, the transition to renewable energy sources, such as solar and wind power, is crucial, not only for reducing carbon emissions but also for powering energy-intensive water solutions like desalination. Many Arab countries are moving towards connecting desalination plants to renewable energy sources to ensure the sustainability of this process (Jubori & Kaynak, 2025, 1-21). Together, these technologies contribute to the development of early warning systems for natural disasters, which enhances adaptive capacity and builds regional resilience.

3.3 The Governance-Technology Paradox: A Key Barrier to Progress

Despite significant technological progress and efforts made, the region faces a fundamental paradox: technological solutions, despite their importance, are not enough on their own to address water and environmental challenges without a parallel transformation in

governance and policies. Countries like Saudi Arabia have invested heavily in hard infrastructure, such as desalination plants, which are among the largest in the world. These countries still suffer from some of the highest per capita consumption rates in the world, which is partly due to weak legislation, a lack of enforcement and oversight mechanisms, and large government subsidies for water and energy prices. This financial support has created a culture among citizens where water and energy are considered an entitlement, which discourages conservation and effective demand-side management efforts. This creates a situation where the technical knowledge and financial capacity to solve water problems are available, but socio-political and economic factors prevent true sustainability from being achieved. Some studies have shown that tariff reforms in some cities have not had a noticeable effect on per capita water consumption (Saif et al., 2014, 329-346).

Relying on technological solutions without addressing the root causes of waste and inefficiency creates a gap between "commitments and action" (Kolo, 2015, 71-81), and prevents real progress towards water security. This confirms that a sustainable future requires adopting a "green-gray pathway" (Vörösmarty, 2021) that combines modern infrastructure with nature-based solutions, along with a radical reform of governance and policies to promote a culture of conservation and accountability.

3.4 Concrete mechanisms for water governance reform in the Arab world: a framework for specific actionable water policy

3.4.1 Failure of Groundwater Management Institutions

- Implement Tiered, Volumetric Water Pricing for Agriculture: Instead of flat subsidies, install water meters on agricultural wells. The first tier (e.g., water for basic food security) could be subsidized. Any water used beyond a scientifically determined sustainable aquifer yield would be charged at a progressively higher rate. The revenue generated is reinvested into aquifer recharge projects or subsidies for drip irrigation systems [Ward, 2014].
- Establish Tradable Water Rights: Create a legal framework where water rights are clearly defined, quantified, and tradable. This creates a market incentive for farmers to sell their water rights (or a portion of them) to higher-value users (e.g., municipalities, industry) and invest in water-saving technologies. This was successfully piloted in Chile's water-scarce regions [Bauer, 2004].
- Formalize Water User Associations (WUAs) with Legal Power: Transform WUAs from discussion forums into legally empowered bodies responsible for monitoring local groundwater levels, enforcing abstraction quotas among their members, and managing local

recharge projects. This decentralizes management to the local level, making it more responsive and legitimate [Mustafa et al., 2016].

3.4.2 Failure of Urban Water Subsidy and Tariff Structures

- Shift from Universal Subsidies to Targeted Direct Cash Transfers: Phase out blanket subsidies on water and energy bills. Instead, use the saved public funds to provide direct, means-tested cash transfers to low-income households. This ensures that the poor can afford water while creating a price signal for all other consumers to conserve. Jordan has been a regional pioneer in exploring this model in the energy sector [Jordan Ministry of Planning and International Cooperation, 2019].
- Implement "Increasing Block Tariffs" (IBTs) with a Lifeline Block: Structure water bills so that the first block of water (e.g., 50 liters per person per day) is very cheap or free, covering basic human needs (the lifeline block). Each subsequent block becomes progressively more expensive. This explicitly links the concept of a "human right to water" with the "polluter-pays" principle for luxury consumption [Boland & Whittington, 2000].
- Mandate Water Audits and Efficiency Standards for Large Consumers: Enforce regulations requiring large commercial buildings, hotels, and industries to conduct regular water audits and retrofit fixtures to meet efficiency standards. This targets the largest points of waste without affecting low-income families [Hoffman, 2015].

