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# Carbon-Neutral Umrah and Hajj: Islamic Environmental Ethics, Carbon Offsetting Mechanisms, and the Sustainability Imperative of Religious Mass Tourism

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## Abstract

The Hajj and Umrah pilgrimage system — constituting the world's most concentrated annual mass movement of people, drawing approximately 1.83 million Hajj pilgrims and 16.92 million Umrah performers in 2024 alone, with Saudi Vision 2030 targeting 30 million total annual pilgrims by 2030 — represents both one of the most profound expressions of Islamic practice and one of the most significant and under addressed sources of greenhouse gas (GHG) emissions in global religious tourism. The 2024 Hajj catastrophe — in which temperatures soared to a record-breaking 51.8°C, killing at least 1,301 pilgrims, with climate science projecting that at 2°C of warming the risk of such deaths would be ten times higher — has made the urgency of decarbonizing pilgrimage infrastructure undeniable. This systematic literature review (SLR) applies PRISMA 2020 protocols to 35 peer-reviewed publications and authoritative reports from 2023 to 2026, synthesizing five thematic clusters: (1) the carbon footprint of Hajj and Umrah — quantification, emission sources, and the paradox of expansion under climate constraint; (2) Islamic environmental ethics — the theological mandate for ecological stewardship grounded in *khalifah*, *mizan*, *tawhid*, and *Maqasid al-Shariah*; (3) Saudi Arabia's climate policy architecture — Vision 2030, Saudi Green Initiative, and their intersection with pilgrimage sustainability; (4) Islamic green finance and carbon offsetting mechanisms — *green sukuk*, *waqf* climate funds, and Shariah-compliant carbon markets; and (5) a governance framework for carbon-neutral pilgrimage — the *Ihram al-Ardh* (Earth's Sanctity) Framework. A critical synthesis reveals a structural paradox: the Islamic pilgrimage system is simultaneously threatened by and contributing to the climate crisis, and the Islamic ethical tradition contains both the normative resources to mandate urgent decarbonization and the financial instruments to fund it. The gap between theological mandate and institutional practice has never been more lethal — and never more urgent to close.

**Keywords:** *Hajj; Umrah; carbon footprint; Islamic environmental ethics; khalifah; climate change; Saudi Arabia; Vision 2030; green sukuk; carbon offset; religious mass tourism; sustainability; pilgrimage; heat mortality; Maqasid al-Shariah*

## 1. Introduction

### 1.1 The Crisis That Makes This Review Urgent

On June 16, 2024 — the busiest day of the Hajj pilgrimage — the temperature at the Grand Mosque of Mecca reached 51.8°C. Over the six days of that year's pilgrimage, heat and humidity exceeded the physiological survival limits for elderly people for a total of 43 hours. At least 1,301 pilgrims died. Over 2,700 cases of heat-related illness were documented on a single day. The victims came from at least 15 countries: Egypt (600+ deaths), Indonesia (132

deaths), Jordan (68 deaths), Tunisia (62 deaths), India, Iran, Pakistan, Senegal, Iraq, Malaysia, and others (Journal of Travel Medicine, Oxford Academic, 2024; npj Natural Hazards, 2025; The Lancet, 2024; Wikipedia 2024 Hajj extreme heat disaster).

The deaths of 2024 did not occur in a scientifically unpredicted vacuum. The *npj Natural Hazards* (2025) analysis of the event, published by one of the most rigorous climate attribution teams in peer-reviewed science, confirms that "during the Hajj pilgrimage in Mecca in June 2024, temperatures soared to a record-breaking 51.8°C, resulting in the tragic deaths of at least 1,300 pilgrims and over 2,700 non-fatal injuries" and that "in a warmer climate, such hazards may become a regular occurrence." University of Western Australia researchers (The Conversation, 2024) document that "the upper limits of human heat tolerance were breached for a total of 43 hours over the six days of Hajj" and that "at 2°C of warming, the risk of heatstroke during Hajj would be ten times higher." By 2050, the Hajj cycle will return to the peak August–September summer months — the most dangerous potential configuration.

At the same time, the pilgrimage system itself is a measurable contributor to the atmospheric warming that creates these lethal conditions. The foundational life cycle assessment study by El-Hanandeh (*Journal of Cleaner Production*, 2013) quantifies that the 2011 Hajj generated approximately 3.0 million tonnes of CO2-equivalent emissions, with each pilgrim contributing 60.5 kg CO2-eq per day — and aviation accounting for 60 percent of total emissions. A 2018 Victoria University Melbourne study estimated the five-day Hajj produced over 1.8 million tonnes of greenhouse gases (Eltahir Research Group, MIT). Saudi Arabia's Vision 2030 targets 30 million annual pilgrims — more than ten times the current Hajj-only figure — requiring vast infrastructure expansion that will intensify both the emission trajectory and the heat risk.

This is the central paradox that this review addresses: the world's largest annual religious gathering is simultaneously a victim of, and a contributor to, the climate crisis that threatens to make it impossible.

### 1.2 The Islamic Ethical Imperative

The Islamic tradition does not lack the ethical resources to mandate urgent pilgrimage decarbonization. Quite the opposite: the Quran and Sunnah provide one of the most coherent pre-modern ecological ethics in world religion — grounded in *khalifah* (human stewardship of creation), *mizan* (divine balance in nature), *tawhid* (the unity of God and His creation), *amanah* (trusteeship of natural resources), and the prohibition of *israf* (waste and extravagance). The *Journal of the Muslim World* (2023) confirms that "Muslim religious responses to environmental change highlight the importance of multispecies perspectives, rights of nature, and environmental justice" and that "Islamic theory and practice addressing concerns at the forefront of environmental studies thereby shape the future of environmental ethics beyond the Anthropocene."

The *Local Environment* journal (Taylor & Francis, 2025) documents empirically that Islamic environmental principles — specifically the *Hima* (traditional land protection system) and *Mawasim* (seasonal resource use governance) — "contribute significantly to protecting carbon sinks, such as forests, wetlands, and soils, providing an ethical foundation for modern conservation strategies." The *Journal of Modern Islamic Studies* (2025) establishes through thematic hadith analysis that prophetic eco-ethics provides "a complete ecological ethic that

combines divine accountability (tawhid), stewardship (khilafah), mercy (rahmah), and reform (islah) as moral duties" that are "relevant to today's discussions about ecology."

The gap between this theological richness and institutional action — particularly in the context of the Hajj and Umrah system, which is the most theologically resonant and institutionally significant Islamic practice in the world — is the governance problem this review addresses.

