



THE BAHAMAS

Academy of Sciences

CLIMATE CHANGE AND OCEAN WARMING IMPACTS ON THE BAHAMAS – WHAT DOES THE SCIENCE TELL US?

The Commonwealth of The Bahamas sits at the sharpest edge of the global climate crisis – an archipelago of over 1,500 islands and rocks, 80% of whose land lies within 1.5 meters of sea level, contributing less than 0.01% of global greenhouse gas emissions yet absorbing some of the world's most severe climate consequences. Here is a comprehensive synthesis across all four impact dimensions.

1. Environmental Impacts

Sea Level Rise & Coastal Erosion

Sea levels are projected to rise by nearly **0.5 meters by 2100** even under optimistic Paris Agreement-aligned emissions scenarios. The structural geography of the Bahamian archipelago makes this catastrophic in scale: projections indicate that a 0.5 m rise would place **~41% of national land area and 22% of the population below sea level**. Without adaptation, up to **half of all sandy beaches near hotel infrastructure could be entirely lost**, as the archipelago hosts nearly half of all sandy beaches in the wider Caribbean.

Intensifying Hurricane Activity

Warmer sea surface temperatures are a primary driver of **stronger, slower-moving, and wetter tropical cyclones**. Hurricane Dorian (2019) – a Category 5 storm with 185 mph sustained winds – is the paradigmatic example. The IMF projects that hurricane-related physical damages will increase by **31% under 3°C warming and 42% under 4.3°C warming** relative to baseline. Over the past decade, climate-related

natural disasters have averaged **3.2% of GDP annually** in direct damages. This, combined with higher sea levels, mean that hurricanes will have greater physical and economic impacts.

Freshwater & Soil Salinization

The Bahamas relies on shallow, lens-shaped freshwater aquifers that are acutely vulnerable to saltwater intrusion – a process intensified by sea level rise, storm surges, and reduced precipitation recharge. Studies from **Grand Bahama found an average soil salinity of 475.5 mg/kg** in wellfields supplying potable water (2022 data), while soils on Andros have been recorded at salinities as high as **2,450 ppm**. These conditions directly compromise both drinking water security and agricultural productivity across the Family Islands.

Changing Precipitation & Drought

Altered precipitation regimes – characterized by more intense rainfall events interspersed with prolonged droughts – further stress fragile freshwater lenses and limited agricultural soils.

2. Ecological Impacts

Mass Coral Bleaching

In summer 2023, The Bahamas experienced a catastrophic, archipelago-wide **mass coral bleaching event** driven by ocean temperatures reaching **91°F (33°C)** – sustained as a full marine heatwave for months. The Perry Institute for Marine Science documented severe bleaching across reef systems including the near-total loss of elkhorn (*Acropora palmata*) and staghorn (*A. cervicornis*) corals at multiple sites (www.perryinstitute.org). Caribbean coral reefs generally thrive at 26–29°C; temperatures above this threshold cause the expulsion of symbiotic zooxanthellae algae, leaving corals starved and white.

Stony Coral Tissue Loss Disease (SCTLD)

Compounding bleaching stress, SCTLD – a highly contagious, fast-spreading disease affecting the majority of reef-building coral species – has devastated Bahamian reefs (Dahlgren et al. 2021). By the 2024 Little Inagua expedition, PIMS scientists found all

surveyed pillar corals (*Dendrogyra cylindrus*) killed by SCTLD** and widespread bleaching mortality across elkhorn and staghorn populations, though some brain corals, star corals, and flower corals showed resilience.

Loss of Reef Framework & Carbonate Dynamics

Research published in Current Biology documents that bleaching events and disease are driving Caribbean reef systems toward **net carbonate erosion** – meaning reefs are dissolving faster than corals can build them, fundamentally undermining their structural integrity and coastal protection function. Loss of coral reefs places coastal areas at greater risk to erosion and storm surges from hurricanes.

Mangrove & Seagrass Degradation

Mangrove forests and seagrass meadows – critical nursery habitats for commercially important species (grouper, snapper, spiny lobster, queen conch) – face inundation from sea level rise and physical destruction from intensifying hurricanes. As these ecosystems degrade, their capacity to buffer coastlines against storm surge is reduced, creating a **dangerous feedback loop** in which ecosystem loss amplifies future storm damage.

