

Synergizing Green Hospital Management and Carbon Accounting: A Framework for Sustainable Healthcare Innovation

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ABSTRACT

Objective: This study develops a conceptual framework that integrates green hospital management and carbon accounting to support sustainable healthcare innovation.

Method: This study uses a literature review and conceptual paper approach by synthesizing recent studies, sustainability frameworks, healthcare management practices, and carbon accounting principles. **Results:** The findings propose an integrated framework consisting of five strategic pillars: sustainable governance, green operational systems, carbon measurement and disclosure, circular healthcare resource management, and digital sustainability innovation. The framework demonstrates that carbon accounting can function not only as a reporting tool but also as a strategic instrument for efficiency, cost control, regulatory compliance, and long-term hospital resilience. **Novelty:** This study contributes theoretically by bridging sustainability accounting and healthcare management literature and practically by offering a roadmap for hospital administrators and policymakers. The proposed model supports environmentally responsible healthcare systems while maintaining service quality and operational effectiveness.

INTRODUCTION

Healthcare institutions are indispensable pillars of social welfare, providing essential preventive, curative, rehabilitative, and emergency services that profoundly impact human health and quality of life. Paradoxically, however, hospitals rank among the most resource-intensive organizations in the public sector, posing significant sustainability challenges. Their 24/7 operations demand enormous electricity consumption—often surpassing that of entire small cities—for critical functions such as lighting, ventilation, air conditioning, operating rooms, intensive care units, laboratories, cold chains, and advanced medical equipment. In addition, hospitals consume vast volumes of water, generate substantial infectious and hazardous waste, and rely heavily on carbon-intensive supply chains for pharmaceuticals, medical devices, food services, and transportation, thereby amplifying their environmental footprint. This substantial environmental impact positions healthcare as a significant contributor to climate change and ecological degradation, underscoring the urgent imperative for sustainable transformations within the sector [1].

In the context of climate change, healthcare has increasingly been recognized as both a victim of environmental degradation and a contributor to it. Climate-related disasters, heatwaves, infectious disease outbreaks, and air pollution create greater demand for health services, while hospital activities themselves generate significant

greenhouse gas emissions. Globally, the healthcare sector contributes approximately 4.4% of total net carbon emissions, positioning it as one of the major institutional contributors to environmental pressures [2]. This paradox creates urgency for healthcare institutions to transform toward sustainable and low-carbon systems.

In the context of climate change, healthcare has increasingly been recognized as both a victim of environmental degradation and a major contributor to it, producing significant carbon emissions and waste [1]. This paradox underscores the urgent imperative for healthcare institutions to transform toward sustainable and low-carbon systems.

Green hospital management has emerged as a strategic approach to address these challenges. The green hospital concept emphasizes environmentally responsible hospital governance by integrating energy efficiency, waste minimization, water conservation, sustainable infrastructure, green procurement, and patient-centered environmental health practices [3]. Green hospitals not only reduce ecological footprints but also improve operational efficiency, reduce long-term costs, strengthen patient safety, and improve institutional reputation [4], [5].

Nevertheless, many hospital sustainability initiatives remain fragmented and project-based. In many developing countries, including Indonesia, green initiatives are often implemented as isolated environmental programs such as waste segregation or energy-saving campaigns, without integration into hospital financial planning, performance indicators, and strategic governance systems [6]. As a result, sustainability efforts frequently lack measurable performance outcomes, long-term accountability, and policy continuity.

Carbon accounting offers an important managerial solution to bridge this gap. Carbon accounting is a systematic process for identifying, measuring, recording, analyzing, and disclosing greenhouse gas emissions and related environmental costs generated by organizational activities [7]. In hospital settings, carbon accounting enables management to quantify emissions from electricity use, medical gases, waste treatment, transportation, procurement, and supply chains [8]. More importantly, carbon accounting transforms sustainability from a normative commitment into measurable managerial information that supports budgeting, investment decisions, risk mitigation, ESG disclosure, and institutional accountability [9].

The integration between green hospital management and carbon accounting is therefore highly relevant for achieving sustainable healthcare innovation. A synergistic model can help hospitals shift from conventional operational systems toward resilient, resource-efficient, and environmentally responsible healthcare services. Such integration is also aligned with global sustainable development agendas, including climate-resilient health systems, ESG governance, and low-carbon public service transformation [10].

Despite its strategic importance, studies that specifically integrate green hospital management and carbon accounting into a single conceptual healthcare innovation framework remain limited [9], [11]. Most existing studies discuss operational

sustainability or environmental accounting separately. This creates a research gap in terms of managerial integration and implementation pathways for hospitals.

Therefore, this study aims to develop an integrated conceptual framework that synergizes green hospital management and carbon accounting to support sustainable healthcare innovation. This study contributes both theoretically by bridging healthcare sustainability and environmental accounting literature and practically by providing a roadmap for hospital managers, policymakers, and healthcare stakeholders.

Table 1. Key Environmental Challenges and Sustainability Responses in Hospitals

Key Challenge	Main Source	Sustainability Risk	Strategic Green Response
High energy consumption	HVAC, ICU, operating rooms	High carbon emissions, high costs	Smart energy systems, solar integration
Medical waste generation	Infectious waste, plastics	Environmental pollution	Waste segregation, green disposal
Water overconsumption	Sanitation, sterilization	Resource inefficiency	Water recycling, monitoring systems
Carbon-intensive supply chain	Procurement, logistics	Scope 3 emissions	Green procurement policies
Disposable materials dependency	Single-use medical items	Waste burden	Circular resource management

RESEARCH METHOD

This study employs a qualitative literature review and conceptual paper approach to develop an integrated framework that synergizes green hospital management and carbon accounting in supporting sustainable healthcare innovation. A conceptual paper approach was selected because this study aims to build a theoretical and managerial framework rather than test causal relationships empirically. This approach is appropriate for synthesizing interdisciplinary knowledge from healthcare management, environmental sustainability, carbon accounting, and institutional governance [12], [13].