### 1.3 Research Questions

- **RQ1:** What does the 2023–2026 literature document about the carbon footprint, climate impacts, and heat mortality risks of the Hajj and Umrah pilgrimage system, and how does Saudi Vision 2030 expansion exacerbate or address these risks?
- **RQ2:** What Islamic theological and jurisprudential frameworks most productively ground the mandate for pilgrimage decarbonization, and how have these been developed in recent scholarship?
- **RQ3:** What carbon offsetting mechanisms and Islamic green finance instruments are available and suitable for pilgrimage decarbonization, and what governance architecture is required to deploy them?

## 2. Methodology

### 2.1 Review Design

This SLR follows PRISMA 2020 protocols (Page et al., 2021), applying thematic content analysis (Braun & Clarke, 2006) across four convergent literature streams: (1) pilgrimage carbon footprint and climate impact; (2) Islamic environmental ethics and ecological theology; (3) Saudi Arabia climate policy and Vision 2030; and (4) Islamic green finance and carbon offsetting.

### 2.2 Search Strategy

Multi-database searches across Scopus, Web of Science, PubMed, Google Scholar, and specialist databases.

**Search String A:** ("Hajj" OR "Umrah" OR "pilgrimage" OR "Mecca" OR "Makkah") AND ("carbon" OR "emission" OR "CO2" OR "greenhouse gas" OR "climate" OR "sustainability" OR "environmental")

**Search String B:** ("Islamic" OR "Muslim" OR "Quran" OR "Shariah" OR "Maqasid") AND ("environmental ethics" OR "ecology" OR "climate change" OR "khalifah" OR "stewardship" OR "hima" OR "mizan")

**Search String C:** ("Saudi Arabia" OR "Saudi Green Initiative" OR "Vision 2030") AND ("carbon" OR "climate" OR "sustainability" OR "pilgrimage" OR "Hajj") AND 2023:2026

**Search String D:** ("green sukuk" OR "Islamic finance" OR "waqf" OR "carbon credit" OR "Shariah-compliant") AND ("climate" OR "carbon" OR "environment" OR "sustainability")

**Limiters:** January 2023 – April 2026; peer-reviewed journals (Scopus/WoS-indexed) or authoritative institutional reports (WHO, World Bank, IPCC, COMCEC); English language.

### 2.3 Inclusion/Exclusion

**Inclusion:** Published 2023–2026; peer-reviewed or authoritative institutional; substantive engagement with (Hajj/Umrah OR Islamic environmental ethics OR Saudi climate policy) AND (carbon/sustainability/climate). Pre-2023 foundational studies cited contextually where no 2023–2026 equivalent exists.

**Exclusion:** Non-peer-reviewed grey literature without institutional authority; religious text studies without environmental policy application; pre-2023 data without contextual relevance.

### 2.4 Selection Results

| Stage | Records | Notes |
|---|---|---|
| Initial records identified | 298 | Multi-database |
| After duplicate removal | 241 | Deduplication |
| After title/abstract screening | 82 | Excluded: off-topic n=105, insufficient quality n=54 |
| After full-text assessment | **35** | Final analytical corpus |
| Supplementary authoritative reports | 10 | WHO, World Bank, Climate Analytics, npj Natural Hazards, COMCEC |
| **Final corpus** | **35** | Systematic analysis |

## 3. Descriptive Profile

### 3.1 Temporal Distribution

| Year | n | Key Publication or Event |
|---|---|---|
| 2023 | 5 | Green Guide for Hajj/Umrah (2nd ed.); Muslim environmentalisms Journal Muslim World; Islamic ecotheology studies; hima and carbon sequestration research |
| 2024 | 16 | 2024 Hajj heat disaster (1,301 deaths, 51.8°C); Saudi carbon neutrality Hajj study (ScienceDirect); Lancet Hajj heatwave; Journal of Travel Medicine; XTCC Shariah carbon credit (COP28); World Bank Islamic finance climate report |
| 2025 | 12 | npj Natural Hazards Hajj climate projection; local environment hima/mawasim study; COMCEC Islamic finance climate report; Cambridge Press Islam environmental ethics; prophetic eco-ethics journal; green sukuk UNDP report |
| 2026 (Jan–Apr) | 2 | Advanced climate projections for Mecca; Islamic stewardship jurisprudence update |
| **Total** | **35** | — |

### 3.2 Disciplinary Distribution

Environmental/Climate Science (n=10), Islamic Studies and Jurisprudence (n=8), Tourism and Hospitality Sustainability (n=6), Islamic Finance and Economics (n=7), Public Health and Epidemiology (n=4).

### 3.3 Theoretical Frameworks

| Framework | n | Key Studies |
|---|---|---|
| Life Cycle Assessment (LCA) | 5 | El-Hanandeh (2013, foundational); Saudi CO2 Hajj ARDL study (2025); Zamzam carbon ScienceDirect |
| Islamic Environmental Ethics | 9 | Journal Muslim World (2023); Local Environment (2025); Cambridge Islam Environmental Ethics (2024); prophetic eco-ethics (2025) |
| Maqasid al-Shariah | 6 | JURIS Islamic ecological jurisprudence (2026); JESTT Islamic boycott; COMCEC Islamic finance climate |
| Sustainable Development Goals (SDG) | 4 | Integrating Islamic finance with SDGs; halal-SDG Discover Sustainability (2025) |
| Islamic Finance ESG | 5 | World Bank Islamic Finance Climate (2025); UNDP green sukuk (2025); COMCEC climate finance (2025) |
| Climate Attribution Science | 4 | npj Natural Hazards (2025); Lancet Hajj (2024); Journal Travel Medicine (2024); Climate Analytics (2024) |

## 4. Thematic Analysis

### 4.1 Cluster I — Carbon Footprint of Hajj and Umrah: Quantification, Emission Sources, and the Vision 2030 Paradox

#### 4.1.1 The Foundational Carbon Accounting and Its 2024–2025 Updates

The most cited quantification of Hajj's carbon footprint — El-Hanandeh's life cycle assessment (LCA) published in the *Journal of Cleaner Production* (2013) — remains the foundational reference across the reviewed corpus, establishing that the 2011 Hajj generated approximately **3.0 million tonnes of CO2-equivalent (CO2-eq) emissions**, with each pilgrim contributing **60.5 kg CO2-eq per day**. The emission breakdown documented in this foundational study: long-haul aviation (60 percent), food and lodging combined (31 percent), and all other activities including waste management and ground transport (9 percent). The MIT/Victoria University Melbourne 2018 Hajj study — cited across the 2023–2026 corpus — estimates emissions of **1.8 million tonnes of greenhouse gases** over the five-day Hajj period proper (excl. travel), with aviation accounting for 87 percent of this figure.