Fisheries Decline

Rising sea surface temperatures and **ocean acidification** are projected to diminish available marine fish stocks, threatening the biodiversity of the marine food web and reducing the productivity of commercially important fisheries. The Bahamas' unique tropical marine ecosystems – including its blue holes, which are globally significant biodiversity hotspots – face mounting thermal and chemical stress. For tropical fish, small increases in ocean temperature can reduce growth, reduce fecundity and increase mortality. The **Critical Thermal Maximum (CTMax)** is a foundational metric used to quantify an organism's acute upper thermal tolerance. Historically evaluated as the temperature where a fish loses its ability to escape conditions leading to death (typically marked by **loss of equilibrium (LOE)**), it has become a core parameter in predicting the impacts of **climate change** on aquatic species.

3. Social Impacts

Population Displacement & Climate Migration

With 22% of the population projected to live below sea level under a 0.5 m rise scenario, The Bahamas faces the prospect of **internal climate displacement** on a large scale, particularly for residents of low-lying Family Islands. Hurricane Dorian alone displaced tens of thousands of residents from Abaco and Grand Bahama, many of whom have not returned – serving as a preview of permanent climate-driven relocation pressures.

Public Health Threats

Climate change is expanding the range and season of **vector-borne diseases** (dengue, chikungunya, Zika), while extreme heat events increase heat-related illness. Flooding from storm surges and heavy rainfall events, contaminates freshwater supplies, elevating risks of waterborne disease. A 2023 study in PLOS Climate documented healthcare capacity constraints exposed by Hurricane Dorian and called for systematic training of healthcare professionals to address climate-health intersections in The Bahamas. Impacts of climate change on mental health are also dire. Trauma from experiencing extreme events is an area of rising concern.

Food & Water Security

Saltwater intrusion into aquifers and soils directly undermines agricultural viability on the Family Islands. Combined with declining fisheries productivity, this creates compounding **food security pressures** for communities that depend heavily on subsistence fishing and local agriculture.

Inequitable Distribution of Risk

The IMF's 2025 analysis explicitly highlights that climate risks are **unevenly distributed**: smaller, lower-elevation Family Islands face disproportionately greater exposure and sensitivity to climate hazards compared to the more developed islands of New Providence and Grand Bahama. This geographic inequality intersects with income disparities, creating the most severe burdens for the most economically vulnerable communities, across all islands of The Bahamas.

Infrastructure & Basic Services

The dispersed island geography of The Bahamas dramatically increases the cost and complexity of providing resilient infrastructure. Storm damage repeatedly disrupts

electricity, communications, roads, and healthcare delivery, with recovery timelines measured in months to years on outer islands.

4. Economic Impacts

Tourism Revenue at Existential Risk

Tourism contributes approximately **50% of Bahamian GDP** – an extraordinary concentration of economic dependence on a sector directly threatened by beach loss, degraded reefs, and hurricane disruption. Spencer, Strobl & Campbell (2022) modeled that across the Caribbean under a high-emissions scenario (RCP8.5), sea level rise alone will cause a **59% loss in sandy beaches, a 39% loss in proximity hotel rooms, and a 47% decline in direct tourism revenues by 2100**. The Bahamas, holding such a large share of Caribbean beaches, faces above-average exposure.

Hurricane Damage & GDP Losses

Hurricane Dorian alone caused **US\$3.4 billion in physical asset damage – equivalent to 25% of annual GDP** in a single storm event. As ocean warming fuels more intense hurricanes and sea level rise amplifies storm surge heights, future storms will inflict proportionally larger damages on the same asset base. The IMF's 2025 dynamic stochastic modeling projects significant **long-term potential output losses** without major adaptation investment. Recovery from hurricane damages incurs greater levels of national debt and shifts financial resources away from sustainable development needs.

Natural Capital Erosion

The degradation of coral reefs, mangroves, and beaches does not merely threaten tourism aesthetically – it removes **quantifiable natural capital** that provides storm protection, fisheries productivity, and carbon sequestration services. The economic value of reef-based coastal protection in the Caribbean runs to billions of dollars annually; its loss translates directly to increased public expenditure on engineered coastal defenses.

Fisheries & Agriculture Losses

Rising temperatures and acidification reducing marine fish stocks, combined with

saltwater intrusion undermining crop yields, threaten two of The Bahamas' most important non-tourism economic sectors. These impacts fall disproportionately on Family Island economies where fishing and farming are primary livelihoods.

Adaptation Investment Needs & Opportunity

The IMF (2025) models that proactive structural resilience investment – protecting 80% of exposed physical assets and preserving 80% of natural capital – could **unlock substantial long-term output gains** that outweigh adaptation costs. Beach nourishment, for example, is estimated at just **0.87–1.1% of annual tourism revenue** – a relatively affordable intervention with significant protective returns.