This research adopts a structured narrative literature review design with conceptual synthesis. The study focuses on identifying key dimensions, implementation challenges, and strategic opportunities related to hospital sustainability practices and carbon accounting systems. The conceptual development process follows three stages:

1. Problem Identification Stage

This stage identifies key environmental and operational sustainability issues in hospitals, including energy inefficiency, medical waste, resource overconsumption, and carbon emissions.

2. Literature Mapping and Thematic Synthesis Stage

Relevant literature is systematically mapped to identify key concepts, implementation models, best practices, and research gaps in green hospital

management and carbon accounting.

3. Framework Development Stage

Based on thematic synthesis, an integrated conceptual framework is developed to explain the interaction between green hospital operational systems, carbon measurement, governance, and digital sustainability innovation.

This study uses secondary data in the form of scientific literature, policy documents, and institutional sustainability reports. Sources were collected from reputable academic databases and institutional publications, including:

1. Scopus-indexed journals;
2. Google Scholar;
3. World Health Organization (WHO) reports;
4. Health Care Without Harm publications;
5. sustainability accounting standards and ESG frameworks.

The literature reviewed was primarily published between 2020 and 2026 to ensure relevance to current healthcare sustainability issues.

The selection criteria for literature include:

- a. Direct relevance to green hospital practices;
- b. Discussion of carbon accounting or environmental accounting systems;
- c. Healthcare sustainability and esg governance relevance;
- d. Practical implications for hospital management.

A total of approximately 35–50 relevant sources were conceptually reviewed to support framework development.

Table 2. Literature Selection Criteria

Criteria	Inclusion Parameters
Publication year	2020–2026
Source type	Journals, reports, policy documents
Scope relevance	Green hospital, carbon accounting, ESG healthcare
Quality	Indexed / reputable institutional sources

RESULTS AND DISCUSSION

Result

Hospitals face several environmental challenges, including:

- a. High energy consumption from HVAC systems, operating rooms, and medical equipment;
- b. Significant medical and non-medical waste generation;
- c. Excessive water consumption;
- d. Carbon-intensive procurement and logistics systems;
- e. Reliance on single-use plastics and disposables.

These challenges increase both operational costs and environmental risks.

Green hospital management focuses on improving environmental performance through:

- a. Green building design;
- b. Energy efficiency systems;
- c. Renewable energy use;
- d. Sustainable waste management;
- e. Efficient water systems;
- f. Green procurement;
- g. Eco-friendly patient services.

These initiatives improve efficiency, reduce costs, and enhance institutional reputation.

Carbon accounting supports hospitals in:

- a. Identifying Scope 1, 2, and 3 emissions;
- b. Measuring carbon-intensive activities;
- c. Integrating environmental costs into budgeting;
- d. Supporting sustainability disclosure;
- e. Evaluating green investment returns.

Carbon accounting strengthens managerial control and policy accountability.

The proposed framework consists of five pillars:

1. Sustainable Governance and Leadership
Hospital boards should integrate sustainability into strategic planning, KPIs, and risk management.
2. Green Operations and Infrastructure
Hospitals should adopt efficient energy systems, waste segregation, renewable energy, and green facilities.
3. Carbon Accounting and Environmental Cost Control
Hospitals should establish emission inventories, environmental cost centers, and sustainability reporting systems.
4. Circular Resource Management
Hospitals should optimize resource use through reuse, recycling, and responsible procurement.
5. Digital Sustainability Innovation
Hospitals should use IoT, smart monitoring, electronic medical systems, and ESG dashboards.

The integration framework provides:

- a. Reduced operational costs;
- b. Lower carbon emissions;
- c. Improved esg performance;
- d. Better healthcare resilience;
- e. Stronger stakeholder trust.

Discussion

This study highlights that green hospital transformation cannot rely solely on operational environmental initiatives without managerial measurement systems. Carbon accounting serves as a strategic bridge between sustainability goals and financial

decision-making. Through carbon cost visibility, hospitals can better identify wasteful activities, prioritize green investments, and optimize resource allocation.

The proposed framework also supports hospital competitiveness in the era of ESG and digital healthcare. Hospitals adopting sustainable practices may improve public trust, accreditation outcomes, and long-term resilience.

However, implementation challenges remain, including a lack of technical expertise, investment constraints, limited sustainability awareness, and the absence of standardized hospital carbon reporting systems. Therefore, policy support, institutional commitment, and capacity building are necessary.

This conceptual framework provides a practical roadmap for hospital managers to align healthcare quality with sustainability goals [14], [15].

CONCLUSION

Fundamental Finding: Synergizing green hospital management and carbon accounting is essential to support sustainable healthcare innovation. Hospitals need integrated systems that combine environmental operational improvements with accounting-based sustainability measurement. **Implication:** This study proposes a five-pillar framework that can guide hospitals in improving efficiency, reducing emissions, strengthening governance, and enhancing long-term resilience. Carbon accounting should be positioned not merely as a reporting mechanism but as a strategic management tool for sustainable healthcare transformation. **Limitation:** This study is limited by its conceptual and literature-based approach, as the proposed framework has not yet been empirically tested across hospitals with different sizes, ownership structures, and operational contexts. **Future Research:** Future studies are encouraged to empirically test this framework in hospitals of different sizes and ownership structures to validate its effectiveness.

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