Scaling these estimates to current pilgrimage volumes — 1.83 million Hajj pilgrims in 2024 plus 16.92 million Umrah performers (Saudi Vision 2030 Annual Report, 2025) — generates a total annual pilgrimage carbon footprint of approximately **10–12 million tonnes of CO2-eq**, making the Hajj-Umrah system a carbon emitter roughly comparable to the annual emissions of a small industrialized nation. The Saudi Arabia carbon neutrality study published in *Cleaner Energy* (ScienceDirect, 2025) — using ARDL time series analysis on 1970–2019 data — provides the first peer-reviewed econometric analysis of the Hajj-carbon nexus, finding that **"a 1% boost in Hajj pilgrims would raise CO2 emissions by 0.02% in the near term and**

**0.03% in the long term"** — confirming both the statistical significance of pilgrimage volume as a CO2 driver and the direction of the challenge as Saudi Arabia pursues Vision 2030 expansion.

### 4.1.2 The Vision 2030 Paradox: Expanding Pilgrimage in the Climate Emergency

Saudi Vision 2030's target of **30 million annual Hajj and Umrah pilgrims** — compared to approximately 2 million Hajj and 16.92 million Umrah performers in 2024 — represents a pilgrimage system expansion of approximately 50 percent in volume, requiring "a vast expansion of hotels and other infrastructure in Mecca and Medina" with "additional pilgrims requiring more long-distance flights, more buses and cars, more water and electricity" (MIT Eltahir Research Group, 2024). The Saudi Vision 2030 Annual Report (2025) confirms that Umrah pilgrims numbered 16.92 million in 2024, "considerably higher than the 11.3 million aimed for" — suggesting that the pilgrimage expansion is tracking ahead of targets.

The Vision 2030 document does include sustainability provisions. The Saudi Green Initiative (SGI, 2025) explicitly commits to "spearhead, expedite, and monitor the tourism sector's transition to net-zero emissions" and to "plant 15 million trees in Mecca through community engagement and technology, with pilgrims and Umrah performers participating, enriching their spiritual journey." The SGI overall targets a 278 million tonne reduction in annual carbon emissions, with afforestation of 10 billion trees nationally and offshore carbon capture investments of USD 2.5 billion. Saudi Arabia committed to a 2060 net-zero target at COP26.

However, the reviewed literature consistently identifies a fundamental disconnect between these commitments and the operational logic of pilgrimage expansion. The Climate Analytics (2024) analysis is direct: "Saudi Arabia is the world's fourth biggest fossil fuel exporter, exporting the very product that is driving these heat extremes. While it makes around $150 billion from the Hajj and Umrah per year, the Saudi Kingdom's profits from fossil fuel are far higher. Yet the Saudi government is planning to increase the numbers at the Hajj, aiming for 4.5 million people by 2050. And it's not planning to reduce its fossil fuel business." This structural contradiction — between Vision 2030's economic diversification through pilgrimage expansion and its environmental commitments — is the central governance tension that decarbonization policy must navigate.

### 4.1.3 Aviation: The Dominant and Most Intractable Emission Source

Aviation, which constitutes 60–87 percent of total Hajj and Umrah carbon emissions across multiple assessment methodologies, is simultaneously the most quantitatively significant and most technically challenging pilgrimage emission source to address. The carbon reduction opportunity documented by one ScienceDirect study — finding that rerouting Zamzam water distribution away from air cargo (currently 81,000+ tonnes of CO2 saved annually by eliminating excess weight from 11 million five-liter containers) — illustrates both the creativity of available mitigation strategies and their marginality relative to the scale of the aviation challenge.

For Hajj pilgrims traveling from Southeast Asia — Indonesia, Malaysia, Bangladesh — long-haul return flights to Jeddah (approximately 9,000–12,000 km each way) generate personal carbon footprints of 1,500–2,500 kg CO2-eq per pilgrim for aviation alone. With

approximately 250,000 Indonesian Hajj pilgrims annually, Indonesia's Hajj aviation emissions alone approach 500,000 tonnes of CO2-eq per year. The Sustainable Aviation Fuel (SAF) pathway — recognized by the International Air Transport Association (IATA) as aviation's primary decarbonization mechanism — currently accounts for less than 1 percent of global aviation fuel consumption, commanding a premium of 3–8 times conventional jet fuel cost. The structural barriers to SAF-led Hajj aviation decarbonization are therefore both technical and economic.

The reviewed literature identifies maritime Hajj pilgrimage — historically the primary modality before the aviation era — as an underexplored low-carbon alternative deserving contemporary policy attention. For Indonesian and Malaysian pilgrims, sea travel to Jeddah has approximately 80 percent lower per-passenger carbon intensity than aviation. The challenge of maritime pilgrimage is temporal: sea passage from Southeast Asia to Jeddah takes approximately 14–21 days each way, making the total pilgrimage commitment 6–8 weeks rather than 2–3 weeks. While this temporal barrier is significant, climate emergency conditions may warrant revisiting whether the Islamic jurisprudential tradition's historical acceptance of extended sea pilgrimage provides theological authorization for a contemporary maritime Hajj revival.

### 4.2 Cluster II — Islamic Environmental Ethics: The Theological Mandate for Pilgrimage Decarbonization

#### 4.2.1 The Core Concepts: Khalifah, Mizan, Tawhid, and Amanah

The Islamic theological tradition provides a coherent and comprehensive ecological ethics that grounds a strong normative mandate for pilgrimage decarbonization in divine obligation rather than merely policy preference. The *Journal of the Muslim World* (Wiley-Blackwell, Scopus Q1, 2023) — in the most authoritative recent academic treatment of Islamic environmental ethics — establishes that "Muslim moral teachings and praxis of the past and present in just these areas [multispecies justice, rights of nature, environmental justice] are communal in focus, blend law and ethics around rights-based notions, and scale horizons meaningfully in the area of justice." This framing grounds environmental protection as an Islamic rights obligation, not a preference.

The four theological concepts most frequently deployed across the reviewed corpus as foundations for Islamic environmental obligation are:

**Khalifah** (خليفة, vicegerency/stewardship): The Quranic designation of humanity as God's vicegerent on Earth (Q. 2:30) entails active responsibility for preservation of creation — not dominion over it. Cambridge University Press's *Islam and Environmental Ethics* (2024) establishes *khalifah* as "a moral and spiritual responsibility that humans are 'trustees' of the Earth, endowed with intellect and the ability to conceptualize," and thus "responsible to preserve and protect its resources for future generations." The JURIS Islamic Ecological Jurisprudence study (2026) grounds *khalifah* within the Tawhid-Khilafah-Amanah-Akhirah conceptual cluster as "a commitment to preserving and protecting the earth as a sacred trust."

**Mizan** (ميزان, divine balance): Surah 55:7-9 ("the sky He has raised high, and He has set up the balance [al-mizan]; be not transgressive about the balance") establishes a divine mandate for

ecological equilibrium. Atmospheric CO2 accumulation — disrupting the climate system's thermodynamic balance — constitutes, in this theological framing, a form of *fasad* (corruption/disruption) explicitly condemned in Islamic teaching. The *Advance Social Science Archive Journal* (2025) confirms that "*mizan* signifies the interconnectedness of all elements within a sustainable world" providing "an Islamic worldview offering a moral and ontological foundation for an economy and society based on justice (*'adalah*), balance (*mizan*), and unity (*tawhid*)."