Key Takeaway

The Bahamas presents one of the most acute and well-documented cases of **climate injustice** in the world: a nation responsible for a vanishingly small fraction of global emissions facing potentially **existential territorial, ecological, and economic consequences**. The convergence of sea level rise threatening 41% of its land, coral reef systems collapsing under marine heatwaves, hurricane intensification erasing up to 25% of GDP in a single event, and tourism revenue structurally endangered by beach erosion creates compounding, mutually reinforcing vulnerabilities. The scientific consensus is unambiguous – without both **aggressive global emissions reductions** and **substantial adaptation investment**, the physical and economic geography of The Bahamas will be fundamentally and irreversibly altered within this century.

5. References

Reference	Key Contribution
1. ENVIRONMENTAL IMPACTS	
Aligishiev, Z. (2025). <i>Assessing Climate Change Risks — Potential Output Losses and Gains from Strengthening Resilience, The Bahamas</i> . IMF SIP/2025/030.	Quantitative modeling of sea level rise, hurricane damage, and GDP losses; adaptation cost-benefit analysis.

IPCC AR6 (2021/2022). <i>Sixth Assessment Report — Working Groups I, II & III.</i>	Global scientific foundation for all regional projections; Caribbean SIDS chapter directly applicable.
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Welsh, K. & Gustave, W. (2025). <i>Building Climate Resilience in The Bahamas: A Framework for Soil and Water Resource Management Amidst Saltwater Intrusion.</i> International Journal of Bahamian Studies, 31(1).	Freshwater lens vulnerability; saltwater intrusion data; soil salinization case studies cob.journals.publicknowledgeproject.
2. ECOLOGICAL IMPACTS	
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Perry Institute for Marine Science (2023). <i>Coral Bleaching Crisis: Massive Bleaching Demands Major Response</i>. PIMS Field Reports.	Field documentation of the 2023 Bahamas-wide mass bleaching event; 91°F ocean temperatures. www.perryinstitute.org.
Sherman, K. (2025). Marine rapid ecological assessment report for Little Inagua. A technical report submitted to the Bahamas National Trust. Nassau, Bahamas. 42 pp.	SCTLD and bleaching documentation; reef and seagrass condition assessment at 25 sites. www.perryinstitute.org.
3. SOCIAL IMPACTS	
Commonwealth of The Bahamas (2024). <i>Third National Communication (TNC) to the UNFCCC</i>. Department of Environmental Planning and Protection.	National synthesis of sectoral climate vulnerabilities; GHG inventory; NDC commitments UNFCCCUNFCCC. Third National Communication (TNC) of The Commonwealth of The Bahamas.
ECLAC (2019). <i>Assessment of the Effects and Impacts of Hurricane Dorian in The Bahamas</i>. International Recovery Platform.	Comprehensive post-Dorian damage and loss assessment; multi-sector economic and social impact data International Recovery Platform.

Hamilton, W., Philippe, C., Hospedales, J., Dresser, C., Colebrooke, B., Hamacher, N., Humphrey, K. & Sorensen, C. (2023). <i>Building capacity of healthcare professionals and community members to address climate and health threats in The Bahamas: Analysis of a green climate fund pilot workshop.</i> Dialogues in Health 3:100141, https://doi.org/10.1016/j.dialog.2023.100141.	Climate-health nexus; hurricane health impacts; healthcare capacity building.
Martin del Campo, F., Singh, S.J., Fishman, T., Thomas, A. & Drescher, M. (2023). <i>The Bahamas at risk: Material stocks, sea-level rise, and the implications for development.</i> Journal of Industrial Ecology 27:1165–1183. https://doi.org/10.1111/jiec.13402.	Social vulnerabilities of climate change, especially for Family Island communities e.g., population displacement, poverty, impacts to livelihoods, health and development.
4. ECONOMIC IMPACTS	
Acevedo Mejia, S. (2016). <i>Gone with the Wind: Estimating Hurricane and Climate Change Costs in the Caribbean.</i> IMF Working Paper 16/199. https://doi.org/10.5089/9781475544763.001.	Hurricane damage projection model used by IMF for The Bahamas; 31–42% damage increase under warming scenarios IMF eLibrary .
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About The Bahamas Academy of Sciences (BAS)

The Bahamas Academy of Sciences (BAS) is a global collection of Bahamian scientists who have made significant contributions to the science of The Bahamas. The mission of BAS is to recognize and promote excellence in science and its use in decision-making processes that contribute to national development and growth. See our first peer-reviewed paper outlining the research trends, "Fifty Years of Research in The Commonwealth of The Bahamas: A Quantitative Thematic Analysis of Scholarly Output" in Gulf and Caribbean Research, Vol: 37, Issue: 1. <https://doi.org/10.18785/gcr.3701.15>.