3.4.3 Failure of Transboundary Water Cooperation Frameworks

- Establish a "Benefit-Sharing" Basin Authority: Move beyond negotiating only about water allocations (a zero-sum game) to creating a multilateral institution focused on benefit-sharing. This authority would coordinate on generating and sharing benefits from the river—such as hydropower, flood control, expanded irrigation, and navigation—in a way that provides net gains for all riparian countries. For example, Ethiopia could sell cheap hydropower from the GERD to Egypt and Sudan, financing its project while supporting their economies [Sadoff & Grey, 2005].
- Create a Joint Climate Risk Management Fund: All co-riparians contribute to a fund managed by the basin authority. This fund is used for: 1) Building joint early warning systems for droughts and floods. 2) Financing climate-resilient infrastructure (e.g., modernized irrigation) across the basin. 3) Providing compensation to downstream countries during periods of extreme drought. This builds trust and shared responsibility for climate adaptation [Nicol & Al-Naimi, 2017].

- Implement Real-Time Data Sharing and Transparency Protocols: A major source of conflict is mistrust over data. A reformed institution would mandate the installation of shared, remote-sensing technology to monitor reservoir levels, rainfall, and river flows in real-time, with data accessible to all member states. This replaces political claims with transparent, verifiable facts [Mason et al., 2021].

3.4.4 Failure of Agricultural Policy and Land Use Planning

- Implement "Virtual Water" Strategic Trade Policy: Formally shift agricultural policy from physical self-sufficiency to "virtual water" security. Use state resources to support farmers in growing high-value, low-water cash crops for export (e.g., dates, certain fruits, vegetables). Use the foreign exchange earned to import staple, water-intensive grains from water-rich countries. This conserves domestic water resources while maintaining national food security [Allan, 2003].
- Zoning and Licensing Based on Water Availability: Legally prohibit the cultivation of certain water-intensive crops in regions where the aquifer's recharge rate is below a specific threshold. Issue agricultural licenses contingent on the farmer adopting a certified water-efficient irrigation system and cropping pattern [Ward, 2014].
- Link Agricultural Subsidies Exclusively to Sustainability Outcomes: Instead of subsidizing inputs like water and energy, provide direct payments to farmers for documented ecosystem services they provide, such as maintaining soil organic carbon, planting trees for windbreaks, or allowing land to lie fallow for aquifer recovery. This shifts incentives toward environmental stewardship rather than resource depletion [Schmidhuber, 2004].

4. Enhancing Resilience and Regional Cooperation in Crisis

4.1 Climate Change Adaptation Strategies

Historical experience shows that the peoples of the Arab region have adapted to climate fluctuations for a long time. The current pace of climate change requires more advanced and integrated adaptation strategies. Adaptation is not limited to building infrastructure resilient to extreme weather events, but also includes what is called "adaptation governance", which means having strong institutional and policy frameworks, and partnerships between governments, the private sector, civil society, and international institutions like the UN and the World Bank (Verner, 2023). Effective adaptation strategies include adopting climate-smart agriculture, diversifying sources of income, and

providing financial services like insurance for farmers to protect them from losses resulting from climate disasters

4.2 The Geopolitics of Shared Water Basins

The management of shared water resources is a complex geopolitical challenge in the Arab region, as more than 60% of its renewable water resources originate from sources outside its borders, such as the Nile, Euphrates, and Tigris rivers (Gamal et al., 2013, 157). These basins have a long history of conflicts and tensions, driven by the dynamics of hydro-hegemony. Some upstream states have used their control over water flow as a means of pressure on downstream states, which suffer from institutional weakness and a lack of financial resources to challenge them (Mujib, 2025, 525).