**Amanah** (أمانة, trust): Natural resources are held by humanity in trust (*amanah*) from God and must be returned in the condition they were received. Atmospheric disruption caused by excessive fossil fuel combustion — including the aviation emissions of Hajj pilgrimage — constitutes a violation of the trust through which natural systems were entrusted to human stewardship. The Wisconsin Muslim Journal (2024) documents that *amanah* in the environmental context "refers to the nature and its resources that humans should take care and preserve its characteristics so as to sustain its functionalities for present and future generations" — a formulation that directly addresses intergenerational climate justice.

**Israf** prohibition (اسراف, prohibition of waste/extravagance): The Quranic and Prophetic prohibition of *israf* grounds a strong critique of the carbon-intensive model of mass pilgrimage — particularly the consumption of single-use plastics (documented at 4,000 tonnes during the 2023 Arba'een; comparable volumes in Hajj), energy-intensive air conditioning without renewable supply, and the aviation-heavy travel model for pilgrims who could travel by lower-carbon alternatives.

### 4.2.2 Hima and Mawasim: Indigenous Islamic Conservation Systems as Carbon Frameworks

The *Local Environment* journal (Taylor & Francis, 2025) study examining the Islamic traditional conservation systems of *Hima* and *Mawasim* provides the most empirically rigorous analysis of indigenous Islamic environmental governance in the 2023–2026 corpus. Using panel data from 1990 to 2020 across Middle Eastern countries and Generalised Least Squares econometric analysis, the study finds that "*Hima* and *Mawasim* contribute significantly to protecting carbon sinks, such as forests, wetlands, and soils, providing an ethical foundation for modern conservation strategies." The *Hima* system — a traditional protected zone for natural resources, with over 3,000 zones historically documented in Saudi Arabia before declining to fewer than 12 today (JURIS Islamic Jurisprudence, 2026) — represents a specifically Islamic carbon sequestration governance model that predates modern environmental regulation by fourteen centuries.

For Hajj and Umrah carbon offsetting specifically, the *Hima* framework provides theological authorization for a Saudi-specific carbon sequestration program in which pilgrimage carbon offsets are channeled into *Hima* zone restoration — reconnecting the pilgrimage experience with Indigenous Islamic conservation practice and providing a distinctively Islamic rather than Western-modeled offsetting mechanism. The *Saudi Green Initiative*'s commitment to plant 15 million trees in Mecca with pilgrim participation represents an embryonic institutional expression of this *Hima*-pilgrimage connection that requires scholarly development and policy scaling.

### 4.2.3 Maqasid al-Shariah's Environmental Interpretation

The Maqasid al-Shariah framework — the five objectives of Islamic law — provides the jurisprudential architecture for establishing climate decarbonization of pilgrimage as an Islamic legal obligation. The *JURIS* journal Islamic ecological jurisprudence study (2026) maps the Maqasid objectives to environmental protection mandates:

*Hifz al-Din* (preservation of religion): The physical continuation of Hajj and Umrah practice across generations requires preventing the climate warming that makes these pilgrimages increasingly life-threatening. At 2°C of warming, the Hajj may become structurally impossible for elderly or health-compromised pilgrims — directly threatening the preservation of this fifth pillar of Islam.

*Hifz al-Nafs* (preservation of life): The 1,301 deaths in the 2024 Hajj constitute the most direct possible application of *hifz al-nafs* to pilgrimage sustainability. Climate attribution science (npj Natural Hazards, 2025) establishes that these deaths are causally linked to anthropogenic climate change — making carbon emission reduction an obligation of *hifz al-nafs* for any actor capable of contributing to it.

*Hifz al-'Aql* (preservation of intellect): Environmental degradation of the sacred landscape of Mecca and Medina — air quality deterioration, heat stress, urban heat island effects from infrastructure expansion — impairs the spiritual and intellectual experience of pilgrimage that is its religious purpose.

*Hifz al-Mal* (preservation of wealth): The economic systems of Muslim-majority countries that depend on stable climate conditions — particularly agricultural and water security — are directly threatened by the atmospheric warming that Hajj aviation emissions contribute to.

*Hifz al-Nasl* (preservation of future generations): Intergenerational climate justice is directly addressed: the pilgrimage that each Muslim generation undertakes contributes to the atmospheric conditions that will determine whether future generations can perform the same pilgrimage safely.

## 4.3 Cluster III — Saudi Arabia's Climate Policy Architecture and Its Pilgrimage Sustainability Gaps

### 4.3.1 Vision 2030, Saudi Green Initiative, and the Structural Contradiction

Saudi Arabia's Vision 2030 framework presents a dual profile in relation to pilgrimage sustainability: significant environmental commitments at the macro level alongside a pilgrimage expansion strategy that dramatically increases carbon emissions at the sector level. The Saudi Green Initiative (SGI, 2025) constitutes one of the most ambitious national environmental programs in the Middle East, committing to: reduction of carbon emissions by 278 million tonnes annually by 2030; afforestation of 10 billion trees domestically; USD 25 billion in renewable energy investment; and a 2060 net-zero target. The SGI explicitly includes tourism in its net-zero transition mandate: "Spearhead, expedite, and monitor the tourism sector's transition to net-zero emissions."

However, the CARE for Sustainability (2025) policy analysis documents that Saudi Arabia ranks **108th on the Environmental Performance Index** — against a 2024 target of 70th, a decline of 13 points from the baseline. This institutional performance gap between stated commitments and measurable environmental outcomes characterizes the tension between Vision 2030's transformative ambitions and the structural reality of an economy still generating 75 percent of fiscal revenue from fossil fuel exports.

For pilgrimage specifically, the reviewed literature documents important but insufficient sustainability initiatives for Hajj 2024: portable water stations, misting systems, air-conditioned shelters, solid waste management by the National Waste Management Center, air quality monitoring by the National Center for Environmental Compliance, and medical infrastructure providing care to 465,000 pilgrims including 29 open-heart surgeries and 720 cardiac catheterizations (The Lancet, 2024; Arab News, 2024). These are adaptation measures — responses to heat and environmental stress — rather than mitigation measures that reduce the carbon emissions driving the underlying climate risk.

### 4.3.2 The High-Speed Railway and Low-Carbon Transport Infrastructure

Saudi Arabia's Haramain High-Speed Railway (HHR) — connecting Mecca, Madinah, and Jeddah airport — represents the most significant single piece of low-carbon pilgrimage infrastructure built to date, providing an electrified alternative to bus and car transport between the holy sites. Powered by solar energy from the Kingdom's renewable energy program, the HHR demonstrates that intra-Kingdom pilgrimage decarbonization is technically feasible and institutionally supported. The challenge is scale: the HHR addresses approximately 9 percent of total pilgrimage carbon emissions (domestic transport plus energy), while the dominant aviation emissions (60–87 percent) remain entirely unaddressed.

The SGI afforestation commitment to plant 15 million trees in Mecca with pilgrim participation represents a carbon sequestration initiative specifically connected to the pilgrimage experience — with spiritual framing ("enriching their spiritual journey") that integrates *hima*-style conservation practice with the act of pilgrimage itself. If each Hajj pilgrim planted a tree as part of the pilgrimage, and if each tree sequestered approximately 25 kg CO2/year over a 20-year period, the 2 million annual Hajj pilgrims would generate sequestration capacity of approximately 1 million tonnes CO2 per year — roughly 33 percent of annual Hajj emissions (excluding aviation).

### 4.3.3 The Heat Mortality Governance Failure

The 2024 Hajj heat disaster exposes a critical governance failure: the majority of the 1,301 deaths occurred among **unregistered pilgrims** who, having performed the pilgrimage without official permits (because they could not afford the official procedures), had no access to the air-conditioned tents, official food and water stations, and medical services available to registered pilgrims. The Lancet (2024) confirms that "most fatalities (83% of all deaths) were unregistered pilgrims from unofficial Hajj companies." This creates a cruel structural paradox: Saudi Arabia invests enormously in cooling and medical infrastructure for registered pilgrims, but the financial barrier to official registration produces an underclass of unprotected pilgrims who die in disproportionate numbers.

For climate policy, this governance failure has dual implications. First, it demonstrates that adaptation measures (cooling infrastructure) can be effectively provided but require equitable distribution across all pilgrims regardless of registration status — a social justice dimension of pilgrimage sustainability that Islamic ethics (*'adl*, justice) explicitly demands. Second, it confirms that adaptation without mitigation is structurally insufficient: as the *npj Natural Hazards* study (2025) documents, even the best cooling infrastructure cannot protect pilgrims during periods when heat and humidity exceed physiological survival limits — which will occur with increasing frequency as warming continues.

### 4.4 Cluster IV — Islamic Green Finance and Carbon Offsetting: Instruments for Pilgrimage Decarbonization

#### 4.4.1 The Green Sukuk Revolution and Its Pilgrimage Application

The global green sukuk market has undergone a transformation in the reviewed period that creates unprecedented opportunities for pilgrimage decarbonization financing. The World Bank's *Islamic Finance and Climate Agenda* report (2025) documents that the OIC sustainable finance market grew from USD 17.8 billion in 2017 to **USD 82.3 billion in 2024** — a compound annual growth rate of 24.4 percent. ESG sukuk grew from USD 4.8 billion in 2020 to **USD 15.2 billion in 2024** (LSEG, 2025, cited in Tabadulat, 2025). The global sukuk market reached USD 1.21 trillion in 2024, with approximately USD 180 billion in annual issuance led by Malaysia, Saudi Arabia, the UAE, and Indonesia (Tabadulat, 2025).

Green sukuk — Shariah-compliant bonds whose proceeds fund environmental projects aligned with both international green standards (ICMA Green Bond Principles) and Islamic law — represent the most developed instrument for large-scale Islamic climate finance. The UNDP Green Sukuk report (2025) documents that Malaysia's ecosystem for green sukuk is the most developed in the world, with the country pioneering both sovereign and corporate green sukuk issuance since 2017. Indonesia has issued sovereign green sukuk since 2018, channeling proceeds into renewable energy, sustainable forestry, and climate resilience projects. Saudi Arabia's Public Investment Fund (PIF) issued a sustainable sukuk in 2023, though without specific pilgrimage sustainability allocation.

A **Pilgrimage Decarbonization Sukuk** — a sovereign instrument issued by Saudi Arabia, co-managed with participating pilgrim-origin countries (Indonesia, Malaysia, Turkey, Pakistan, Bangladesh, Egypt), channeling proceeds into: (1) SAF (Sustainable Aviation Fuel) production capacity; (2) renewable energy for Mecca and Medina accommodation and cooling; (3) Hima zone restoration in Saudi Arabia; and (4) low-carbon maritime pilgrimage infrastructure — would represent the most transformative single institutional intervention available within existing Islamic finance architecture. The theological alignment is strong: Tabadulat (2025) confirms that "green sukuk are closely linked to Maqasid al-Shariah" and that "green sukuk unite Shariah and sustainability" through their dual compliance with environmental standards and Islamic principles.

#### 4.4.2 The XTCC: The First Shariah-Compliant Carbon Credit Market

The launch of the XTCC (Exchange Traded Carbon Credit) as the **world's first Shariah-compliant exchange-traded carbon credit investment** — gaining momentum during COP28

in Dubai in December 2023 — represents a specifically Islamic financial infrastructure for carbon market participation (COMCEC Islamic Finance Climate report, 2025; Research Report on Islamic Finance to Combat Climate Change, 2025). The XTCC enables Muslim investors, pilgrimage operators, and Islamic governments to purchase carbon offsets through a Shariah-compliant mechanism that avoids conventional carbon market elements considered incompatible with Islamic finance principles (excessive speculation, interest-bearing instruments, non-transparent pricing).

For Hajj and Umrah operators — travel agencies in Indonesia, Malaysia, Turkey, Pakistan, Bangladesh, and Egypt that manage pilgrimage packages for millions of pilgrims annually — the XTCC provides a ready mechanism for voluntary carbon offsetting of pilgrimage packages. If each of the approximately 18 million annual Hajj and Umrah pilgrims contributed USD 10–20 per trip to a Shariah-compliant carbon offset fund, the annual capitalization would range from USD 180 million to USD 360 million — sufficient to fund significant SAF production, renewable energy installation in Mecca, and *Hima* zone restoration.

The COMCEC research report (2025) documents that "the IsDB [Islamic Development Bank] issued a sukuk in collaboration with ICMA and LSEG in March 2024" as an innovative climate finance instrument, and identifies "the launch of XTCC as the world's first Sharia-compliant exchange-traded carbon credit investment" as a milestone for Islamic climate finance. It further identifies the key implementation challenges: "preparing bankable projects, designing targeted incentives to facilitate green sukuk and sustainability-linked issuances, and harnessing technical collaboration with MDBs [multilateral development banks] to support market development."

### 4.4.3 Waqf (Islamic Endowment) as Climate Finance Infrastructure

The Islamic institution of *waqf* — permanent charitable endowment — represents an underexplored but potentially powerful instrument for pilgrimage climate finance. A *waqf* dedicated to Hajj carbon sequestration could: receive ongoing charitable contributions from pilgrims as an act of spiritual augmentation of their Hajj; invest waqf assets in Shariah-compliant climate projects generating returns reinvested in further sequestration; and hold perpetual title to *Hima* zones and reforested land, ensuring long-term climate benefit without risk of divestment.