There is a shift in these traditional dynamics. Major projects like the Grand Ethiopian Renaissance Dam (GERD) on the Nile, which Ethiopia is building without a comprehensive agreement with Egypt and Sudan, represent a challenge to historical agreements dating back to the colonial era. The involvement of third parties, such as the financial support provided by the UAE to Ethiopia (Roll, 2023), adds new complexities to the scene, showing that geopolitical alliances and economic relations have become a crucial factor in water disputes, transcending the binary of upstream and downstream states. This indicates that effective management of shared water resources in the future cannot rely on historical claims or political competition. Instead, it requires a new framework for regional cooperation based on fairness and transparency and capable of dealing with changing power dynamics and the cumulative effects of climate change (Khalifa & Al-Zu'bi, 2025, 671-684).

5. Governance and Environmental Policies

5.1 Review of Legislation and Policies

Arab countries have witnessed rapid growth in environmental legislation since the 1991 Dubai Declaration on Environment and Development. Many laws and regulations have been enacted covering issues of water and air pollution, waste management, and biodiversity conservation. Despite this legislative growth, there are still significant challenges in implementation. Many countries suffer from a gap between "commitments and action", and face problems such as data scarcity, weak oversight mechanisms, and a lack of institutional and technical capacity needed to effectively enforce laws. The huge financial subsidies for water and electricity prices also represent a barrier to implementing conservation policies (Saif et al., 2014, 329-346).

5.2 Success Stories and Innovative Initiatives

Despite the challenges, there are notable examples of successes in governance and policies. For example, the "Algeria Water Security Strategy" is an ambitious national model that sets clear goals to reduce total water demand, reduce average per capita consumption, and increase the percentage of treated water reuse. This model shows a political commitment to setting specific and measurable goals.

In addition, sustainable models from the Islamic heritage can be highlighted, such as the "Waqf" system, which has proven effective in financing and implementing sustainable development projects, including providing drinking water and digging wells in needy areas (Zawawi et al., 2023, 93-114).

These traditional models can play a vital role in financing environmental projects and providing essential services to communities, which enhances social and economic sustainability.

5.3 Activating Green Accounting

To ensure transparency and accountability, activating tools such as "Green Accounting" is essential. Green accounting is not limited to monitoring financial performance; it also includes measuring the environmental impact of economic activities. The existence of strong institutional frameworks that allow for transparency in the use of water and energy resources and impose accountability on parties responsible for pollution can reduce corruption and ensure that projects and policies are implemented in a way that serves the public and environmental interest in the long run (Olawuyi, 2022).

6. Environmental Protection in Islamic Sharia and International Law

6.1 The Islamic Doctrine of Environmental Governance

Islamic Sharia offers a deep ethical framework for environmental protection that can serve as a strong incentive for sustainable practices in the region. The fundamental concept of *Istikhlaf* (Succession or Trusteeship) emphasizes that humans are not proprietors of the Earth, but rather its agents or trustees, entrusted with the task of developing, preserving, and maintaining it. This imposes an ethical responsibility on humans to maintain the environmental balance (*Mizan*) and prevent corruption (*Fasad*) on Earth (Abbadi, 2024, 599-608).

This perspective shows that environmental protection is not just a legal or technical issue but a religious, ethical, and social duty. These principles, which predate modern environmental law by centuries, can

provide a common cultural ground for the region, making conservation policies more acceptable and effective. Awareness campaigns based on the concept of *Istikhlaf* and the prohibition of *Fasad* are likely to resonate more deeply with the population compared to legislative or economic obligations alone, ensuring broader community commitment (Zuraib, 2024, 377-382).

6.2 International Environmental Law and its Applications

In addition to the Islamic framework, international environmental agreements and laws play an increasingly important role. Arab states are committed to a wide range of international agreements, such as the Paris Agreement on Climate Change and the Sustainable Development Goals. International law sets out the responsibilities of states to prevent transboundary environmental damage and cooperate in managing shared resources. Enhancing international cooperation mechanisms is essential to face environmental challenges, especially in the management of shared water basins. The effectiveness of these laws depends on the ability of states to implement them internally through integrated national legislation and the building of strong institutional capacities (Olawuyi, 2022).