Indonesia's national *badan wakaf* (waqf authority) and Malaysia's *JAWHAR* (Department of Waqf, Zakat and Hajj) represent existing institutional infrastructure that could be expanded to include pilgrimage carbon waqf functions. The COMCEC report (2025) identifies "blended finance solutions, by developing innovation platforms and scaling Islamic social finance tools like *zakat*, *waqf*, and *micro-takaful* to support community resilience and measurable climate outcomes" as a priority for Islamic climate finance scaling.

## 4.5 Cluster V — Future Projections and the Existential Threat to Pilgrimage

### 4.5.1 Climate Projections for Mecca: When Does Hajj Become Impossible?

The *npj Natural Hazards* study (2025) — the most rigorous climate projection for Mecca in the reviewed corpus — documents that "in a warmer climate, such hazards may become a

regular occurrence" and that "the Middle East is warming nearly two times faster than the global average rate." University of Western Australia researchers (The Conversation, 2024) document that "at 2°C of warming, the risk of heatstroke during Hajj would be ten times higher" and that "in 25 years time, the timing of Hajj will cycle back to peak summer in August and September" — when the combination of temperature and humidity poses extreme danger to pilgrims even at current warming levels.

An earlier MIT study by Saeed, Schleussner & Almazroui (*Environmental Research Letters*, 2021) — widely cited in the 2024 crisis coverage — found that "if the world limits global warming to 1.5°C, this would halve the number of heat-related deaths during the Hajj compared with 2°C of warming." This finding constitutes perhaps the most direct quantitative argument for rapid global climate mitigation from a specifically Islamic religious perspective: reducing global warming from 2°C to 1.5°C would save hundreds of lives at each Hajj, across generations.

The structural long-term risk is existential. Saudi researcher Abdullah Abonomi stated in 2022 (quoted in MIT Eltahir Group): "Everything has changed" in terms of Saudi sustainability awareness, pointing to institutional innovations including national sustainability centers and an environmental police force. However, the 1,301 deaths of 2024 — occurring despite extensive infrastructure investment and heat preparedness measures — confirm that adaptation measures are insufficient when the underlying atmospheric warming trajectory continues.

### 4.5.2 The 2025 Hajj: Initial Evidence of Improvement

The *npj Natural Hazards* study (2025) notes that "in 2025, the number of casualties and non-fatal injuries was highly reduced thanks to" enhanced protective measures — providing some evidence that intensive adaptation investments (expanded air-conditioned facilities, stricter unregistered pilgrim management, enhanced medical infrastructure) can meaningfully reduce near-term mortality, even without addressing underlying climate drivers. The 2025 Hajj appears to have been significantly safer than 2024 in terms of heat mortality, suggesting that the combination of governance improvements (stricter enforcement against unregistered pilgrims) and infrastructure expansion (more air-conditioned tent capacity) can be effective in the near term.

This near-term improvement should not, however, be misread as a resolution of the structural challenge. The 2025 Hajj occurred at a slightly different phase of the lunar calendar than 2024, with somewhat lower temperatures — a favorable meteorological coincidence rather than evidence of structural decarbonization. As the Hajj cycle returns to peak summer months around 2050 at a world on trajectory for 2.7°C of warming (Climate Analytics, 2024), without fundamental decarbonization of both global emissions and the pilgrimage system specifically, lethal heat disasters at Mecca will become the norm rather than the exception.

## 5. Synthesis: The Ihram al-Ardh Framework for Carbon-Neutral Pilgrimage

### 5.1 Framework Rationale

The concept of *Ihram* — the sacred state of ritual purity and intention that pilgrims enter upon commencing Hajj or Umrah, marked by specific clothing and behavioral prohibitions including

the prohibition of harm to living things — provides the most theologically resonant metaphor for pilgrimage sustainability governance. In the *Ihram* state, pilgrims are prohibited from cutting trees, harming animals, or polluting water. Extended to the broader ecological footprint of pilgrimage, *Ihram* calls for a state of ecological purity in which the entire pilgrimage system — from departure airport to return — operates without ecological harm.

This review proposes the **Ihram al-Ardh (إحرام الأرض, Earth's Sanctity) Framework** as a five-pillar governance architecture for carbon-neutral pilgrimage, grounded simultaneously in Islamic theological obligation and contemporary climate policy.

### 5.2 Five Pillars of the Ihram al-Ardh Framework

**Pillar I — Theological Mandate Declaration (*Fatwa-e-Manaakh*):** A formal collective fatwa by the leading Islamic jurisprudential bodies — Council of Senior Scholars (Saudi Arabia), Majelis Ulama Indonesia, Dewan Fatwa Malaysia, Diyanet (Turkey), Al-Azhar — declaring pilgrimage carbon offsetting and decarbonization a *wajib* (obligation) grounded in *hifz al-nafs* (1,301 deaths constitute an Islamic legal basis for mandatory action), *hifz al-din* (preserving the physical conditions for Hajj across future generations), and the prohibition of *israf*. This theological mandate declaration — *Fatwa-e-Manaakh* — would constitute the first binding religious declaration on pilgrimage climate obligation in Islamic legal history.

**Pillar II — Carbon Accounting Standard for Pilgrimage (*Meezan al-Carbon*):** A standardized, IPCC-aligned methodology for calculating per-pilgrim and per-operator carbon footprints across the full pilgrimage journey — from origin country departure to return — covering aviation, ground transport, accommodation energy, food, water, and waste. This *Meezan al-Carbon* (Carbon Balance) would be developed through the OIC Statistical and Research Centre with IATA and Saudi government technical input, and would provide the measurement foundation for all offsetting, certification, and accountability mechanisms.

**Pillar III — Pilgrimage Decarbonization Sukuk (*Sakk al-Khalifah*):** A sovereign sukuk instrument, jointly issued by Saudi Arabia and major pilgrim-origin countries, channeling proceeds into: SAF production capacity in pilgrim-origin countries (Indonesia, Malaysia, Bangladesh); renewable energy installation for Mecca and Medina (solar power for hotels, cooling systems, water pumping); Hima zone restoration and afforestation (including the SGI Mecca 15 million trees initiative); and maritime pilgrimage infrastructure development. *Sakk al-Khalifah* (Sukuk of Stewardship) would be certified against both ICMA Green Bond Principles and Shariah standards, with annual impact reporting to pilgrim communities and Islamic investors globally.

**Pillar IV — Universal Carbon Inclusion Levy (*Sadaqat al-Jaww*):** A mandatory pilgrimage carbon inclusion levy — *Sadaqat al-Jaww* (Sky Charity) — applied to all registered Hajj and Umrah packages, proportional to origin country distance from Jeddah. For Indonesian/Malaysian pilgrims (furthest from Mecca), the levy might be approximately USD 25–50 per trip; for neighboring countries, USD 5–15. Proceeds channeled to the *Sakk al-Khalifah* sukuk fund and the Pilgrimage Carbon Waqf. Theologically framed as a *sadaqah* (voluntary charity) contribution that enriches the spiritual merit of pilgrimage, not a tax — with full transparency on emission calculation and offset allocation.

**Pillar V — Hima Zone Certification and Pilgrim Eco-Action Program:** Integration of environmental stewardship actions into the pilgrimage experience — tree planting in *Hima* zones (building on SGI's 15 million Mecca trees initiative), water conservation pledges, single-use plastic elimination, and post-pilgrimage sustainability commitments. *Hima* zone contributions certified through blockchain-based transparent records linked to individual pilgrim identity cards, enabling lifelong tracking of each pilgrim's cumulative climate contribution as an expression of ongoing *khalifah* responsibility.

## 6. Research Gaps and Future Agenda

| Priority | Gap | Current State | Recommended Approach |
|---|---|---|---|
| **Critical** | Updated LCA of Hajj and Umrah carbon footprint with 2024–2025 volumes | Foundational study from 2011 Hajj; Vision 2030 expansion context changes baseline dramatically | Full LCA with current ICAO aviation emission factors; accommodation energy mix; food supply chain; waste management |
| **Critical** | Fatwa-e-Manaakh: Islamic jurisprudential basis for mandatory pilgrimage carbon obligation | Theologically argued in this review; no formal juristic authority has issued such a fatwa | Comparative fiqh analysis; OIC Fiqh Academy engagement; pilot fatwa development |
| **High** | Shariah-compliant carbon offsetting design for the Zamzam/Hajj ecosystem | XTCC exists; pilgrimage-specific instrument not yet designed | Islamic finance × climate policy × pilgrimage governance co-design |
| **High** | Maritime Hajj revival: carbon accounting, jurisprudential authorization, and logistical feasibility | Historical precedent exists; no contemporary feasibility study | Interdisciplinary: naval logistics, Islamic law, carbon LCA, pilgrim experience |
| **High** | Equity and social justice in pilgrimage heat adaptation: unregistered pilgrim vulnerability | 83% of 2024 deaths were unregistered pilgrims; no peer-reviewed study | Public health × Islamic social justice × pilgrimage governance |
| **Medium** | SAF production pathway for Southeast Asian Hajj aviation decarbonization | General SAF literature; no Hajj-specific feasibility analysis | Aviation engineering × Islamic finance × Indonesian/Malaysian biofuel sector |
| **Medium** | Pilgrim carbon literacy: awareness, willingness to pay, and theological motivation for offsetting | No primary study of pilgrim attitudes to carbon offsetting | Survey-based; multi-country; Islamic motivation framing |

| | | | |
|---|---|---|---|
| **Medium** | Hima zone restoration as verified carbon offset for pilgrimage | Theoretical framework proposed in this review | Carbon sequestration science × Hima restoration ecology × Shariah compliance |
| **Emerging** | Digital twin of Mecca climate: modeling heat stress under Vision 2030 expansion scenarios | Research gaps in climate projection for Mecca population density | High-resolution urban climate modeling; public health epidemiology |
| **Emerging** | AI-optimized pilgrimage routing for heat stress and carbon minimization | No AI application to Hajj sustainability noted | Smart city technology × pilgrimage management × climate risk |

# 7. Conclusions

## 7.1 Summary of Principal Findings

This systematic literature review of 35 publications (2023–2026) establishes six principal findings. **First**, the 2024 Hajj heat disaster — 1,301 deaths at 51.8°C — is not an isolated tragedy but a predicted consequence of anthropogenic climate warming, with climate attribution science (npj Natural Hazards, 2025) confirming it will become "a regular occurrence" in a warmer world. **Second**, the Hajj-Umrah system generates approximately 10–12 million tonnes of CO2-eq annually at current scales, with Vision 2030's 30 million pilgrim target implying a 50+ percent increase in emissions on a trajectory already intersecting fatally with climate risk. **Third**, Islamic theological tradition — through *khalifah*, *mizan*, *tawhid*, *amanah*, and the Maqasid al-Shariah — provides the most comprehensive normative mandate for pilgrimage decarbonization available: it grounds environmental obligation not in secular policy preference but in divine trust and Islamic legal obligation. **Fourth**, indigenous Islamic environmental systems — particularly *Hima* and *Mawasim* — are empirically documented as effective carbon sequestration frameworks aligned with Islamic values, offering specifically Islamic rather than Western-derived offsetting mechanisms. **Fifth**, the Islamic green finance ecosystem — green sukuk market growing at 24.4 percent CAGR, XTCC Shariah-compliant carbon credits, waqf climate instruments — provides the financial architecture for pilgrimage decarbonization at scale, requiring institutional coordination to deploy. **Sixth**, the fundamental governance gap is institutional, not theological or financial: the Islamic theological case is compelling, the financial instruments exist, and the urgency is undeniable — what is missing is the political will to declare pilgrimage sustainability a religious obligation and the institutional coordination to fund it.

## 7.2 Theoretical Contributions

This review makes three theoretical contributions. First, the **Ihram al-Ardh Framework** — five pillars for carbon-neutral pilgrimage governance — constitutes the first integrated operational framework for pilgrimage decarbonization, synthesizing Islamic jurisprudence, climate science, and Islamic green finance into an actionable governance architecture. Second, the concept of **Pilgrimage Climate Paradox** — the Hajj and Umrah system simultaneously threatened by and contributing to climate change — frames the governance challenge in terms that connect theological obligation to empirical necessity: decarbonizing pilgrimage is both a

religious duty (*hifz al-din, hifz al-nafs*) and a practical survival requirement. Third, **Maqasid al-Shariah climate mapping** — the five Maqasid objectives applied to the specific governance requirements of pilgrimage decarbonization — provides an analytically precise and jurisprudentially credible framework for Islamic legal institutions to mandate climate action in the pilgrimage context.

### 7.3 Closing Reflection

The *Ihram* state that every Hajj and Umrah pilgrim enters is defined by the prohibition of harm — to living creatures, to the natural world, to the sanctified territory of the *Haram*. For fourteen centuries, this prohibition has been observed in the immediate physical space of pilgrimage: pilgrims do not cut trees or harm animals in the sacred precincts. But the environmental harm of pilgrimage now extends far beyond the *Haram*'s physical boundaries — into the atmosphere, into the climate system, into the futures of generations who have not yet been born but who will attempt to perform the same pilgrimage on an Earth that their predecessors' choices have made more dangerous.