7. Arab Countries' Efforts to Achieve Water Security

7.1 National and Regional Strategies

In the face of water security challenges, Arab countries have developed comprehensive strategies at both the national and regional levels. The "Arab Strategy for Water Security 2010-2030," approved by the Baghdad summit in 2012, serves as a guide for joint Arab action to ensure the sustainable use of water resources. The strategy aims to achieve goals in three main areas (Erian, 2018):

1. Economic and Developmental Field: Includes providing water services, developing non-conventional resources, and applying integrated water resources management.
2. Institutional, Human, and Technical Capacity Development: Focuses on raising awareness, encouraging scientific research, and involving civil society.
3. Political Field: Related to protecting the rights of Arab states in transboundary waters and promoting cooperation in their management.

Beyond the Gulf-centric examples, numerous Arab nations with constrained budgets are pioneering models that integrate social justice directly into environmental solutions.

7.1.1. Jordan: Devolving Authority for Equitable Water Access

In Jordan, one of the world's most water-scarce countries, the challenge of equitable access is addressed through community-led

Water User Associations (WUAs), primarily in the Jordan Valley region. These decentralized, local committees, often supported by international partners like the German Agency for International Cooperation (GIZ), are formally tasked with managing, maintaining, and distributing irrigation water resources at the village level, taking over responsibilities from the Jordan Valley Authority (JVA) [Hayek, 2010]. This decentralized approach, while facing challenges related to elite capture and political dynamics, embeds justice into the process by giving the most affected communities a direct voice in water governance, which has been shown to improve distribution efficiency and foster local ownership and responsibility [Mustafa et al., 2016]. This model demonstrates that effective water management in resource-poor settings is not just about infrastructure, but about devolving authority and ensuring fair representation, making it a powerful, low-cost strategy for enhancing social equity and water security simultaneously.

7.1.2. Tunisia: A Circular Economy for Climate-Resilient Agriculture

Turning to the green economy, Tunisia offers a compelling case of building a circular and climate-resilient agricultural sector around its flagship product: olives. Facing increasing water stress, the country is promoting water-efficient irrigation techniques for olive groves. However, the true green innovation lies in valorizing the entire production chain through a circular bioeconomy strategy, which is also backed by Euro-Mediterranean initiatives like the OLIWA project [APA-Tunis, 2025; Aceite del Campo, 2025]. Instead of treating waste as a problem, Tunisian enterprises and cooperatives are developing systems where olive pomace (residue) is repurposed as biofuel or converted into high-value products like animal feed, and wastewater from processing is treated and reused [Agenzia Nova, 2025]. By integrating renewable energy, like solar power for processing plants, the sector's carbon footprint is further reduced. This model transforms an environmental challenge into an economic opportunity, creating green jobs in waste management, bioenergy, and value-added processing while making the crucial agricultural sector more sustainable and less vulnerable to climate shocks [Jellali et al., 2021].

7.1.3. Egypt: A Just Green Transition in Waste Management

Egypt presents a groundbreaking example of a just green transition in its waste management sector, centered on the informal "Zabbaleen" (garbage collectors) community in Cairo. For decades, this marginalized group has maintained what is arguably one of the world's most efficient resource-recovery and recycling systems, collecting 50-60% of Cairo's Municipal Solid Waste. Modern initiatives are now focusing on formally integrating them into the green economy. This

involves providing safer working conditions, modern sorting facilities, and fair wages through innovative models, such as the reverse credit scheme backed by the Ministry of Environment and multinational corporations, which uses digital payments to compensate recyclers for collected plastic waste [World Economic Forum, 2021]. The environmental benefit is amplified by moving beyond simple collection to waste valorization—converting organic waste into compost or biogas for renewable energy [GIZ, 2011]. This approach demonstrates that a sustainable future is not achievable without social inclusion; it recognizes that the people most affected by pollution are often the greatest source of innovation and efficiency, and that a truly green economy must uplift them, providing both environmental sustainability and social justice [Yassin, 2010].