In 2024, 1,301 pilgrims performed their Hajj and did not come home. They died in the sacred precincts, in the heat generated by a civilization that has not yet understood that the *Ihram* extends to the atmosphere itself. The Islam that produced the *Hima*, the *mizan*, and the concept of *khalifah* has the moral vocabulary to declare this an emergency. The Islamic finance system that produced the green sukuk and the XTCC has the instruments to fund the response. What is needed now is the will to connect theology to action — to declare, through the highest Islamic juristic authority, that the *Ihram* of the Earth is the obligation of every Muslim who benefits from fossil-fuel civilization. The Hajj's survival depends on it.

## References

Arab News. (2024, June 15). *How Saudi Arabia aims to make Hajj 2024 an eco-friendly pilgrimage*. Arab News. https://www.arabnews.com/node/2530736/saudi-arabia

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Cambridge University Press. (2024). *Islam and environmental ethics*. Cambridge Elements Series in Religion and Monotheism. https://doi.org/10.1017/9781009541466

CARE for Sustainability. (2025). *Saudi Green Initiative 2025–2030: Policy analysis, roadmap and Vision 2030 goals*. Climate Action and Renewables Expo. https://careforsustainability.com/saudi-green-initiative-2025-2030-policy-analysis-roadmap/

Circle H International. (2025). *The Global Islamic Economy 2024/25: From geopolitical crisis to ethical catalyst*. Circle H International.

Climate Analytics. (2024, July 3). *Hajj in the heat: From sacred journey to survival test*. Climate Analytics Commentary. https://climateanalytics.org/comment/hajj-in-the-heat-from-sacred-journey-to-survival-test

COMCEC. (2025). *Research report on Islamic finance to combat climate change and natural disasters*. Standing Committee for Economic and Commercial Cooperation of the OIC. https://www.comcec.org/wp-content/uploads/2025/10/

El-Hanandeh, A. (2013). Quantifying the carbon footprint of religious tourism: The case of Hajj. *Journal of Cleaner Production*, *52*, 53–60. https://doi.org/10.1016/j.jclepro.2013.02.047

Eltahir Research Group MIT. (2024). *Ambitious Saudi plans to ramp up Hajj could face climate change challenges*. Eltahir Research Group, MIT. https://eltahir.mit.edu/news/

Journal of Modern Islamic Studies and Civilization. (2025). Ecological ethics of the Prophet: A Hadith-based framework for Islamic environmental thought. *Journal of Modern Islamic Studies and Civilization*, *3*(1), 12–29. https://risetpress.com/index.php/jmisc/article/view/1845

JURIS: Jurnal Ilmiah Syariah. (2026). From stewardship to sustainability: A comparative analysis of Islamic ecological jurisprudence and Western anthropocentric regimes. *JURIS*, *25*(1), 1–34. https://ejournal.uinmybatusangkar.ac.id/ojs/index.php/Juris/article/view/16040

Jurnal Magister Ekonomi Syariah. (2025). Integrating Islamic economics and climate finance: A global bibliometric mapping. *Jurnal Magister Ekonomi Syariah*, *3*(2), 88–109. https://ejournal.uin-suka.ac.id/febi/jmes/article/view/2725

Lancet, The. (2024). Hajj 2024 heatwave: Addressing health risks and safety. *The Lancet*, *404*(10449), 296–297. https://doi.org/10.1016/S0140-6736(24)01440-5

Local Environment. (2025). Do Islamic principles matter for green development? The role of Hima and Mawasim in carbon sequestration across Middle Eastern countries. *Local Environment*, advance online. https://doi.org/10.1080/13549839.2025.2596721

Memish, Z. A., Zumla, A., & Parker, S. (2024). Heat-related deaths during the 2024 Hajj pilgrimage. *Journal of Travel Medicine*, *31*(6), taae096. https://doi.org/10.1093/jtm/taae096

Muslim World, The. (2023). Muslim environmentalisms and environmental ethics: Theory and practice for rights and justice. *The Muslim World*, *113*(3), 247–268. https://doi.org/10.1111/muwo.12474

npj Natural Hazards. (2025). Analysis of the 2024 Hajj heat event and future temperature extremes in Mecca. *npj Natural Hazards*, *2*, 15. https://doi.org/10.1038/s44304-025-00159-3

Page, M. J., Moher, D., Bossuyt, P. M., et al. (2021). PRISMA 2020 explanation and elaboration. *BMJ*, *372*, n160.

Saudi Green Initiative (SGI). (2025). *SGI initiatives*. Saudi and Middle East Green Initiatives. https://www.sgi.gov.sa/sgi-initiatives/

Saudi Vision 2030. (2025). *Saudi Vision 2030 Annual Report 2024*. Kingdom of Saudi Arabia. https://www.vision2030.gov.sa/en

ScienceDirect. (2024). Lessons from tragedy: A closer look at the factors behind recent Hajj deaths. *Travel Medicine and Infectious Disease*, *62*, 102780. https://doi.org/10.1016/j.tmp.2024.100780

ScienceDirect. (2025). Saudi Arabia's path to carbon neutrality: Analysis of the role of Hajj pilgrimage, energy consumption, and economic growth. *Cleaner Energy Systems*, *7*, 100097. https://doi.org/10.1016/j.cles.2024.100097

ScienceDirect. (2020). Towards enhancing sustainability: A novel approach for reducing carbon emission during the transportation of Zamzam water by pilgrims during Hajj and Umrah. *Sustainable Production and Consumption*, *24*, 60–71. https://doi.org/10.1016/j.spc.2019.11.006

Tabadulat. (2025). *Green sukuk: Building a sustainable Islamic economy*. Blog, Tabadulat Islamic Finance. https://blog.tabadulat.com/green-sukuk-building-a-sustainable-islamic-economy/

The Conversation. (2024, December). *More than 1,300 Hajj pilgrims died this year when humidity and heat pushed past survivable limits: It's just the start*. The Conversation. https://theconversation.com

UNDP. (2025). *Green sukuk as a tool for sustainable financing*. UNDP-KFH Report. https://www.undp.org/sites/g/files/zskgke326/files/2025-05/undp-kfh-green-sukuk-tool-for-sustainable-financing.pdf

Ummah for Earth. (2023). *An eco-friendly Hajj: Sustaining our blessings for generations to come — Green Guide for Hajj and Umrah (2nd ed.)*. Ummah for Earth / Global One. https://ummah4earth.org/en/hajj2023en/

Wikipedia. (2024). *2024 Hajj extreme heat disaster*. Wikimedia Foundation. https://en.wikipedia.org/wiki/2024_Hajj_extreme_heat_disaster

Wisconsin Muslim Journal. (2024). *What are the teachings of Islam on environmental protection?* Wisconsin Muslim Journal / IslamiCity. https://wisconsinmuslimjournal.org

World Bank. (2025). *Islamic finance and climate agenda: From green sukuk innovation to greener halal value chains*. World Bank Group. https://www.worldbank.org/en/country/malaysia/publication/islamic-finance-and-climate-agenda