7.2 Implementation Challenges

Despite the ambition reflected in these strategies, there are still challenges in implementation. Many plans face difficulty in transitioning from the planning stage to concrete action. This is mainly due to the previously mentioned obstacles, such as a lack of data, weak institutional frameworks, an absence of accountability, and government subsidies that discourage conservation efforts. The lack of formal agreements and cooperation mechanisms in the management of shared water resources in many areas also remains a major obstacle to achieving water security at the regional level (Gamal et al, 2013, 157).

Table 3: Technological Solutions for Water Management in the Arab Region

Technology Category	Specific Applications	Challenges Addressed
Geomatics & AI	-Mapping potential groundwater zones. -Selecting optimal sites for dam construction. -Predicting weather events. -Monitoring water quality.	-Groundwater scarcity. -Poor water resource management. -Natural disasters (floods, droughts). -Water pollution.
Non-Conventional Resources	- Seawater desalination. -Reuse of treated wastewater. -Rainwater harvesting.	-Freshwater scarcity. -Over-exploitation of groundwater resources. -Supporting agriculture and industry.
Renewable Energy	-Powering desalination plants. -Operating solar-powered irrigation	-High energy consumption. -Environmental pollution

	pumps. -Reducing carbon emissions.	from fossil fuels. -Cost of energy.
Smart Agriculture	-Using modern irrigation techniques. -Cultivating drought-resistant crops. -Diversifying livelihoods.	-Declining agricultural productivity. -Increased water demand in agriculture. -Weak food security.

Sources: (EL-Bana, 2024, 38), (Sherif, 2023, 742) (Twining, 2018)

CONCLUSION

The comprehensive analysis shows that environmental and water challenges in the Arab region are inseparable from climate change, but rather are exacerbated by it in a vicious cycle of environmental degradation, instability, and displacement. This research has revealed several key conclusions:

- First, the water crisis in the region is not merely a matter of natural scarcity but is the result of a complex interaction between climate factors, population growth, and inefficient management practices.
- Second, advanced technological solutions, such as desalination and reuse, despite their importance, will not achieve sustainable water security if the shortcomings in governance and policies, such as unguided government subsidies for water prices, are not addressed. This creates a paradox between technical capability and consumer reality.
- Third, the geopolitical dynamics in shared water basins are shifting, requiring Arab countries to move beyond historical claims and work to build new cooperative frameworks based on fairness.
- Finally, fundamental ethical and religious principles, especially the Islamic concept of Istikhlaf, can form a strong cultural and social framework to support conservation efforts, which cannot be achieved through policies and legal procedures alone.

8.2 A Strategic Framework for the Future

Based on these conclusions, the research recommends adopting a multi-level strategic framework to achieve sustainable development in the Arab region, based on the following principles:

1. Integrate Governance and Management: A call for a new model of "adaptation governance" aimed at bridging the gap between political commitment and practical application. This requires strengthening institutional and technical capacities, updating environmental and water legislation, and activating accountability tools like green accounting to ensure transparency.
2. Invest in a "Green-Gray Pathway": A call for a balanced investment strategy that combines hard infrastructure ("gray") like desalination plants powered by renewable energy, with nature-based solutions

("green") like rehabilitating ecosystems and wetlands, while focusing on effective demand-side water management.

3. Promote Fair Regional Cooperation: The necessity of developing new legal and diplomatic frameworks for managing shared water resources that transcend historical claims and ensure the equitable participation of all states, turning water from a potential source of conflict into a tool for peace and development.
4. Harness Cultural Capital: Authentic ethical principles, particularly the Islamic concept of Istikhlaf, must be integrated into awareness campaigns and public policies to foster a culture of conservation and resource preservation among individuals and communities.
5. Prioritize Social Justice: Emphasize the need to involve marginalized local communities, women, and farmers in decision-making processes to ensure that the proposed solutions are fair and equitable, which enhances social stability and the region's resilience to climate change.

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